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Heavy Metals (Cd, Cu, Pb and Zn) Concentrations in *Telescopium telescopium* from Dumai Coastal Waters, Indonesia

[1,3]B. AMIN, [1]A. ISMAIL, [2]M.S. KAMARUDIN, [1]A. ARSHAD & [1]C.K. YAP
[1]*Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[2]*Department of Aquaculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Malaysia*
[3] *Department of Marine Science, Faculty of Fisheries and Marine Science, University of Riau, Pekanbaru 28293, Indonesia*

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ABSTRAK

Kepekatan kadmium, tembaga, plumbum dan zink dalam siput laut, Telescopium telescopium *ditentukan untuk memberi maklumat tentang tahap kandungan logam di Selat Melaka di sebelah perairan Indonesia. Sampel* T. telescopium *diambil di kawasan air pasang surut di empat stesen di Dumai pada Julai 2004. Keputusan pada kajian terkini menunjukkan kepekatan logam pada tisu lembut* T. telescopium *berbeza di setiap stesen pensampelan: berat kering masing-masing 0.33 - 069 µg/g; 9.38 - 52.29 µg/g; 1.73 - 10.78 µg/g; 14.69 - 69.87 µg/g; untuk kadmium, tembaga, plumbum dan zink. Sampel dari stesen Sungai Dumai mengumpulkan lebih banyak kandungan logam apabila dibandingkan dengan stesen lain.* T. telescopium *yang kecil mengumpulkan lebih banyak logam daripada* T. telescopium *yang besar. Korelasi negatif di antara kepekatan logam dan saiz (panjang dan berat) diperhatikan (kecuali sample Cd dan Cu dari Sungai Mesjid) dengan sesetengah variasi dalam pekali kerelasi yang menunjukkan pengawalan logam oleh* T. telescopium. *Sungai Dumai menunjukkan Indeks Pencemaran Logam (MPI) yang paling tinggi iaitu 12.57 dan Indeks Beban Pencemaran Tomlinson (PLI) sebanyak 34.35 dengan Lubuk Gaung mencatatkan indeks yang rendah bagi kedua-duanya iaitu 3.26 dan 8.89. Secara umumnya, nilai MPI dan PLI menunjukkan pencemaran logam di perairan pinggir laut Dumai belum lagi merupakan satu ancaman yang serius dan tiada langkah pembaikan drastik diperlukan. Walau bagaimanapun, sebagai salah satu kawasan yang paling membangun di Sumatera, kajian lanjut adalah perlu untuk menaksir variasi masa dalam logam dan kepekatan untuk spesies ini dan organisma-organisma penunjuk lain yang mungkin selain dalam sedimen dari kawasan-kawasan sekeliling dalam usaha untuk mendapatkan lebih kefahaman tentang status pencemaran di perairan pinggir laut Dumai.*

ABSTRACT

Concentrations of cadmium, copper, lead and zinc in the marine gastropod, Telescopium telescopium, *were determined to provide background information on heavy metal levels in the Straits of Malacca in the Indonesian side. Samples of* T. telescopium *were collected from intertidal Dumai coastal waters at four stations in July 2004. The results of the present study showed that metal concentrations in the soft tissue of* T. telescopium *varied at different sampling stations: 0.33 – 0.69 µg/g; 9.38 – 52.29 µg/g; 1.73 – 10.78 µg/g; 14.69 – 69.87 µg/g dry weight for cadmium, copper, lead and zinc, respectively. Samples from Sungai Dumai station accumulated more heavy metals when compared to other stations. Smaller* T. telescopium *accumulate more metals than larger ones. Negative correlations between metal concentrations and size (length and weight) were observed (except Cd and Cu in samples from Sungai Mesjid) with some variation in the correlation coefficients which indicated metal regulation by the* T. telescopium. *Sungai Dumai showed the highest Metal Pollution Index (MPI) of 12.57 and Tomlinson Pollution Load Index (PLI) of 34.35 with Lubuk Gaung showing the lowest with 3.26 and 8.89, respectively. In general, the MPI and PLI values indicate that metal pollution in Dumai coastal waters is not a serious threat yet and no drastic rectification measures are needed. However, as one of the most developing regions in Sumatera, further studies are necessary to assess temporal variation in metal accumulation and*

concentration for this species and other possible indicator organisms as well as in sediment from the surrounding areas in order to gain a better understanding of pollution status in Dumai coastal waters.

INTRODUCTION

Increased population and rapid economic and industrial development can cause many ecological problems to marine and coastal areas. Like many other developing regions, the Dumai coastline is subjected to negative impacts of industrial development and anthropogenic activities. It is also likely to receive impacts from the Straits of Malacca which is an international waterway and is known as one of the busiest shipping lanes in the world. These days, there are many industries and major oil and commercial ports operating in Dumai. Other possible sources of heavy metal pollution in this area includes urbanization activities, land-based inputs such as deforestation, disposal of industrial wastes, sewage and solid waste disposal, mangrove swamp conversion and land reclamation and sea-based inputs from shipping, dumping and fishing.

Gastropods are common inhabitants of mangrove ecosystems and are suitable organisms for monitoring environmental contamination and metal bioavailability studies (Peerzada *et al.* 1990; Leung and Furness 1999; de Wolf *et al.* 2000; Blackmore 2001; Cubadda *et al.* 2001; Conti and Cecchetti 2003; Liang *et al.* 2004). Elevated concentrations of heavy metals in Dumai waters have been previously detected such as in surface water and sediment (Amin and Zulkifli 1997); mudskipper (Amin 2000); barnacles (Efriyeldi and Amin 2001) and mangrove (Amin 2001). The present study aims to provide background information concerning heavy metal concentrations in *T. telescopium* from Dumai coastal waters.

MATERIALS AND METHODS

A total of ninety-six specimens of *T. telescopium* were collected in July 2004 from four locations in the mangrove area of Dumai coastal waters (*Fig. 1*). Three different size groups of small (38 – 55 mm), medium (57 – 75 mm) and large (75 – 90 mm) were selected and brought back to the laboratory. They were then cleaned with distilled water and the soft tissues were removed from the shells. All the soft tissues were oven dried to constant weight at 105°C (Mo and Neilson 1994). The dried soft tissues were then digested following the procedures outlined by Yap *et al.* (2003). The dried soft tissues were digested in concentrated nitric acid (AnalaR grade, BDH 69%) and placed in a hot-block digester at low temperature (40° C) for 1 hour and fully digested at high temperature (140° C) for at least 3 hours. The digested samples were then diluted to 40 ml with double distilled water. After filtration, heavy metals were determined by an air-acetylene flame atomic absorption spectrophotometer (AAS) Perkin-Elmer Model 3110. The data are presented in $\mu g/g$ dry weight. All glassware and equipments used were acid-washed to avoid possible contamination and the accuracy of the analyses was checked against blanks and by the standard addition testing procedure. Percentages of recoveries for heavy metal analysis were 103.6 %, 97.7 %, 96.6 % and 98.3 % for Cd, Cu, Pb and Zn respectively. Procedural blanks and quality control samples made from the standard solutions for Cd, Cu, Pb and Zn, prepared from 1000 mg/l stock solution (BDH Spectrosol) of each metal, were analyzed every five specimens in order to check for sample accuracy.

In order to compare the total concentrations of metals at different sampling sites, a metal pollution index (MPI) was calculated based on an equation used by Usero *et al.* (1996; 1997) and Giusti *et al.* (1999). A Tomlinson pollution load index (PLI) was also measured because it can be used as an index of bioavailability of heavy metal for molluscs in coastal waters (Tomlinson *et al.* 1980; Angula 1996).

RESULTS AND DISCUSSION

The results of the present study showed that the mean metal concentrations in the soft tissue of *T. telescopium* were varied at different sampling stations : 0.33 – 0.69 $\mu g/g$; 9.38 – 52.29 $\mu g/g$; 1.73 – 10.78 $\mu g/g$; 14.69 – 69.87 $\mu g/g$ dry weight for cadmium, copper, lead and zinc respectively. Higher metal concentrations were found in samples from Sungai Dumai followed by Tanjung Medang, Sungai Mesjid and Lubuk Gaung (Table 1 and *Fig. 2*). Amin and Zulkifli (1997) and Amin (2000) reported that metal concentrations in sediment and mudskippers from Sungai Dumai were higher when compared to other locations in Dumai and Rupat waters.

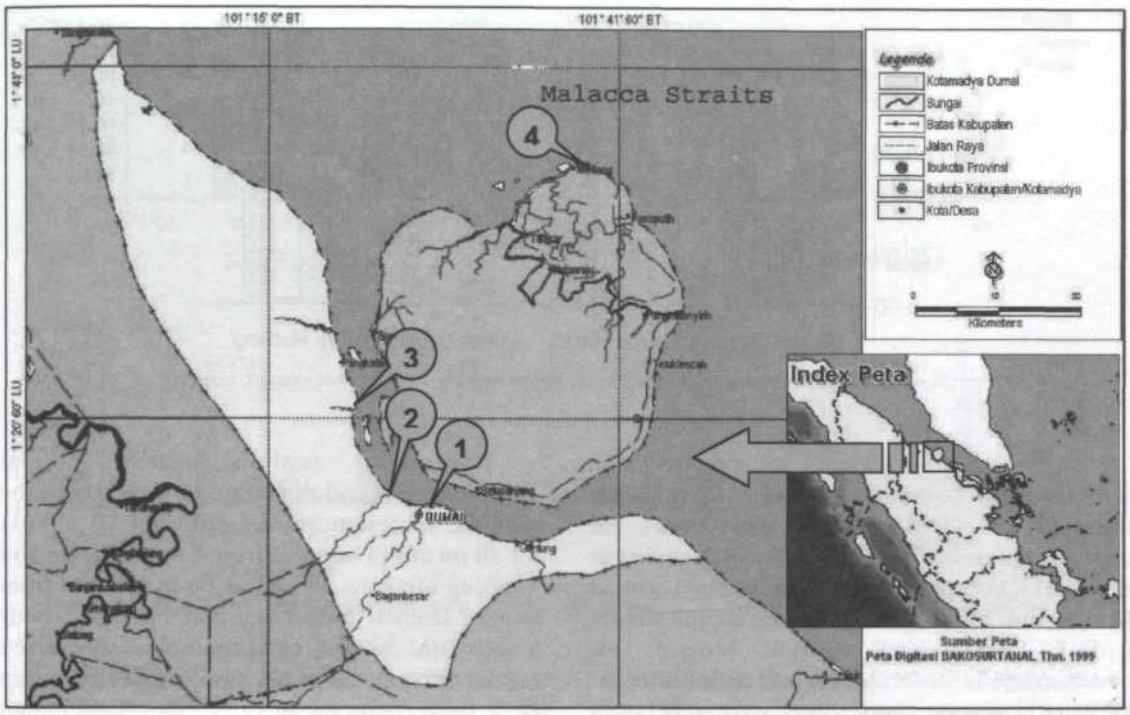

Fig. 1: Map of Dumai and sampling locations in Sungai Dumai (1), Sungai Mesjid (2), Lubuk Gaung (3) and Tanjung Medang (4)

TABLE 1
Heavy metal concentrations in *T. telescopium* from Dumai coastal waters (Means ± SD)

Station	Size class	Length (mm)	Weight (g)	Concentration (mg/g d.w)			
				Cd	Cu	Pb	Zn
Sg. Dumai	Small	51.13 ± 5.38	1.00 ± 0.48	0.83 ± 0.50	57.75 ± 26.11	14.88 ± 10.21	85.74 ± 46.28
	Medium	64.50 ± 5.93	1.42 ± 0.36	0.66 ± 0.34	58.56 ± 25.97	12.37 ± 4.03	79.60 ± 30.76
	Large	83.13 ± 5.96	3.64 ± 0.66	0.41 ± 0.14	40.56 ± 16.55	5.10 ± 1.76	44.25 ± 5.25
	Average	66.25 ± 14.49	2.02 ± 1.28	0.63 ± 0.39	52.29 ± 23.83	10.78 ± 7.45	69.87 ± 36.01
Sg. Mesjid	Small	51.75 ± 5.06	1.33 ± 0.39	0.56 ± 0.17	15.33 ± 7.20	8.69 ± 11.34	64.41 ± 32.15
	Medium	65.25 ± 4.77	2.03 ± 0.13	0.75 ± 0.20	21.24 ± 10.07	8.54 ± 1.86	49.13 ± 25.36
	Large	77.5 ± 3.78	2.99 ± 0.56	0.75 ± 0.35	23.01 ± 15.26	6.94 ± 2.19	45.69 ± 14.42
	Average	64.83 ± 11.60	2.12 ± 0.79	0.69 ± 0.26	19.86 ± 11.35	8.06 ± 2.00	53.98 ± 24.82
Lubuk Gaung	Small	43.50 ± 4.34	0.68 ± 0.35	0.61 ± 0.28	18.12 ± 7.53	4.50 ± 1.91	25.48 ± 4.95
	Medium	59.5 ± 2.62	1.52 ± 0.22	0.25 ± 0.09	6.65 ± 2.44	2.02 ± 0.91	11.85 ± 5.21
	Large	79.88 ± 2.90	2.79 ± 0.19	0.14 ± 0.08	3.36 ± 2.02	0.81 ± 0.64	6.73 ± 3.07
	Average	60.96 ± 15.54	1.66 ± 0.92	0.33 ± 0.27	9.38 ± 7.88	2.44 ± 1.99	14.69 ± 9.16
Tj. Medang	Small	57.25 ± 4.43	1.80 ± 0.16	0.91 ± 0.35	58.57 ± 9.59	2.57 ± 1.08	75.18 ± 29.05
	Medium	74.5 ± 9.09	3.11 ± 1.26	0.70 ± 0.31	53.97 ± 17.87	1.75 ± 1.25	52.425 ± 23.09
	Large	82.63 ± 6.31	5.43 ± 1.37	0.40 ± 0.25	32.99 ± 22.07	0.88 ± 0.35	30.93 ± 10.21
	Average	71.64 ± 16.64	3.44 ± 1.85	0.67 ± 0.36	48.51 ± 20.07	1.73 ± 1.17	52.85 ± 28.131

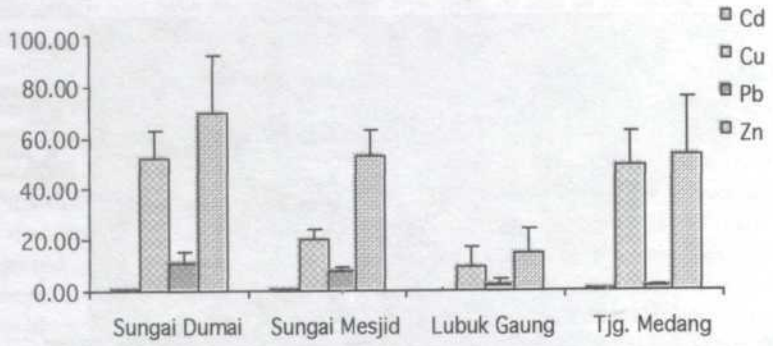

Fig. 2: Heavy metal concentrations in T. telescopium *from Dumai coastal waters*

The ANOVA test showed that Cd and Zn in samples from Lubuk Gaung were significantly different ($P < 0.01$) from other stations. All concentrations of Cu were significantly different ($P < 0.01$), except between samples from Sungai Dumai and Tanjung Medang and samples from Lubuk Gaung and Sungai Mesjid. Pb concentrations were also significantly different ($P < 0.01$) among the stations, except between Sungai Dumai and Sungai Mesjid as well as between Lubuk Gaung and Tanjung Medang.

Sungai Dumai estuary is located in the city centre and the sampling area received anthropogenic wastes from densely populated sorrounding areas carried by the river. This area is also very close to an oil refinery, dock yard and international tankers activities. Heavy metal concentrations in *T. telescopium* was in the order of Zn > Cu > Pb > Cd. In general the concentrations of these metals were considered to be low when compared with data on the same species from Australia as reported by Peerzada *et al.* (1990).

The present results showed that smaller *T. telescopium* accumulate more metals than larger ones (*Fig. 3*) and thus size is an important variable to consider for metal accumulation. Concentrations of all metals in a smaller sample size from Lubuk Gaung and Tanjung Medang as well as Pb in samples from Sungai Dumai were significantly higher ($P < 0.05$) from the larger size. However, although they showed a similar trend, metal concentrations in samples from Sungai Mesjid and Sungai Dumai (except Pb), did not differ significantly ($P > 0.05$). A study on snails by Williamson (1980) found that higher levels of metals were found in smaller specimens suggesting that increases in metabolic rates in relation to different body sizes might affect heavy metal uptake and elimination.

Regression analysis between metal concentrations and the length and weight of the samples were significantly different ($P < 0.01$) for all metals in samples from Lubuk Gaung and Tanjung Medang, as well as Pb in samples from Sungai Dumai, indicating that increased body length and weight corresponds to decreased metal concentrations. No significant relationship ($P > 0.05$) between metal concentrations and body length and weight in samples from Sungai Mesjid as well as for Cd, Cu and Zn in samples from Sungai Dumai was found.

Negative correlations between metal concentrations and size (length and weight) were observed (except Cd and Cu in samples from Sungai Mesjid) with some variation in the correlation coefficients which gave an indication of metal regulation by the *T. telescopium*. The decrease in heavy metal concentrations with an increase in body size of the organisms have also been found in other molluscan species and their possible causes were mainly related to the metabolic activities at different ages of the organisms (Boyden, 1977; Olafsson, 1986; Jones *et al.* 1992; Swaileh and Adelung, 1994; Kraak *et al.* 1994; Bilos *et al.* 1998).

The MPI values based on cadmium, copper, lead and zinc in *T. telescopium* for each sampling site as well as the PLI values which were calculated based on the minimum concentrations measured in the present study (as the baseline) are shown in Table 2. Sungai Dumai showed the highest Metal Pollution Index (MPI) of 12.57 and Tomlinson Pollution Load index (PLI) of 34.35 and Lubuk Gaung being the lowest with 3.26 and 8.89 respectively. Giusti *et al.* (1999) reported that MPI values based on nine metals of *Mytilus edulis* from the Northeast England coast were in the range of 10.50 – 25.10 and Chiu *et al.* (2000)

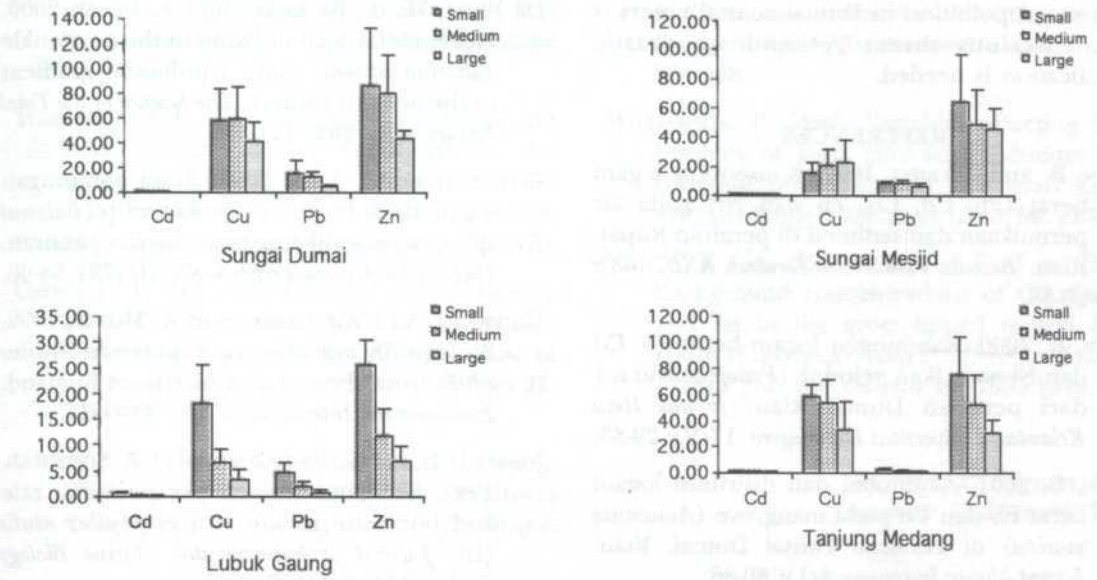

Fig. 3: Mean heavy metal concentration in different size groups of T. telescopium from Dumai coastal waters

reported MPI values of between 5.00 to 9.23 based on five metals of *Perna viridis* from Hong Kong waters; whilst Yap *et al.* (2003) reported MPI values of 4.35 – 11.70 in *P. viridis* from Peninsular Malaysia which was based on four metals.

According to Angula (1996), PLI is able to give an estimate of the metal contamination status and the necessary action that should be taken. A PLI value of ≥ 100 indicates an immediate intervention to ameliorate pollution; a PLI value of ≥ 50 indicates a more detailed study is needed to monitor the site, whilst a value of <50 indicates that drastic rectification measures are not needed.

The MPI and PLI values indicated that metal pollution in Dumai coastal waters is not a serious threat yet and no drastic rectification measures are needed. However, as one of the most developing regions in Sumatera, further studies are required to assess temporal variation in metal accumulation and concentration for this species and other possible indicator organisms as well as in sediment from the surrounding areas in order to gain a better understanding of the pollution status in Dumai coastal waters.

CONCLUSION

The present study showed that *T. telescopium* from Sungai Dumai accumulates more heavy metals as compared to other stations. Smaller *T. telescopium* accumulate more metals than larger ones and thus size is an important variable to consider for metal accumulation. Simple linear regression analyses indicated negative correlations between metal concentrations and size (except for Cd and Cu in Sungai Mesjid) with some variation in their correlation coefficients which give an indication of metal regulation by the *T. telescopium*. Sungai Dumai showed the highest MPI and PLI values and Lubuk Gaung the lowest, but these values indicate

TABLE 2
MPI and PLI values for *T. telescopium* from Dumai coastal waters

Station	MPI	PLI
Sungai Dumai	12.57	34.35
Sungai Mesjid	8.74	3.26
Lubuk Gaung	7.39	23.88
Tanjung Medang	8.89	20.21

that metal pollution in Dumai coastal waters is not a serious threat yet and no drastic rectification is needed.

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