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SHORT COMMUNICATION

The Impact of Anthropogenic Activities on Heavy Metal (Cd, Cu, Pb and Zn) Pollution: Comparison of the Metal Levels in the Green-Lipped Mussel *Perna viridis* (Linnaeus) and in the Sediment from a High Activity Site at Kg. Pasir Puteh and a Relatively Low Activity Site at Pasir Panjang

*YAP, C. K., ISMAIL, A., TAN, S. G. & RAHIM ISMAIL, A.
Department of Biology, Faculty of Science,
Universiti Putra Malaysia, 43400 UPM Serdang,
Selangor, Malaysia

It has been a common practice to select different environmental backgrounds in biomonitoring studies of heavy metal contamination (Yap *et al.* 2002a; 2002b; 2003a; 2003b). It is expected to obtain different pollutant concentrations in a selected biomonitoring agent. An interesting question that may arise here is 'Are all heavy metal levels high in a known high human activity sampling site ?' This question comes to mind since most researchers would assume a positive answer while ecotoxicologists would like to know which metal(s) is(are) high (maybe not all heavy metals) at that sampling site. The environmental background is closely related to the description of the sampling site which can range from an uncontaminated or pristine site to a highly contaminated site that is known to receive a lot of anthropogenic inputs.

In the present study, sediment samples and the green-lipped mussel *Perna viridis* were used to assess human impacts on the aquatic environment. Bryan and Langston (1992) documented several advantages in using sediment and mussels for this purpose. Firstly, sediment plays a major role in the transport and storage of metals; secondly, sediment is frequently used to identify sources of pollutants spatially and temporally; and thirdly, sediment can also be used to locate the main sinks for heavy metals as these elements are persistent in the marine environment (Nriagu 1978). The sediment samples are also geochemically fractionated and thus the percentages of anthropogenic input of metal can be calculated.

We chose the green-lipped mussel *Perna viridis* because marine mussels are often chosen for biomonitoring studies. The advantages of choosing this species are that they are sedentary organisms, long lived, easily identified and sampled, reasonably abundant and available throughout the year, tolerant to natural environmental fluctuations and pollution. In addition, these organisms have good net accumulation capacities and are ecologically important (Phillips 1980; Farrington *et al.* 1987). Yap *et al.* (2003a) reported the background levels of heavy metals in *P. viridis* collected from the west coast of Peninsular Malaysia.

In this study, two sites with contrasting environmental conditions were selected for the study. Kampung (Kg.) Pasir Puteh at the Straits of Tebrau (Johor) was selected since it has been observed to have a lot of activities such as moorings and petro-chemical plants, shipping, land reclamation, urbanization and other industrial activities. This area is close to Pasir Gudang, which is one of the major industrial areas in Malaysia. In addition, Pasir Gudang Port, one of the largest ports in Malaysia, is also located less than a few kilometers away from this area. There are no baseline data on the heavy metals for Kg. Pasir Puteh before the development of the town, port, marina and

* Corresponding author: *yapckong@hotmail.com* or *Yapckong@fsas.upm.edu.my*

industries. Therefore, it is necessary to use a reference area to allow the effects of human activities to be assessed by comparison. For this purpose, we selected Pasir Panjang in Port Dickson (Negeri Sembilan) since only a few human activities could be seen around the area, namely land reclamation and offshore shipping.

On scientific grounds, although it is a high activity site, Kg. Pasir Puteh is not considered as being contaminated until scientific data have proven it to be so although this is expected. Therefore, samples of an organism, the green-lipped mussel *Perna viridis* and sediment were collected from Kg. Pasir Puteh and Pasir Panjang and analysed for their metal concentrations.

In this study, the levels of heavy metals in the soft tissues, shells and byssus of *P. viridis* and the geochemical fractions of the sediments were determined and the results for the two sites were compared. The objective of this study is to ascertain if the contrasting environmental backgrounds do play important roles in the contamination of Cd, Cu, Pb and Zn at the sites.

The sampling sites at Pasir Panjang (latitude-north: 2°25' and 101°56') and Kg. Pasir Puteh (longitude-east: 1°26' and 103°55') in Peninsular Malaysia are shown in *Fig.* 1. Sampling was conducted between January and May 2000. About 20 similar size mussels (5-7 cm) were selected and analysed individually for heavy metals. The soft tissue of the mussel was dissected by removing the byssus and the shell. Total soft tissues, shells and byssus were dried at 105°C until they reached constant dry weights (dw) (Tanner *et al.* 2000). The analytical procedures for the mussel analysis followed those as described by Yap *et al.* (2003a) while for the analyses of the geochemical fractions of the sediments, the sequential extraction technique (SET) that was described by Badri and Aston (1983) was used. The T-test between any two variables was conducted using the STATISTICA software package.

The levels of Cu, Pb and Zn in their soft tissues, shells and byssus of the mussels collected from Kg. Pasir Puteh were found to be significantly ($P< 0.05$) higher than those collected

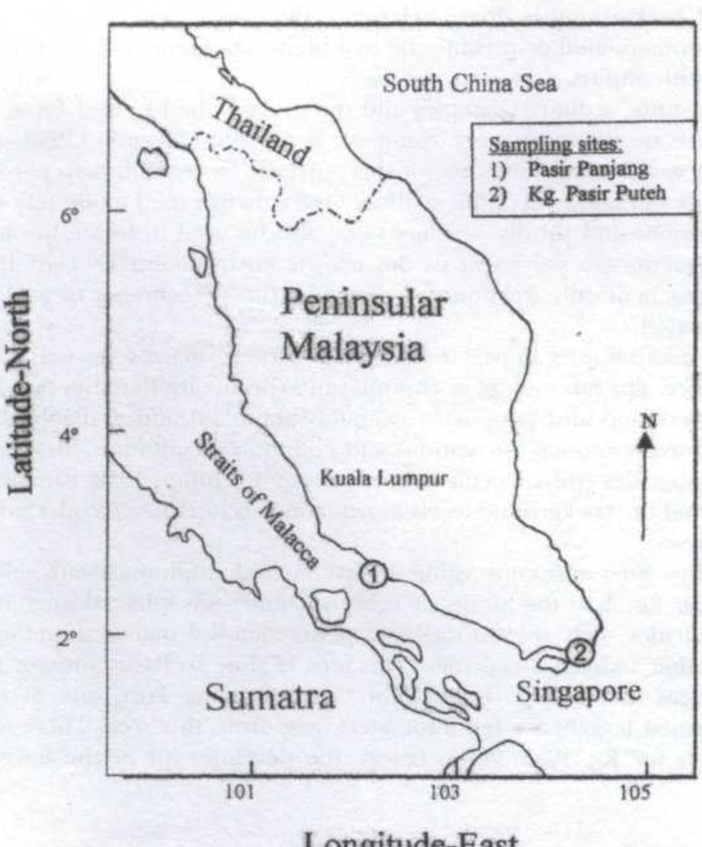

Fig. 1: Map showing the locations of the sampling sites

from Pasir Panjang (Table 1). The similar (not significantly different; P> 0.05) Cd levels in the soft tissues and shells of *P. viridis* collected from both locations were in line with the results for sediment samples in that the easily, freely, leachable or exchangaeble (EFLE) and resistant fractions and total Cd concentration in the sediments were not significantly (P> 0.05) different for the two sampling sites (Table 1).

Since both natural and anthropogenic metals were accumulated together in the sediment, it is difficult to identify which proportion of the total metal concentrations measured in the sediment is natural and which is anthropogenic in origin. The summation of the EFLE, acid-reducible and oxidisable-organic fractions in the SET used were calculated as the non-resistant fraction of the sediment which is believed to be mostly attributable to anthropogenic sources (Badri and

TABLE 1
Concentrations (mg/g dry weight) of Cd, Cu, Pb and Zn in the mussel tissues and sediments with their levels of significance

	Pasir Panjang	Kampung Pasir Puteh	Significance level
Soft tissue mussel			
Cd	0.77 ± 0.20	0.84 ± 0.03	P> 0.05
Cu	7.64 ± 0.20	15.45 ± 0.27	P< 0.01
Pb	4.54 ± 0.09	8.72 ± 0.06	P< 0.001
Zn	74.37 ± 2.36	102.8 ± 1.18	P<0.05
Shell mussel			
Cd	9.44 ± 0.12	9.34 ± 0.09	P> 0.05
Cu	6.92 ± 0.06	7.78 ± 0.07	P< 0.01
Pb	20.70 ± 0.45	32.72 ± 0.14	P< 0.01
Zn	3.99 ± 0.06	7.43 ± 0.04	P< 0.001
Byssus mussel			
Cd	1.06 ± 0.03	1.80 ± 0.06	P< 0.01
Cu	20.56 ± 1.44	51.99 ± 1.06	P< 0.01
Pb	13.52 ± 0.87	17.76 ± 0.72	P< 0.01
Zn	81.22 ± 1.93	192.17 ± 7.72	P< 0.01
Cd			
EFLE	0.23 ± 0.01	0.21 ± 0.01	P> 0.05
Acid-reducible	0.14 ± 0.01	0.25 ± 0.02	P< 0.05
Oxidisable-organic	0.09 ± 0.01	0.33 ± 0.04	P< 0.05
Resistant	0.58 ± 0.08	0.45 ± 0.07	P> 0.05
Total Cd	1.03 ± 0.09	1.24 ± 0.05	P> 0.05
Cu			
EFLE	1.01 ± 0.05	6.19 ± 0.05	P< 0.01
Acid-reducible	0.07 ± 0.00	0.35 ± 0.02	P< 0.05
Oxidisable-organic	2.59 ± 0.08	110.06 ± 3.51	P< 0.01
Resistant	12.50 ± 0.05	23.55 ± 5.36	P< 0.05
Total Cu	16.82 ± 0.13	140.2 ± 1.78	P< 0.01
Pb			
EFLE	5.43 ± 0.33	0.35 ± 0.02	P< 0.05
Acid-reducible	5.64 ± 0.43	15.65 ± 0.08	P< 0.05
Oxidisable-organic	8.02 ± 0.24	42.41 ± 3.05	P< 0.05
Resistant	31.64 ± 0.58	15.57 ± 1.00	P< 0.05
Total Pb	50.78 ± 0.50	77.10 ± 7.91	P< 0.05
Zn			
EFLE	0.15 ± 0.01	0.72 ± 0.08	P< 0.05
Acid-reducible	0.16 ± 0.01	50.00 ± 0.53	P< 0.01
Oxidisable-organic	21.16 ± 1.67	72.68 ± 4.05	P< 0.05
Resistant	92.70 ± 2.60	113.90 ± 19.79	P> 0.05
Total Zn	116.9 ± 3.94	243.9 ± 15.32	P< 0.05

Note: P indicates the significance level of metal levels between the two sites.

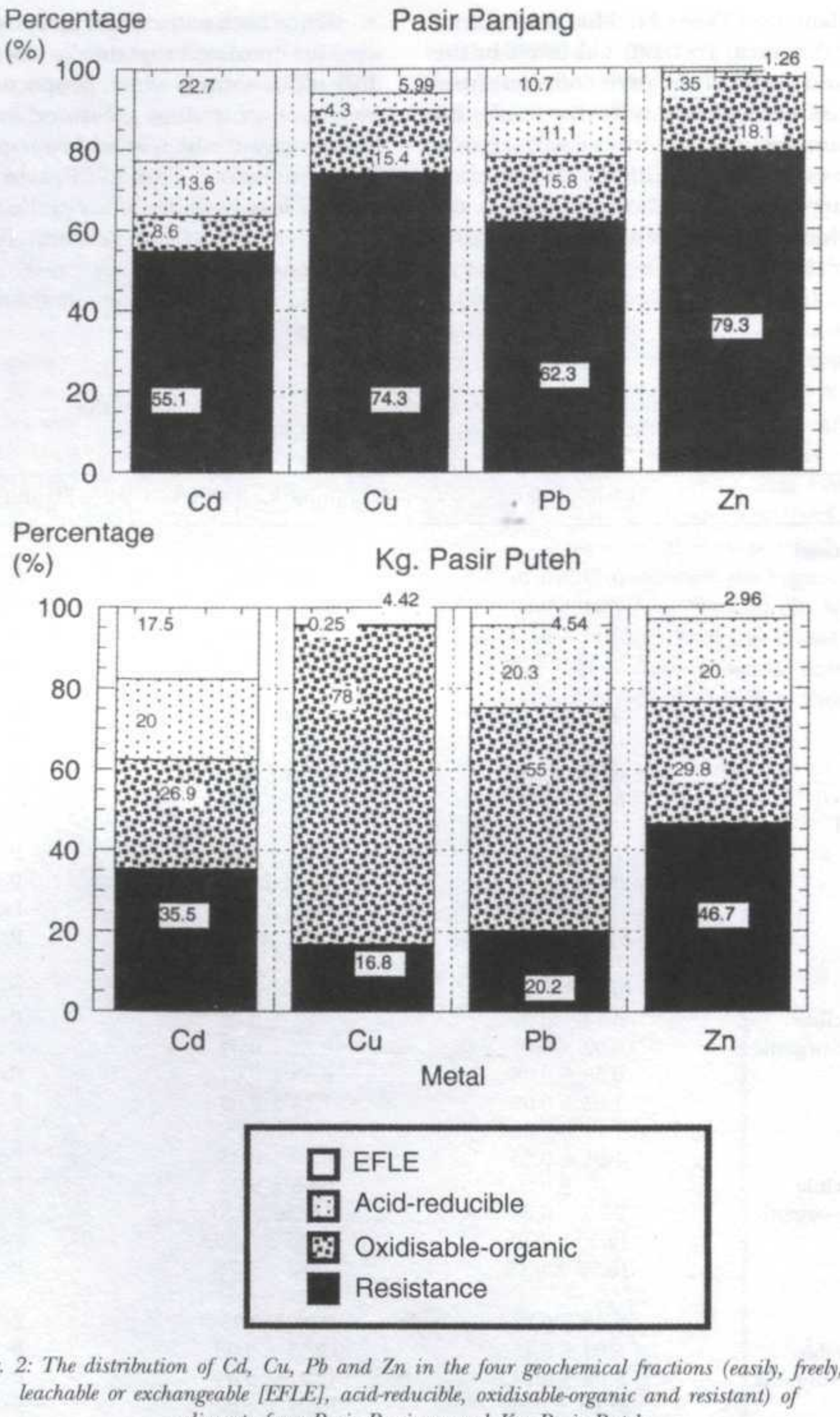

Fig. 2: The distribution of Cd, Cu, Pb and Zn in the four geochemical fractions (easily, freely, leachable or exchangeable [EFLE], acid-reducible, oxidisable-organic and resistant) of sediments from Pasir Panjang and Kg. Pasir Puteh

Aston 1983; Yap *et al.* 2002b). *Fig.* 2 shows that the non-resistant fractions of the geochemical extraction in Pasir Panjang were 44.9, 25.7, 37.7 and 10.7% for Cd, Cu, Pb and Zn, respectively. In comparison, the non-resistant fractions from Kg. Pasir Puteh were higher with 64.5, 83.2, 79.8 and 53.3% for Cd, Cu, Pb and Zn, respectively. This probably indicates that Kg. Pasir Puteh has received more anthropogenic input of the metals.

The conditions of the two sites were probably the reason why Mashinshian *et al.* (2002) chose Kampung (Kg.) Pasir Puteh and Pasir Panjang for their kinetics studies on polycyclic aromatic hydrocarbons (PAHs), conducted in October 1999. In their results, they found that Kampung (Kg.) Pasir Puteh had significantly ($P< 0.05$) higher levels of PAHs than Pasir Panjang. In the samples collected in December 1997 and September 1998, Mashinshian *et al.* (1999) found that the PAH levels in the soft tissues of *P. viridis* collected from Kg. Pasir Puteh were 8 to 16 times higher than those in mussels collected from Pasir Panjang during the two sampling periods, respectively.

Based on the present data, we can conclude that higher levels of Cu, Pb and Zn can be expected judging from the environmental backgrounds of Pasir Panjang and Kg. Pasir Puteh. The results of this study show the importance of site descriptions with different environmental backgrounds. Observation at the sampling site can provide useful information on the association between the contaminants being studied and the activities in the vicinity of the sampling site. We can assume that the high levels of Cu, Pb, Zn and PAHs could have been released from industrial, urban and port activities since these activities could be observed in the vicinity at Kg. Pasir Puteh. This study showed significant differences between the two sites for Cu, Pb and Zn but not for Cd levels. This indicated that although we might expect relatively high levels of contaminants to be found at the sampling site with observable human activities, actually which contaminant(s) that is(are) high should be verified by chemical analyses done in the laboratory.

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