Bull. Environ. Contam. Toxicol. (1994) 53:740–746

Environmental Contamination and Toxicology

Sediment Trace Metal Concentrations from the Mudflats of Kuala Juru and Kuala Muda of Malaysia

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Received: 12 August 1993/Accepted: 25 March 1994

About 4-5000 ha of the mudflats along the western coast of Peninsular Malaysia are currently utilized for the semi-culture of the economically important marine bivalve, *Anadara granosa* (Noordin, 1988). Therefore, information on the status of the trace metal pollution in the culture areas is of considerable value in the interest of public health when shellfish from this area are available for consumption. As an initial assessment of the degree of trace metal pollution in the sediments, an approach to analyse the non-residual (non-lattice held) trace metal concentrations should be of prime consideration rather than the total metal content in the sediments (Chester and Voutsinou, 1981). This approach has the advantage that it is not necessary to restrict the comparison of the non-residual metal fraction to sediments having similar textural composition (Chester and Voutsinou, 1981).

For the above reasons, assorted acids are used to partially extract the non-residual trace metal fraction (Agemain and Chau, 1976; Luoma and Bryan, 1978; Chester and Voutsinou, 1981). The partial extraction of sediment-bound trace metals is not only providing information on the strength of association between metals and sediment compositions (Jenne and Luoma, 1977) but also the potential availability of these metals to aquatic organisms (Tessier and campbell, 1987). It has been shown that the bioavailability of trace metals to the aquatic biota is best related to the easily leachable, non-residual fraction rather than the total sediment bound trace metals (Luoma and Bryan, 1978; Langston, 1980; Tessier *et al.*, 1984). Therefore, it makes very little sense to consider the total metal content in the sediment to be bioavailable to cause damage to aquatic organisms or to the aquatic ecosystems (Waldichuk, 1985).

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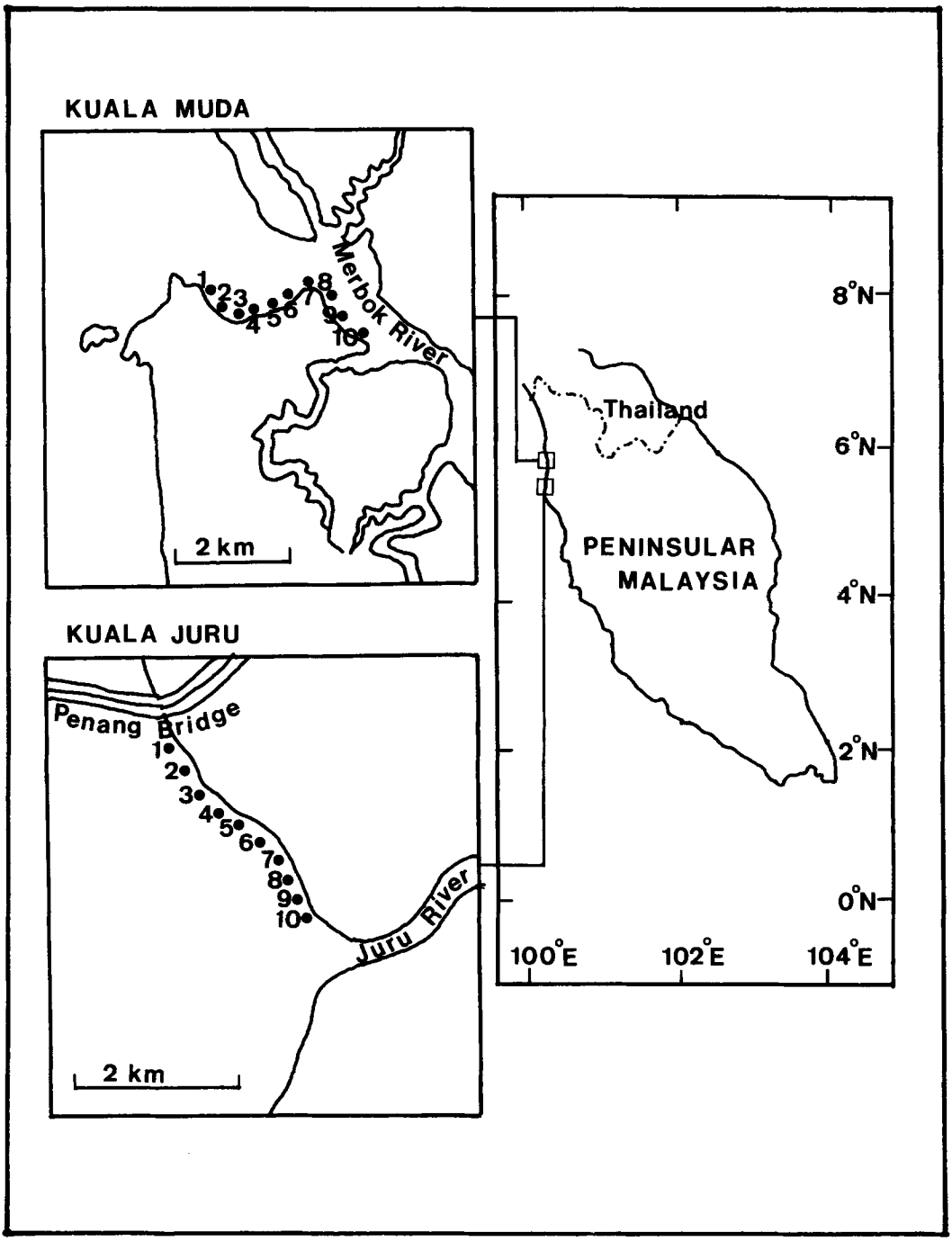

Figure 1. Sampling stations studied

Due to the scarcity of information available, the present investigation, is therefore, to provide an the sediments from the mudflats of Kuala Juru and Kuala Muda where aquaculture activities are being carried out in the areas.

MATERIALS AND METHODS

Field surveys were conducted to assess the total leachable and non-residual trace metal concentrations in sediments collected from the mudflats of Kuala Juru and Kuala Muda (Figure 1). Ten sediment samples were collected along the mean water neap tide from each station. Surface sediments (upper 5 cm) were sorted out, oven-dried (102^{o}C, 8 hr), grounded and sieved. Only sediments of < 210 μm were used for trace metal analyses.

Total leachable trace metals (Cd, Cu, Pb and Zn) were extracted by digesting a gram dry weight of sediment in 3.0 ml of concentrated HNO_3 to semi dryness. Further digestion was accomplished in a mixture of 5.0 ml of concentrated HNO_3 and 1 ml of $HClO_4$. The mixture was again taken to semi dryness (Peerzada and Rohaza, 1989) before making up to a constant volume. Non-residual trace metals (Cd, Cu, Pb and Zn) on the other hand were extracted by continuous agitation of a gram of sediment in 10 ml 1 M HCl for 2 hr. The extract was later filtered under pressure (Luoma and Bryan, 1978). Trace metal concentrations in both the total and non-residual fractions were later determined by the application of the Inductively Coupled Plasma (Baird ICP-2000) method.

Together with procedural blanks, five replicates of one sample were run to determine the percentage coefficients of variation for the trace metals in the non-residual fraction (Cd, 6.2%; Cu, 4.2%; Pb, 6.6%; Zn, 5.4%). For the total leachable fraction, recovery trials (>95%) as well as the Standard Reference Sediment (NCR-CNRC), BCSS-1 (agreement was within 10% of certified values) were quantified as quality assurance of the methods employed.

All results were expressed as means ± standard deviations. Whenever appropriate, differences between mean values were subjected to one way ANOVA. A probability level of $P<0.05$ was used throughout to detect significant diferences.

RESULTS AND DISCUSSION.

The use of 1 M HCl to release the inorganic and organic trace metals without affecting the silicate matrix (Agemain and Chau, 1976; Chester and Voutsinou, 1981) not only provide information on the non-residual trace

metal concentrations but also on the potential bioavailability of these metals to aquatic organisms (Waldichuk, 1985; Tessier and Campbell, 1987; Luoma, 1989). The mean non-residual trace metal concentrations in surface sediments from the mudflats of Kuala Juru and Kuala Muda are in Table 1.

The concentrations of non-residual Cd, Cu, Pb and Zn in the surface sediments of Kuala Juru mudflat are significantly higher than those of Kuala Muda. Elevated levels of these metals in 2-10 orders of magnitude are likely to be attributed to the municipal discharges and most importantly the presence of light and heavy industries in the Prai Industrial Estate (developed in the early 1970s) having their effluent discharged into the Juru River as well as directly into the sea.

Table 1. Levels of non-residual (potentially biologically available) trace metals in sediments of Kuala Juru and Kuala Muda (ppm, dry wt).

stn	Cd	Cu	Pb	Zn
		KUALA JURU		
1	1.3	36	34	226
2	1.6	40	34	247
3	1.3	31	32	208
4	1.1	23	27	168
5	1.1	18	23	129
6	0.8	11	14	124
7	1.4	21	26	144
8	1.3	18	23	130
9	1.8	25	30	183
10	1.7	21	27	159
		KUALA MUDA		
1	0.8	4.4	15	20
2	1.1	4.7	18	21
3	0.9	6.7	14	16
4	0.7	3.9	14	17
5	0.8	2.9	12	17
6	0.8	2.8	11	17
7	0.7	8.3	8.5	14
8	0.7	4.3	10	13
9	0.9	6.5	14	16
10	0.9	4.9	16	17

The impact of industrialization as well as other anthropogenic influences in the Kuala Juru area is further supported by the results in the total leachable trace metal concentrations recorded in the present levels are in 2-3 orders of magnitude higher then the levels recorded earlier by Seng *et al.* (1987) after

leaching the sediments with hydrofluoric acid. The increasing magnitude of selected trace metals pollution in this area should be of considerable concern due to the presence of aquacultural activities in the vacinity of the industrial areas.

In addition, the mudflat of Kuala Muda is significantly less impacted with trace metal pollution when compared with the mudflat of Kuala Juru (Table 2). This is to be expected due to the minimal anthropogenic influences as well as the lacking of heavy industries in the vacinity of the area. Currently, prawn hatcheries and caged fish farming are among the projects introduced by the Department of Fisheries in the area. The future of this industry is unlikely to be affected if steps are taken to control and monitor the level of contamination by heavy metals and other pollutants brought down by the Merbok River as well as municipal discharges originating from nearby villages and towns.

Table 2. Total leachable trace metal concentrations (ppm, dry wt) in surface sediments from the mudflats of Kuala Juru and Kuala Muda.

	Cd	Cu	Pb	Zn
KJ	4.5 ± 0.5	36.8 ± 12.1	64.2 ± 11.5	233 ± 63
KM	4.2 ± 0.8	10.8 ± 3.3	46.7 ± 2.8	39.4 ± 2.2
KJ*	2.5	11.4	27.9	90.5

KJ, Kuala Juru; KM, Kuala Muda; KJ*, Kuala Juru; *, seng *et al.* (1987)

As the aim to assess the degree of trace metal pollution in the sediments, the percentage contribution of non-residual trace metals to the total metal content has to be taken into consideration. This is due to the fact even the bioavailability of a small fraction originating from high concentrations of sediment-bound trace metals assume a considerable impact especially in some benthic organisms (Bryan and Langston, 1992). High percentages of non-residual trace metals observed in the mudfalts of Kuala Juru and Kuala Muda (Table 3) reflect on the importance of easily leachable

Table 3. The percentage contribution of non-residual trace metal to the total metal content in surface sediments from the mudflats of Kuala Juru and Kuala Muda.

	Cd	Cu	Pb	Zn
KJ	30.4 ± 7.4	66.4 ± 12.8	44.3 ± 8.7	72.1 ± 10.1
KM	20.5 ± 4.4	51.6 ± 10.9	28.2 ± 5.6	42.2 ± 5.4

KJ, Kuala Juru; KM, Kuala Muda

geochemical fraction of the sediments. These fractions are associated with metals originating from polluted waters by process of adsorption and organic complexation (Chester and Voutsinou, 1981).

The potential bioavailability of trace metals in these areas are very high. Therefore, under circumstances of elevated trace metals pollution accomodated by prevailing physicochemical parameters, these pollutants are likely to be manifested in aquatic organisms.

The increasing rates of anthropogenic influences as well as continuous discharges of municipal and industrial effluents into the near shore ecosystems are expected to increase the magnitude of heavy metal pollution in the area. This is of considerable concern especially when large areas of the mudflats are currently used for the aquaculture of the marine bivalve, *A. granosa*.

Acknowledgments. The University of Malaya and the Institute of Advanced Studies, UM are acknowledged for the financial support (PJP 345/93, 101/93) and the use of the Baird ICP-2000 respectively.

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