

Accumulation of mercury in sediment and bivalves from Cua Dai estuary, Hoi An city

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Received 17 December 2009; received in revised form 31 December 2009

Abstract. The paper presents the research results of accumulation of Mercury in sediment and two bivalves species: Heamolymph Clam (*Meretrix meretrix*) and Clam (*Corbicula sp.*) from Cua Dai estuary, Hoi An city. The average concentration of Hg in sediments is 0.145 ± 0.052 $\mu\text{g/g}$, under allowed limit by the PELS standard (Canada) (≤ 0.7 $\mu\text{g/g}$). Content of Hg accumulated in the tissues of *Meretrix meretrix* is 0.073 ± 0.045 $\mu\text{g/g}$ and H is 0.066 ± 0.044 $\mu\text{g/g}$, lower than the allowed standard of the Ministry of Health. Concentration of Hg in sediments and tissues of *Meretrix meretrix* is positive correlation, at "medium correlation" ($r = 0.311$, Pvalue = 0.415), while for *Corbicula sp.* is lower correlation, with "weak correlation" ($r = 0.138$, Pvalue = 0.722). Results show that, at Cua Dai estuary (city of Hoi An), *Meretrix meretrix* can be used as bio-indicator species for Hg pollution.

Keywords: toxicity, pollution, accumulation, bioindicator, *Meretrix*, *Corbicula*.

1. Introduction

Pollution of mercury (Hg) in sediments has different origins, such as industrial, agricultural and mining activities... In water environment, Hg usually exists in the form of MeHg with high toxicity and magnification [1-3].

Quang Nam is a province with fast development of industry and mining, especially gold, tin, copper, zinc mining activities... In particular, raw gold mining is the main reason leading to Hg pollution in the Thu Bon River. According to Tran Hieu Nhue (2000), in the Thu Bon River upstream, concentration of Hg exceeded the standard for 5 times [3].

This paper presents the research results initially on Hg accumulation in sediments as well as in two species: Heamolymph Clam (*Meretrix meretrix* Linnaeus, 1758) and Clam (*Corbicula sp.*) in Cua Dai estuary, Hoi An city, Quang Nam province to build scientific basis for the use of indicator species to Hg pollution.

2. Research subjects and methods

Research Subject is Hg, a heavy metal with high toxicity and easily bioaccumulation in bivalves. The bivalves is selected to research is Heamolymph Clam (*Meretrix meretrix* Linnaeus, 1758), family Veneridae, order Veneroida, and Clam (*Corbicula sp.*), family

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Corbiculidea, order Eulamellibranchia. Both are of class Bivalvia, phylum Mollusca. These are the species with high heavy metal bioaccumulation and common presence in Cua

Dai estuary. Cua Dai estuary (Hoi An city) is the area where Hg receiving from industrial activities, agriculture, mining...

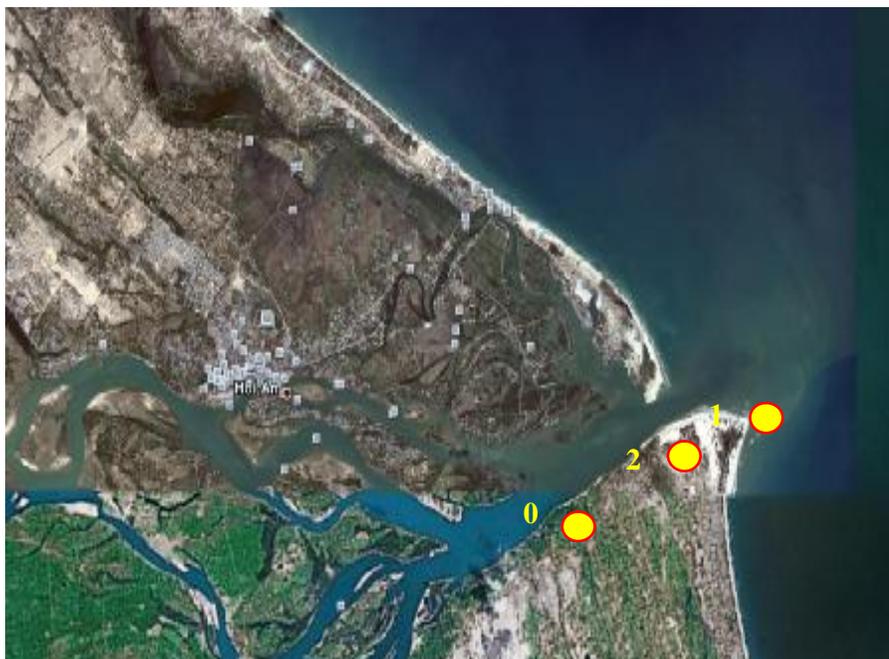


Figure 1. Map of studied points (Cua Dai estuary, Hoi An city, Quang Nam province).

Samples taken at 03 points representing the study area (Figure 1), at three different times is the first one in November 2008; stage 2 on 02 May 2009 and stage 3 in September 2004 2009. The animal samples were collected and stored at 4°C (M. Z. L. Goksu, 2003) and analyzed after 24 hours. Sediment samples were collected simultaneously with animals and take samples at a depth of 0-10 cm.

Classifying bivalves samples according to morphological key by Thai Tran Bai, Dang Ngoc Thanh and Pham Van Mien [4]. Determining the size and weight of bivalves into 3 groups of different sizes. For

Heamolymph Clam (*Meretrix meretrix* Linnaeus, 1758): $l \geq 50$ mm, $40 < l < 50$ mm, $l \leq 40$ mm; for Clam (*Corbicula* sp.): $l \geq 40$ mm, $30 < l < 40$ mm, $l \leq 30$ mm.

Dissolution the sediment samples by $\text{HNO}_3 + \text{H}_2\text{O}_2$ and the bivalves by $\text{HClO}_4 + \text{HNO}_3 + \text{H}_2\text{O}_2 + \text{KNO}_3$ [5,6]. Analyzing Hg by method of atomic absorption spectroscopy (AAS) in the laboratory of Meteorological and hydrological stations of the Central of Vietnam.

Data is processed by statistical methods, comparison of the average value by ANOVA analysis methods and test LSD with significance level $\alpha = 0.05$. Values of

correlation analysis is the transformation formula $x' = \log(x + 10)$.

3. Research results and discussion

3.1. Hg content in sediment at Cua Dai estuary, Hoi An city, Quang Nam province

Results of ANOVA analysis and LSD test ($\alpha = 0.05$) show that Hg content in sediments at Cua Dai (Hoi An) have significant differences in the samples collected 3 stages, lowest in stage 1 ($0.084 \pm 0.019 \mu\text{g/g}$) and higher in stage 2 ($0.199 \pm 0.019 \mu\text{g/g}$) and phase 3 ($0.153 \pm 0.016 \mu\text{g/g}$). Meanwhile, among the studied areas, Hg content without significant differences and range 0.145 ± 0.05 to 0.146 ± 0.08 . This result shows that concentration of Hg in sediments at Cua Dai change over time but less fluctuation in space (Table 1).

Comparing with the results of monitoring in some estuaries of Vietnam (2003) as Quang Ninh, Ha Tinh, Quang Nam, Ba Ria - Vung Tau, concentration of Hg in this area ranges from 0.35 to $0.61 \mu\text{g/g}$; in Nha Trang is $0.64 \mu\text{g/g}$, in Rach Gia is $0.65 \mu\text{g/g}$ [7]. Thus, the concentrations of Hg in sediments at Cua Dai lower than that in the above areas. Comparing with standard PELs (Canada), concentration of Hg in sediments at Cua Dai is under allowing Standard ($\leq 0.7 \mu\text{g/g}$, dry sludge weight) [8].

3.2. Hg content in tissues of Heamolymph Clam (*Meretrix meretrix* L.) and Clam (*Corbicula sp.*)

Samples have been collected over three times in Cua Dai estuary, species of bivalves appear mainly Heamolymph Clam (*Meretrix meretrix* L.) and Clam (*Corbicula sp.*), including 63 individuals of Heamolymph Clam and 58 individuals of clam. Size and average weight of Heamolymph Clam in turn is 34.21 ± 5.19 mm, 13.56 ± 6.08 g and Clam in turn is 46.78 ± 7.80 mm, 35.52 ± 15.73 g (Table 2).

Content of Hg accumulated in the tissues of the *Meretrix meretrix* is of $0.073 \pm 0.046 \mu\text{g/g}$ and the tissues of the *Corbicula sp.* is of $0.066 \pm 0.044 \mu\text{g/g}$, not significant differences (with significance level $\alpha = 0.05$). Concentrations of Hg accumulated in the tissues of both species are lower than the allowing Standard of the Ministry of Health ($\leq 0.5 \mu\text{g/g}$, 46/2007/QD-BYT). However, the concentration of Hg accumulated in the tissues of animals is significant differences in all size groups of both species ($\alpha = 0.05$). The individuals are greater in size, the concentration of Hg accumulated in the body is higher (Table 3). This proves that *Corbicula sp.* and *Meretrix meretrix* are the species capable for accumulating Hg. Therefore the use of two species as food should be careful.

Table 1. Hg content in sediment samples was collected in three stages at Cua Dai estuary, Hoi An city

Location	Stage 1 <i>M</i> ± <i>Sd</i> ($\mu\text{g/g}$)	Stage 2 <i>M</i> ± <i>Sd</i> ($\mu\text{g/g}$)	Stage 3 <i>M</i> ± <i>Sd</i> ($\mu\text{g/g}$)	Average <i>M</i> ± <i>Sd</i> ($\mu\text{g/g}$)
Point 1	0.064	0.218	0.157	$0.146 \pm 0.08a'$
Point 2	0.101	0.199	0.135	$0.145 \pm 0.05a'$
Point 3	0.088	0.181	0.167	$0.145 \pm 0.05a'$
Average	$0.084 \pm 0.019a$	$0.199 \pm 0.019b$	$0.153 \pm 0.016b$	

Table 2. Size and weight of *Meretrix meretrix* and *Corbicula sp.* in Cua Dai estuary, Hoi An city

	<i>Meretrix meretrix</i>		<i>Corbicula sp.</i>	
	Size <i>M±Sd (mm)</i>	Mass <i>M±Sd (g)</i>	Size <i>M±Sd (mm)</i>	Mass <i>M±Sd (g)</i>
Average	34.21±5.19	13.56±6.08	46.78±7.80	35.52±15.73
Minimum	24	6	34	16.2
Maximum	44	25.7	60	69.2

Note: Values with the same letters a, b are not different significantly according to the column and values with the same letter a', b' are not different significantly according to the row ($\alpha = 0.05$)

Table 3. Content of Hg accumulated in tissues of *Meretrix meretrix* and *Corbicula sp.* in Cua Dai estuary, Hoi An city

Length group (mm)	<i>Meretrix meretrix</i> <i>M±Sd</i> ($\mu\text{g/g}$)	Length group (mm)	<i>Corbicula sp.</i> <i>M±Sd</i> ($\mu\text{g/g}$)
> 40	0,118 ± 0,043a (n = 6)	> 50	0,112 ± 0,030a' (n = 8)
30 - 40	0,074 ± 0,036b (n = 9)	40 - 50	0,050 ± 0,027b' (n = 8)
< 30	0,038 ± 0,027c (n = 8)	< 40	0,036 ± 0,030b' (n = 8)

Note: Values with the same letters a, b are not different significantly according to the column and values with the same letter a', b' are not different significantly according to the row ($\alpha = 0.05$)

3.3. Correlation between concentration of Hg in sediment and in *Heamolymph Clam (Meretrix meretrix L.)* and *Clam (Corbicula sp.)* in Cua Dai estuary, Hoi An city

The study by Boyden (1974), Thomson (1982), Luoma et al. (1985), Amiard et al. (1986), Marigomez and Ireland (1990), and Cajaraville cs. (1992) showed that in the bivalves, the accumulation of heavy metals depends greatly on body mass. Normal for the species is not biological indicator of pollution Hg; the volume may be greater, Hg content in the body as small. Therefore, the correlation between concentration of Hg in the environment and the organisms are inversely correlated.

In this study, the correlation analysis shows that Hg content in the tissues of the *Meretrix meretrix* and H correlation is agreement with the volume and size level from "medium correlation" to "close relation" demonstrated two species tend to accumulate Hg increases

with the increase in size and volume. For *Meretrix meretrix*, concentration of Hg accumulated in the tissue "just correlation" with size ($r = 0.475$, $p_{\text{value}} = 0.022$) and "close relation" with mass ($r = 0.719$, $p_{\text{value}} < 0.001$); whereas, for H, Hg content in the body "close relation" with size ($r = 0.731$, $p_{\text{value}} = 0.005$) and "relatively close" to the mass ($r = 0.681$, $p_{\text{value}} = 0.002$) (Figure 2, 3). Meanwhile, the correlation between concentration of Hg in sediments and in *Meretrix meretrix* and H show that: concentration of Hg in sediments and in *Meretrix meretrix* "medium correlation" ($r = 0.311$, $p_{\text{value}} = 0.415$), in contrast to *Corbicula sp.* "weak correlation" ($r = 0.138$, $p_{\text{value}} = 0.722$) (Figure 4).

J. P. Coelho et al. (2006), when research on Hg indicator species of species *Nassarius reticulatus* (L.) in coastal areas of Portugal, said that the concentration of Hg in sediments and in the tissues of *Nassarius reticulatus* correlate inversely at $r = -0.64$ ($p_{\text{value}} < 0.01$) for males

and at $r = -0.52$ ($p_{\text{value}} < 0.01$) for females. This is due to concentration of Hg in the environment is low, so the absorption rate of speed under excreted by the body, especially the concentration of sulfides in the sediments increases reduce the mobility of Hg (Beckvar et al, 1996) [9]. Another study by Megan E. Brown et al on the Hg accumulation of freshwater oyster in Fork Holston River (Virginia, USA), shows that the correlation between concentration of Hg in the

environment and freshwater oyster is low ($r = 0,18, p = 0.28$) [10].

Thus, comparing with the results of the above study, this study shows that although the concentration of Hg in sediments at Cua Dai estuary is not high, the concentration of Hg accumulated in the tissues of *Meretrix meretrix* and *H* is "positive correlation" with correlation coefficient quite high. Therefore, the use of this species as bio-indicator for Hg pollution is feasible.

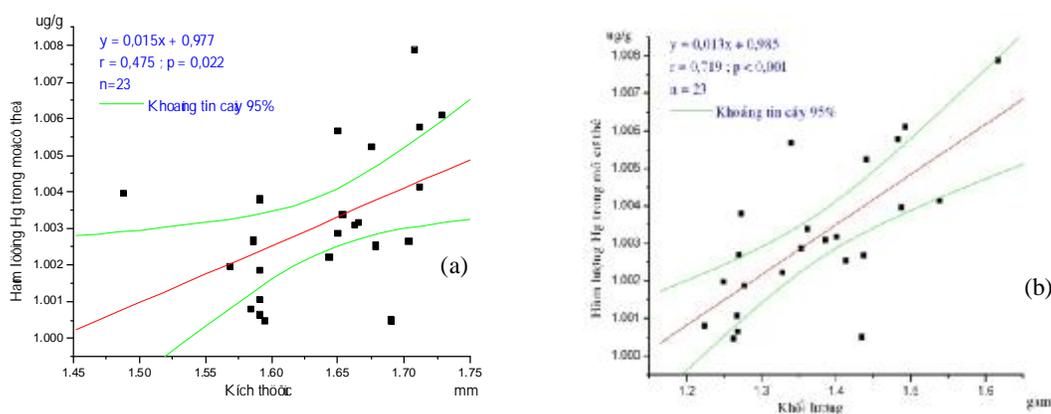


Figure 2. Correlation between the size and volume of the Hg content in the tissue of *Meretrix meretrix* (a): size; (b): mass.

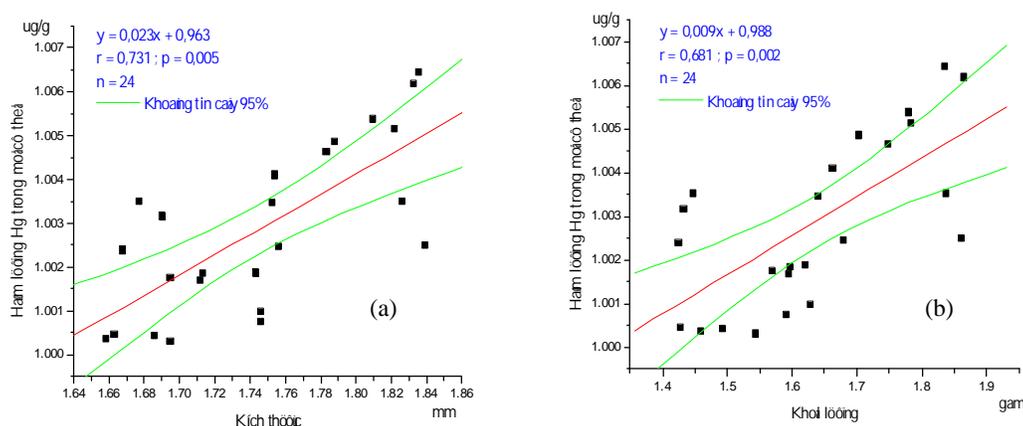


Figure 3. Correlation between the size and volume of the Hg content in the tissue of *Corbicula sp.* (a): size; (b): mass

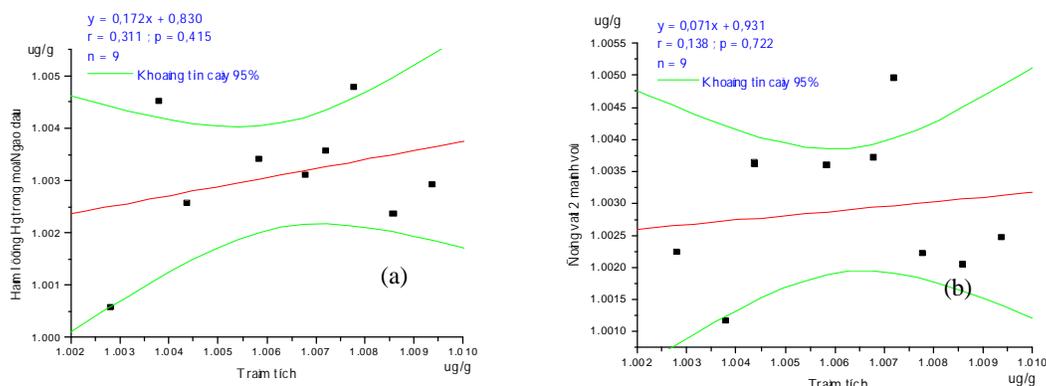


Figure 4. Heavy metal correlation between concentration of Hg in sediments and in tissue of *Meretrix meretrix* (a) and *Corbicula sp.* (b)

4. Conclusions

1. Sediments in Cua Dai estuary (Hoi An town) show no signs of Hg pollution. The average concentration of Hg in sediments is $0.145 \pm 0.052 \mu\text{g/g}$, under the allowed limit by the PELS standard (Canada) ($\leq 0.7 \mu\text{g/g}$).

2. Content of Hg accumulated in the tissues of *Meretrix meretrix* is $0.073 \pm 0.045 \mu\text{g/g}$ and *H* is $0.066 \pm 0.044 \mu\text{g/g}$, lower than the allowed standard of the Ministry of Health. However, the concentration of Hg accumulated in these species may shows a significant increase when their volume and size increases.

3. Concentration of Hg in sediments and tissues of *Meretrix meretrix* is positive correlation, at "medium correlation" ($r = 0.311$, $P_{\text{value}} = 0.415$), while for *Corbicula sp.* is lower correlation, with "weak correlation" ($r = 0.138$, $P_{\text{value}} = 0.722$). Results show that, at Cua Dai estuary (city of Hoi An), *Meretrix meretrix* can be used as bio-indicator species for Hg pollution.

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