

DISTRIBUTION OF HEAVY METALS IN SURFACE WATER, SUSPENDED PARTICULATE MATTER, SEDIMENT AND CLAM (*MERETRIX LYRATA*) FROM DOWNSTREAM OF SAIGON-DONG NAI RIVER, VIETNAM

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Received: 1 April 2016; Accepted for publication: 15 June 2016

ABSTRACT

This study aimed to evaluate distribution of selected heavy metals (Cu, Zn, Pb, Cr and Cd) in clams *Meretrixlyrata* (clam), suspended particulate matter (SPM), water and sediment in the downstream area of Saigon – Dong Nai (SG-DN) River. During March to September 2015, the contamination of those metals at four sampling sites from fresh water to brackish water zone and *Meretrix Lyrata* clams, which were cultured at many clam farms at Can Thanh beach at Can Gio District, were monitored. The concentrations of metals in clam samples were also determined at a comparative sampling site at Tan Thanh beach (Tien Giang province). Generally, the order of metal concentrations in all environmental components along the SG-DN River was Zn>Cu>Cr>Pb>Cd while the metal concentrations in different environmental components at Can Thanh area were in different orders. According to the results, the increasing tendency of only Cu, Zn and Cd concentrations in SPM and sediment from river upstream to estuary were found. All trace metal concentrations in clam samples were higher than in water and smaller than in sediment and SPM at Can Thanh. Only Cr concentrations in medium and small clam samples had positive significant correlations with those in sediment and SPM (medium size only). In comparison with concentrations of trace metals in water, sediment, SPM and clams at Tan Thanh, those at Can Thanh were higher.

Keywords: heavy metals, Meretrix Lyrata, Hard clam, Can Gio, Saigon River.

1. INTRODUCTION

Variety of previous studies shown that heavy metals have been detected in both aquatic organisms and their relative environmental components, such as surface water, suspended particulate matter (SPM) and sediment around rivers downstream and estuarial areas [1 – 3]. Moreover, almost metals influence the environment and human health [3 - 6]. However, some heavy metals are vital trace nutrients but they can have toxic effects at high concentration such as Cr, Cu and Zn; some others can be toxic such as Pb and Cd [7]. Metals from terrestrial areas can enter the marine environment via several major ways such as rivers, atmospheric and industrial wastes. Those metals can be absorbed to SPM and accumulated in bottom sediments [8, 9]. Kennish described that “Estuaries act as a filter for many trace elements, particularly metals. In these coastal ecotones, bottom sediments serve as a reservoir for trace metals, which may be released to overlying waters by dissolution, desorption, and autolytic biological process” [9]. On the other hand, clams are filter feeders that live inside the sediment around coastal areas near estuaries. Their food are often detritus and plankton [10, 11]. Therefore, there were many studies shown that metal concentrations in hard clam were higher than in their living environment because of their metal bioaccumulation abilities [12 - 14].

Saigon – Dong Nai (SG-DN) River basin is one of the biggest river basins in Vietnam. It has received tons of pollutants from agricultural surface run-off, industrial and municipal wastes from the Southern Focal Economic Zone (SFEZ), which consists of Ho Chi Minh City (HCMC) and seven other provinces. Indeed, a daily discharge of 260 tons of solid waste, including 25 tons of hazardous waste, 200,000 m³ of industrial wastewater and 17,000 m³ of hospital effluent into the River were estimated [15]. Thus, this study aimed to monitor selected trace metals (Cu, Pb, Zn, Cd and Cr) in several sites along SG-DN River and the coastal area near its estuary to understand (1) the distribution of those metals in environment and (2) the relationship between the metal contamination in the environment and in the clam *Meretrix Lyrata* at Can Gio district, the coastal zone of HCMC.

2. MATERIALS AND METHODS

2.1. Study area

The selected study area was the downstream area of the SG-DN Rivers, which was about 60 km to upstream from the estuary. Sediment, SPM and surface water samples were collected at three sites along the SG-DN River in April, May, June, July and September 2015. Hard clams (*Meretrix Lyrata*), sediment, SPM and coastal water were sampled at Can Thanh beach located in Can Gio District in March, April, May, June, July and September 2015 (Fig. 1). A comparative site, Tan Thanh clam farm, which is located near the estuary of Tien River, Mekong River branch, was selected to monitor heavy metals in water, SPM, sediment and hard clams samples in March and September 2015.

2.2. Sampling methods

To separate the dissolved and the particulate phases, about 150-200 mL of surface were filtered using 0.45 µm Whatman[®] cellulose acetate (WCA) filter paper at the sampling sites. The filtrated samples were acidified at pH less than 2 using HNO₃ solution and then stored in free metals PP bottles at 4 °C in the dark until metals analysis. The filter papers with SPM cake were

stored in PP boxes at 4 °C in the dark and dried at 60 °C to a constant weight before trace metals analysis.

The Ekman grab was used to sample sediment. About 200 gram of sediment taken at sampling sites was stored in ice-boxes during the transportation from the sites to the laboratory. The sediment samples were dried at 60 °C in oven for about 5 to 6 hours and then grounded to powder before metal analysis.

The clams were collected using hand or a portable clam collector. Those clams were classified into the three sizes as follows: (i) Large size (over 2,000 mm² equivalent to over 24 months age), Medium size (from 1,000 to 2,000 mm², from 6 to 24 months age) and small size (less than 1,000 mm² – less than 6 months age). It was depend on the sampling time, all sizes or two of them were collected. About 30 to 60 clam individuals of each size were packed in one sample and delivered to laboratory immediately and they were then preserved at -20 °C. Each clam sample was dried in oven at 60 °C to a constant weight before metal analysis.

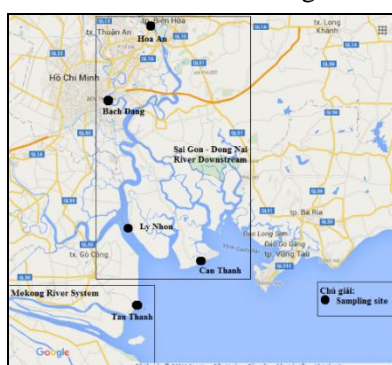


Figure 1. Sampling stations.

2.3. Analysis methods

The dried sediment, SPM and clam samples were digested using a mixture of perchloric acid and nitric acid (HNO₃:HClO₄ 1:1 v/v) and an amount of concentrated sulfuric acid (H₂SO₄) was added [16, 17]. Samples with digesting solution was refluxed at 200 °C for 30 minutes in a clean fume chamber. The completely digested samples were cooled down to room temperature and the insoluble portion was separated by filtration using a 0.45 µm WCA filter paper. Finally, the filtrate was diluted to 50 ml in volumetric flasks with 2 % HNO₃ solution.

Trace metals (Cu, Pb, Zn, Cd and Cr) infiltrate, treated clam fleshes, SPM and sediment samples were analyzed according to USEPA method 2007 by ICP-OES (with level of detection of ± 1 - 5 µg/l). Each sample was analyzed three times and the final results were the average values in ppm (mg/L for water sample and mg/kg of dry weight for sediment, clam and SPM samples).

2.4. Data Analysis

The correlations between heavy metal concentrations in clam fleshes and those in water, sediment and SPM samples was evaluated using SPSS 16.0 and Microsoft Excel 2010.

3. RESULTS AND DISCUSSION

The results shown that heavy metals existed in all kind of samples, especially those in sediment were highest at Can Thanh beach (Table 1). It meant that metals from upstream sites might accumulate in sediment at estuary of SG-DN River. Many similar results about the accumulation ability of sediment at estuary areas have been shown before [8, 9]. The tendency of increasing Cu, Zn and Cd concentrations from upstream sites to estuary were very clear. On the other side, Pb and Cr concentrations at Bach Dang site were higher than in Ly Nhon and Hoa An sites. The high concentrations might be due to influence of activities at ports nearby Bach Dang site (Fig. 2).

Table 1. Average metal concentrations in water, SPM and sediment at studied area in 2015.

Environmental component	Station	Average metal concentration in ppm (range)				
		Cu	Pb	Zn	Cd	Cr
Water	Hoa An	0.028 (0.007-0.039)	0.004 (0.001-0.011)	0.172 (0.117-0.250)	0.001 (ND-0.001)	0.010 (0.003-0.013)
	Bach Dang	0.039 (0.021-0.052)	0.020 (0.015-0.030)	0.296 (0.183-0.402)	0.004 (0.003-0.005)	0.033 (0.017-0.053)
	Ly Nhon	0.029 (0.010-0.041)	0.021 (0.001-0.033)	0.286 (0.142-0.432)	0.009 (0.002-0.012)	0.021 (0.010-0.043)
	Can Thanh	0.090 (0.027-0.122)	0.048 (0.018-0.067)	0.328 (0.184-0.415)	0.015 (0.005-0.021)	0.041 (0.010-0.112)
	Tan Thanh*	0.036 (0.002-0.007)	0.009 (0.002-0.015)	0.224 (0.130-0.317)	0.002 (ND-0.002)	0.029 (0.001-0.057)
<i>QCVN 08-MT:2015¹</i> (Column A2 – water supply purpose)		0.2	0.02	1.0	0.005	0.1
<i>QCVN 10-MT:2015²</i> (Aquatic conservation in coastal area)		0.2	0.05	0.5	0.005	0.1
Sediment	Hoa An	42.97 (22-61.98)	1.48 (1.17-1.78)	137.04 (49-253)	0.24 (0.05-0.53)	3.11 (1.05-9.98)
	Bach Dang	56.13 (37-102.56)	1.75 (1.23-2.36)	169.44 (126.18-245)	1.00 (0.72-1.32)	4.05 (1.55-12.07)
	Ly Nhon	71.45 (54-92.11)	1.70 (1.47-2.14)	172.27 (109-289)	0.74 (0.33-1.1)	3.86 (1.13-10.65)
	Can Thanh	88.87 (78.84-102)	2.37 (1.79-3.7)	300.77 (136.93-503)	1.90 (0.89-2.75)	4.45 (1.67-13.03)
	Tan Thanh*	20.505 (11.16-29.85)	1.34 (0.43-2.25)	187.41 (48.52-326.3)	0.175 (0.16-0.19)	2.085 (0.72-3.45)
<i>QCVN 43:2012³</i>	<i>River sediment</i>	197	91.3	315	3.5	90
	<i>Coastal sediment</i>	108	112	271	4.2	160
SPM	Hoa An	39.63 (10.81-63.96)	1.81 (0.54-3.89)	125.91 (66.89-197)	0.46 (0.01-1.02)	2.87 (1.12-9.11)
	Bach Dang	49.27 (25.34-63.96)	2.30 (1.38-3.89)	190.20 (125-264)	0.64 (0.08-1.09)	3.09 (1.35-9.11)
	Ly Nhon	88.11 (23.12-121)	1.96 (1.35-4.10)	230.16 (113.5-336)	1.15 (0.03-3.78)	2.26 (1.14-5.89)
	Can Thanh	122.4 (30.47-243.2)	1.78 (0.72-3.19)	289.9 (146-345)	2.75 (0.06-9.57)	3.46 (1.62-10.01)
	Tan Thanh*	17.875 (13.41-22.34)	1.515 (0.13-2.9)	86.1 (50.8-121.4)	0.375 (0.15-0.6)	2.41 (0.47-4.35)
Clams	Large	28.01	0.44	209.98	0.45	0.40

Environmental component	Station	Average metal concentration in ppm (range)				
		Cu	Pb	Zn	Cd	Cr
(at Can Thanh)		(20.26-35.76)	(0.10-0.79)	(117.4-302.55)	(0.11-0.79)	(0.35-0.45)
	Medium	22.32 (15.75-33.43)	0.21 (0.15-0.33)	238.39 (128.6-311)	0.67 (0.21-1.17)	0.21 (0.12-0.41)
	Small	24.26 (15.78-49.5)	0.23 (0.11-0.40)	237.99 (152.5-315)	0.50 (0.07-0.73)	0.18 (0.10-0.27)
Clams (at Tan Thanh)*	Medium	17.185 (15.81-18.56)	0.13 (0.08-0.18)	145.6 (98.7-192.5)	0.218 (0.06-0.375)	0.22 (0.14-0.3)
	Small	13.84 (11.2-16.48)	0.095 (0.08-0.11)	137 (115-159)	0.225 (0.04-0.41)	0.12 (0.11-0.13)
QCVN 8-2:2011⁴		-	1.5	-	2.0	-
Thailand Ministry of Public Health		133	6.67	667	-	-
Malaysian Food Regulation		30.0	2.0	100.0	1.0	-

Note: ⁽¹⁾Vietnam National technical regulation (VNTR) on surface water quality; ⁽²⁾VNTR on marine water quality; ⁽³⁾VNTR on sediment quality; ⁽⁴⁾VNTR on the limits of heavy metals contamination in food. ^(*)The average value of two samples taken in March and September only.

The metal contaminations in water shown that Pb and Cd at Ly Nhon and Can Thanh were highest and exceed the limits in the corresponding VNTR. However, in sediment, all metal concentrations reached the limits in VNTR on sediment quality except Zn. In comparison with the food regulations of some nearby countries and Vietnam, all metal results in clam samples met the limits. This result was similar to the study of Nguyen Phuoc Dan et al. [16] and the monitoring results of the Vietnam Ministry of Agriculture and Rural Development [17].

At Can Thanh, all metal concentrations in clam flesh were higher than in water and smaller than in sediment and SPM (Fig. 3a). The concentrations of studied metals in water, sediment, SPM and clam samples at Tan Thanh beach were lower than those at Can Thanh (See Fig. 3b). It might come from the differences of environmental quality between Mekong River and SG-DN River.

In this study, only three positive significant correlations have been found including Cr in sediment and medium clams (Pearson's correlation coefficient $r = 0.91$); Cr in sediment and small clams ($r = 0.845$); and Cr in SPM and medium clams ($r = 0.917$). However, the number of samples was small ($n = 6$), so a more detail study should be taken to understand the correlation between metal concentrations in clams and environmental components.

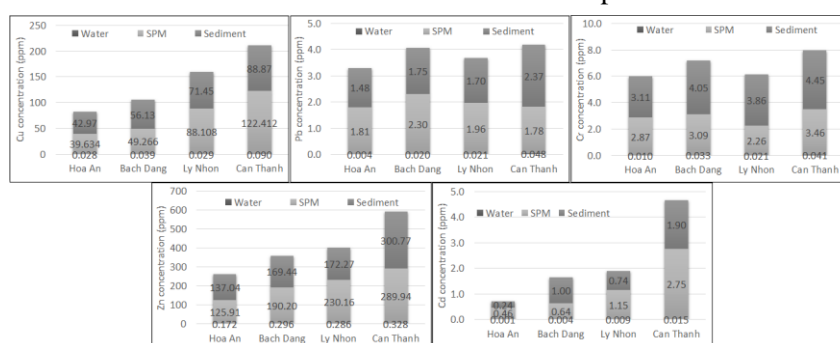


Figure 2. Metal concentrations in water, SPM and sediment at four sampling sites.

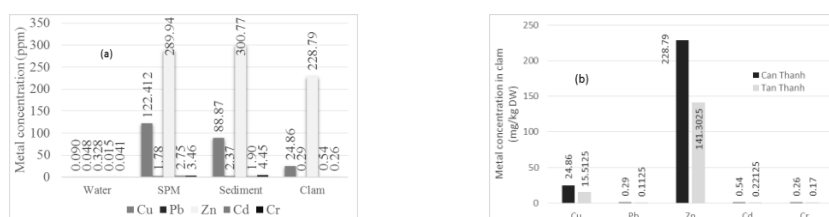


Figure 3. (a) Metal concentrations at Can Thanh; and (b) Metals in clams at Can Thanh and Tan Thanh.

4. CONCLUSIONS

This study shown that some contaminated heavy metals (Cu, Pb, Zn, Cd and Cr) in surface water could accumulate in SPM, sediment and clam at the coastal area near the estuary of SG-DN River. The concentrations of metals in environmental components and Clam *Meretrix Lyrata* at Can Thanh are higher than at Tan Thanh. Only correlations between Cr concentrations in sediment and clam were significant.

Acknowledgements. Authors appreciate financial supports by UNU & GIST Joint Program from Gwangju Institute of Science and Technology and VNU-HCM under grant No. B2016-20-05. The authors also thank to research assistants from laboratories of CARE and Faculty of Environment and Natural Resources for analysis and sampling.

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