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Using *Nassarius stolatus* as a potential heavy metal biomonitor

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Abstract

Nassarius stolatus **was evaluated as the potential heavy metal (Cd, Fe, Mn, Ni and Pb) accumulator in Don Hoi Lot sandbar, Samut Songkhram province, Thailand. This selected species belongs to the Gastropoda, which is widely distributed in the coastal areas from the upper Gulf through the southern part of Thailand. From our findings, the heavy metal accumulations in *N. stolatus* tissues were Fe > Pb > Mn > Ni > Cd. The retrieved bioaccumulation factor (BAF) indicated that *N. Stolatus* has high potential to be a biomonitor for the contaminations of Fe and Mn in water and Cd, Ni and Pb in sediment.**

Key Words: biomonitor, heavy metal, *Nassarius stolatus*

Don Hoi Lot sandbar are located in Samut Songkhram province, Thailand. It is one of the most coastal biodiversity in the upper Gulf of Thailand[17]. This area is known as the important aquaculture sites, famous tourist attractions as well as many kinds of industries. These increasing anthropogenic activities can expose a large amount of heavy metal contaminations to the coastal environments, thus, effecting on the living organisms' health. The Pollution Control Department of Thailand reported the major heavy metals contamination found in this area including cadmium (Cd), iron (Fe), manganese (Mn), nickel (Ni), and lead (Pb)[12,15]. Our previous report showed the sediment contamination consisted of Cd (0.85 ± 0.28 μg/g), Fe (5806.53 ± 333.51 μg/g), Mn (409.40 ± 26.23 μg/g), Ni (8.05 ± 0.28 μg/g) and Pb (25.84 ± 0.68 μg/g)[9]. To assess the degrees of heavy metal contaminations, many organisms that bioaccumulate pollutants were used as the biomonitors[5,10]. The main purpose of using biomonitor is the reduction in time and cost used for determination of heavy metals in environmental samples (water and sediment). However, the biomonitors or bioaccumulators must have the basic requirements that they are widely distributed and available all year round; they accumulate and tolerate to the high concentrations of heavy metals present in their environments without being killed; they are

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Table 1. Average heavy metal accumulations (mean ± SEM) in sediment, water and *N. stolatus* tissues

Heavy metal	Average concentration		
	Sediment (μg/g)	Water (μg/mL)	*N. stolatus* (μg/g)
Cd	0.86 ± 0.05	0.02 ± 0.00	8.14 ± 0.82
Fe	5891.07 ± 61.72	0.06 ± 0.00	210.24 ± 11.88
Mn	499.20 ± 16.18	0.02 ± 0.00	135.17 ± 15.33
Ni	8.25 ± 0.11	0.08 ± 0.00	49.52 ± 5.29
Pb	25.81 ± 0.18	0.02 ± 0.01	205.50 ± 24.26

easily collected and preserved[3]. From all above requirements, *Nassarius stolatus* is a non-edible gastropod normally found in marine environment, especially in intertidal areas including Don Hoi Lot sandbar. It feeds as a benthic scavenger. In addition, the filter respiration and benthic feeding of gastropod can uptake and accumulate heavy metals through gills as well as gastrointestinal tract[14]. *N. stolatus* rapidly consumes a large amount of foods compared to its body weight. It was susceptible to heavy metal toxicities, i.e., Cd, Cu and Zn[2]. Therefore, it could be used as a potential biomonitor for heavy metal contaminated areas.

The aims of this study were to determine the accumulations of Cd, Fe Mn, Ni and Pb in *Nassarius stolatus* collected from Don Hoi Lot sandbar, and to assess the potential use of *N. stolatus* as a biomonitor of heavy metals contaminated water and sediment.

N. stolatus as well as water and sediment were collected from Don Hoi Lot sandbar. Forty sampling points were systematic located by using GPS from N 13°20'02.1" E 100°01'09.9" to 13°21'48.3" E 100°00'32.5". The performances of *N. stolatus* were recorded. Water was filtered through filter paper (Whatman No.4) to remove debris and a few drops of HNO_3 (70%) were added before determining heavy metal concentrations. Sediment and *N. stolatus* tissues were oven dried at 70°C for 48 hours. Then, dried sediment and tissues (0.5 g) were digested with wet acid-digestion using the mixtures of HNO_3 (70%) and H_2O_2 (35%) (1 : 1 v/v)[1]. After complete digestion, all samples were determined for heavy metal concentrations using a flame atomic absorption spectrophotometer (FAAS; 240B Agilent Technologies). The limits of quantification (LOQ) were 0.01 μg/g for Mn, 0.02 μg/g for Cd and Fe, 0.03 μg/g for Ni and 0.07 μg/g for Pb. The recovery percentages of all heavy metals ranged from 91%–112%. All data were statistically analyzed using SPSS version 16.0 (SPSS Inc., Illinois, USA). The descriptive statistics (mean and standard error of the mean) of heavy metal concentrations in all samples were calculated. The bioaccumulation factor (BAF) was also calculated to compare the heavy metal uptake through all routes of exposure by *N. stolatus* according to the following equation[11];

$$BAF = C_t / C_m$$

Where, C_t is the heavy metal concentration in mollusk tissue and C_m is the heavy metal concentration in water or sediment.

The average shell length and weight of collected *N. stolatus* (n = 109) were 1.28 ± 0.06 cm and 0.73 ± 0.05 g, respectively. Their size and weight characteristics indicated that *N. stolatus* is a small to medium sized gastropod similar to other species belonging to the Family Nassariidae. These characteristics were positively correlated with the accumulation of heavy metals found in mollusk tissues[5,7,10]. The heavy metal accumulation in *N. stolatus* tissues were Fe > Pb > Mn > Ni > Cd (Table 1). Among these heavy metals, the level of Fe was the highest. The finding was similar to other gastropods in previous studies[6,7,18]. It suggested that Fe is an essential element important for metabolic

Table 2. Comparative bioaccumulation factor (BAF) of *N. stolatus* tissues with other gastropod species

Heavy metal	*Nassarius stolatus*		*Cerathidea cingulata*[a]	*Cipangopaludina chinensis*[b]	*Planaxis sulcatus*[a]	*Thais carinifera*[c]
	BAF-water	BAF-sediment	BAF-sediment	BAF-sediment	BAF-sediment	BAF-sediment
Cd	362.77	9.76	0.17–0.30	9.00	–	4.40
Fe	4,164.17	0.04	0.003–0.01	–	247.5	–
Mn	9,517.93	0.27	0.11–0.12	–	100.5	–
Ni	617.35	6.21	0.02–0.03	–	–	–
Pb	890.75	8.02	0.01–0.02	11.20	104.1	0

[a]Manavi (2013)
[b]Tornimbeni, *et al.* (2013)
[c]Ibrahim and Abu El-Regal (2014)

activities of marine organisms including mollusks[8,20]. The observed heavy metal concentrations in *N. stolatus* tissue indicated that Don Hoi Lot sandbar was contaminated with these heavy metals.

By using the BAF, *N. stolatus* was classified as a bioaccumulator for heavy metals in water and sediment[4]. The BAF-water and BAF-sediment values in *N. stolatus* were shown in Table 2. The BAF-water of Fe and Mn were greater than 1,000, whereas the BAF-sediment of Cd, Ni and Pb were greater than 2. These results indicated that *N. stolatus* was the macro-concentrator for Fe and Mn as well as Cd, Ni and Pb in water and sediment, respectively[4]. The higher BAF-sediment values of most heavy metals were found in *Planaxis sulcatus* and *Thais carinifera* (Table 2) indicating that these gastropods have high potential to concentrate these heavy metals in their tissues[4]. Because of their life cycle and feeding behaviour, gastropods are exposed to greater pollution including heavy metals and therefore accumulate higher levels of heavy metals than their environments[13]. Mollusks uptake dissolved heavy metals in water during respiration and feeding, whereas benthic feeding gastropods also extensively uptake insoluble heavy metals from sediments[14,19]. Apart from the environmental or geochemical factors (i.e. sediment texture, rate of sedimentation, resuspension, pH, and organic matter), the biological factors also affect heavy metal bioaccumulation[19]. The comparative BAF-sediment values of the other 4 gastropods (*Cerathidea cingulate, P. sulcatus, T. carinifera,* and *Cipangopaludina chinensis*) and *N. stolatus* indicated that species variation is one of the important biological factors for heavy metal bioaccumulation. The differences of heavy metal bioaccumulation in gastropod tissues are caused by the variations of heavy metal affinities to the binding proteins, especially metallothioneins[16]. In addition, the accumulation can also be different due to gastropod size, sex, age, genotype, phenotype, feeding activity as well as reproductive stage.

In summary, although *N. stolatus* was a small to medium-sized gastropod, it can accumulate 5 heavy metals in their tissues (Fe > Pb > Mn > Ni > Cd). *N. stolatus* also showed a high capacity to bioconcentrate heavy metals from water (Fe and Mn) and sediments (Cd, Ni, and Pb) when compared to other gastropods. Therefore, it can be a suitable heavy metal biomonitor for contaminated water and sediment.

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