Accumulation of Pb and Zn in mollusk bivalves, Geloina erosa and its growth patterns in mangrove ecosystem of Reuleung, Aceh Besar District, Indonesia

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Abstract. Heavy metals, Pb and Zn were detected and analyzed in the soft tissue of mollusk bivalvia, *Geloina erosa* and in water and sediment from the mangrove ecosystem of Reuleung, Aceh Besar District, Aceh during the end of December 2017. *G. erosa* were taken from 3 observation stations by purposive sampling captured during low tide. Concentrations of Pb and Zn in water were lower than those in sediment, the soft tissue of *G. erosa*. All detected heavy metal concentrations were higher in sediment than in tissue of *G. erosa*. Pb levels were found highest at 12.995 mg/kg in sediment, while Zn content was 45.045 mg/kg. The accumulation of Pb in *G. erosa* was found very small at 0.0001 mg/kg, whereas the accumulation of Zn in *G. erosa* was found at 32.139 mg/kg. The *G. erosa* growth pattern showed a negative allometric pattern ($b<3$), this reflects a long-term accumulation of Pb and Zn by a shell of *G. erosa*.

Keywords: *Heavy Metal Zinc, Lead, Geloina Erosa, Growth Patterns.*

1 Introduction

The mangrove forest is one of the ecosystems in coastal areas and in the area live various aquatic biota, especially bivalves. Bivalvia is a group of shellfish, which have a soft body and are protected by two shells that are cupped, as in *Geloina erosa (G. erosa)*. Like other bivalve inhabitants of ecologically stable local environments, *G. erosa* can defined as a K-strategist [1]. The growth of shellfish includes growth of muscles, length of shell and can be interpreted as a process of length, weight or increase in volume of an organism. Shellfish have a food source in the form of plankton, the availability of plankton in the waters will indicate the level of aquatic fertility. Local residents in the area around of the Reuleng River is also called *G. erosa* as "lokan".

These shellfishes are found along the Reuleung River watershed, which is dominated by mangrove ecosystems that are habitat for these shellfishes. Groups of shellfish from the Corbioculidae family associated with mangroves such as *G. erosa* [1], [2]. The reduction of

IGC 2018, October 03-05, Banda Aceh, Indonesia

DOI 10.4108/eai.3-10-2018.2284263

mangrove forests along the Reuleung River watershed, mainly due to the conversion of mangroves into various needs including settlement, roads, transfer of functions and utilization of mangrove wood for various purposes. As a result of land conversion, it causes damage to mangrove forests so that the habitat of *G. erosa* is gradually decreased. If this condition continues, it is feared that *G. erosa* resources from this area will decline and it is not impossible that one day it will become extinct.

Until now, there are still limited references and information that can be used as a reference for ecological studies both on the distribution and pattern of growth of *G. erosa* in the waters of Reuleng River watershed, so that the resources of this shellfish are almost forgotten. In terms of economic value, this species is quite strategic to be developed in the future, especially this species is one of the species of aquaculture. The entry of pollutants from the area around the Reuleung River is feared that it can affect to the life of *G. erosa* in the mangrove ecosystem. Pollutants can come from household waste, agriculture, small industries such as workshops and others can contribute heavy metals into river waters.

Based on the above conditions, this study was conducted to determine the content of heavy metals (Pb and Zn) and the growth pattern of *G. erosa* which are living in mangrove ecosystems of Reuleung. This is due to the importance of shellfish resource potential in the waters of the Reuleng River as well as germplasm, consumption, and sources of livelihood [3].

2 Materials and Methods

This research was conducted in July 2017, *G. erosa* sampling was taken at the lowest tide in the mangrove forest area along the Reuleng River which was divided into three stations based on the distance of mangrove vegetation. The research location was shown in Figure 1. Determination of sampling points was conducted by purposive sampling. Shellfish samples were immediately collected by scraping the *G. erosa* habitat area using a small machete. Determination of sampling time was based on the tidal pattern, where the sample was taken at the lowest tide. Sampling of shellfish using a line transect method with a length of 30 meters and a 15 meter interval, each line transect consists of three plots measuring 1 x 1 meter.

Water and sediment sampling was carried out by taking it directly from the river with a hand set, then put into a sample bottle (Pyrex) that has been labeled according to observation station and transported to the laboratory for the analysis process. Heavy metal content in water and accumulation in *G. erosa* and sediment was analyzed using Atomic Absorption Spectrophotometer, Shimadzu AA 630 [4] after being destructed using the Toxicity Characteristic Leaching Procedure method [5].

Soft tissues of shellfish were separated from the shell and washed with distilled water. Soft tissue was dried in an oven dryer at 70 ºC. After drying completely, they were powdered in a mortar. Digestion for soft tissue was carried out according to the Toxicity Characteristic Leaching Procedure method [5].

Sediment samples were dehydrated at 70 ºC to a constant weight, then powdered in a mortar. Subsamples of 0.5 g were weighed, 2 ml of concentrated hydrofluoric acid, 2 ml of conc. HNO_3 and 1 ml of H_2O_2 were mixed with the subsamples. Microwave digester was used for digestion. After cooling, solutions were put into 25 ml calibrated flasks and were diluted with deionized water to the mark. After that, filtration and analysis of metal concentrations conducted by Atomic Absorption Spectrophotometer, Shimadzu AA 630 [6].

The length of the shellfish was measured starting from the anterior end to the posterior end of the shellfish, the width of the shellfish measured from the dorsal part to the ventral part of the shellfish, the thickness of the shellfish measured from the top of the shell to the edge of the lower shell. Body weight measurements were carried out by weighing using analytical scales on body weight of *G. erosa*. Body weight measurement was carried out by weighing *G. erosa* using an analytical balance (ACIS, BC-500).

The growth of shellfish can be known through an analysis of the relationship of shellfish length to the body weight (total weight), which was analyzed through the equation (1) and (2) below [7].

$$W = aL^b \quad (1)$$

$$\text{Log } W = \text{Log } a + b \quad (2)$$

W = total weight (g); L = shellfish length (cm); a = Constanta; b = exponential.

Figure 1: Research location.

3 Result And Discussion

a. The concentration of heavy metals (Pb and Zn) in the water phase and sediment

Analysis of Pb and Zn concentration were carried out at each research station, with samples taken including *G. erosa*, sediment, and concentration heavy metals in the water phase. The results of the analysis showed that Pb and Zn ion were found in trace amounts (0.0011 - 0.0012 mg/L) in water phase in mangrove ecosystem of Reuleung, far below the Indonesian river water quality standard. Pb and Zn concentrations in sediments were found in varying amounts (8.246-12.995 mg-Pb/kg and 32.371-45.045 Mg-Zn/kg) and exceed the quality standards for heavy metal content in sediments and river biota (Table 1). These results indicate that Pb and Zn content in sediments of the mangrove ecosystem of Reuleung has exceeded the Indonesian river water quality standards (>0.005 mg/kg). The highest Pb level in sediment was found at Station 1 which reached at 12.995 mg-Pb/kg and the highest Zn level in sediment was at Station 3 (45.045 Mg-Zn/kg). The value of Pb and Zn found in sediment samples was still below the quality standards set by ANZECC ISQG-Low [8]. A bad condition of estuary greatly influences the presence of heavy metals dissolved in sediment. Higher activity around estuary both on land and in the estuary area, the level of heavy metals can also increase.

The presence of these two metal ions in the water phase and sediment also affects the accumulation of these two metals in *G. erosa*. Pb was not found to accumulate in *G. erosa*, but Zn was accumulated in high concentrations (32.139 Mg-Zn/kg), especially in Station 1.

Table 1. Concentrations of Pb and Zn metals in the water phase, sediments, and shellfish from Reuleng River mangrove ecosystem

Station	Sample	Unit	Concentration	
			Pb	Zn
ST-1	Water	mg/L	0.0012	0.0011
	G. erosa	mg/kg	0.0001	32.139
	sediment	mg/kg	12.995	33.503
ST-2	Water	mg/L	0.0012	0,0011
	G. erosa	mg/kg	tr	tr
	sediment	mg/kg	8.246	32.371
ST-3	Water	mg/L	0.0012	0,0011
	G. erosa	mg/kg	tr	tr
	Sediment	mg/kg	9.212	45.045

tr=trace

3.2 Growth Pattern of G. erosa

G. erosa was only found in 2 observation stations, namely station 1 and station 2, while the presence of *G. erosa* was not found. The mangrove land at station 3 has been reclaimed due to road development activities which caused *G. erosa* population to disappear in this station. Relationship between length and the total weight of *G. erosa* at each observation station in the mangrove ecosystem of Reuleng River is presented in Figure 2.

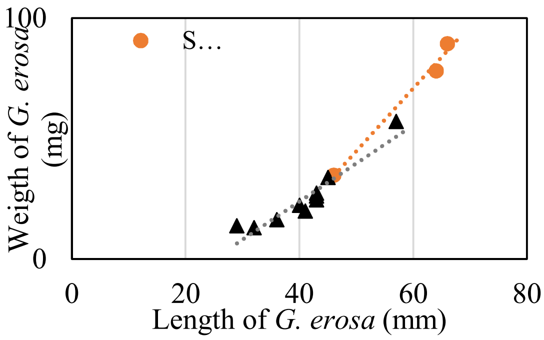

Figure 2. G. erosa growth pattern at Station 1 and 2.

The observation results showed that the value of b for the equation of shell length and shells total weight at the two observation stations showed the same growth pattern. The value of b at Station 1 was 0.3051 with a determination coefficient (R^2) of 0.9982, while at Station 2, the value of b was found at 0.2296 with a coefficient of determination (R^2) of 0.9353. The value of b obtained was lower than 3. This indicated that the growth or the increase in weight of shells at two research stations was slower than the increase in the length of the shell. Therefore, the pattern of growth of *G. erosa* shells in Reuleng River Mangrove Ecosystem was allometric negative. This growth pattern was found to be the same as the five species specific growth of Ostreidae (*Crassostrea virginica, Crassostrea gigas, Crassostrea iridescens, Crassostrea angulata,* and *Ostrea edulis*) that collected in the other part of Kuala Gigieng estuary, Aceh

Besar District [9]. If the value of b<3, the rate of total weight increment and increase in shell length that occurs is unbalanced where the process of increasing shell length that occurs is more dominant when compared to the increase in weight [10]. Furthermore, if the value of b>3, it means that the growth of shell weight is faster than the growth of its length (positive allometric), whereas if the value of b≠3 is a balanced weight and length (isometric). Males and females do not affect to the the length and weight of aquatic biota. Dar et al.[7] reported that no significant difference relationship between males and females to the length and weight of cyprinid fish, *Schizopyge esocinus*. G. erosa is a sexually dimorphic animal [11], but because of no differentiation of external organs between male and female in shells, the sex of juvenile larvae and shellfish is difficult to distinguish [12]. The sex is usually distinguished by morphological appearance and color of gonads [11] as the gonadal structure changes as age and the body increase. *G. erosa* population in the station observation area has one cohort with two length classes and an asyncronous spawner [3]. The increase in the length of *G. erosa* shell occurs very rapidly in young individuals. The shell in the young phase is very thin, making it easier for a faster lengthening process. In this phase, efforts to improve the length and thickness of the shell are preferred. After efforts to improve the growth of shell length and shell thickness take place, then continued with the growth phase of the body [3].

4 Conclusions

This study focused on two heavy metals (Pb and Zn) that have been estimated in *G. erosa* as well as in water and sediment from Reuleng River mangrove ecosystem. The *G. erosa* dwell on the sediment along the Reuleung River watershed, which is dominated by mangrove ecosystems. Abundant and easy to collect, this species makes a favorable choice of biomonitoring for Reuleung River watershed. The highest Pb levels found in sediments were 12.9950 mg/kg, while the highest Zn levels in sediments were 45.0450 mg/kg. Zn content accumulated in G. erosa was 32.1390 mg/kg, while Pb levels were found to be very small at <0.0001 mg/kg. The pattern of growth of *G. erosa* shells in Reuleng River Mangrove Ecosystem was allometric negative (b<3), this reflects a long-term accumulation of Pb and Zn by shell of *G. erosa*.

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