Analysis of Pb and Cd Heavy Metal Contents in Green Mussel (*Pernaviridis* L.) in Alue Naga Waters, Banda Aceh

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Abstract. Alue Naga waters are a coastal area in Banda Aceh city which is thought to have been exploited due to various human activities. The existence of human settlements, tourist spots, fishponds, ports, and places for catching marine biota such as oysters, green mussels and fish are some instances to name a few. This research was conducted in July 2020 using simple random sampling method. Samples of green mussels were taken from a container for cultivation and from the bottom of the stream. Sample analysis was done using Atomic Absorption Spectrophotometer (AAS) at the laboratory of Office for Research and Standardization of Aceh Industries. The heavy metals that were analyzed are Lead (Pb) and Cadmium (Cd). The results showed that the content of Pb found in the cultivated green mussels was <0.0001 mg/Kg and Cd with <0.0002 mg/Kg. The metal content of green mussels found at the bottom of the stream was <0.0004 mg/Kg for cadmium and <0.0001 mg/Kg for lead. The intensity of heavy metal content in the seawater at cultivation locations also did not exceed the quality standard for the stream and aquatic biota with <0.0001 mg/L (Pb) and <0.0004 mg/L (Cd). Therefore, it is safe for human consumption.

**Keyword:** *Pernaviridis, Lead, Cadmium, AAS, quality standards, Alue Naga*

1. Introduction

Alue Naga waters is a stream with brackish water. It has been exploited owing to a number of various human activities ranging from the existence of residential areas, tourist sites, fishponds, ports, and places for catching marine biota such as oysters, green mussels and fish. Alue Naga reservoir has a continuous flow of water with aquaculture areas, home industries, urban waste, which may identify the presence of heavy metal compounds in the stream. Shellfish is a typical organism that can accumulate heavy metals. They have low mobility thus the presence of heavy metals in their bodies is considered to represent the
presence of heavy metals in their habitat. According to [1] shellfish has the potential to be contaminated with heavy metals because it is counted as a filter feeder. As a result, this type of mollusc is often used as a bioindicator in monitoring environmental parameters.

The presence of heavy metals in the stream is hazardous to marine biotas. The properties of heavy metals are hard to degrade. They can accumulate in the aquatic environment and can be difficult to remove. Heavy metals can build up on sediments and on aquatic biota such as shellfish. Sediment is the bottom layer in rivers, lakes, bays, estuaries and soil.

Heavy metals are the main pollutants that are very harmful for human life and aquatic ecosystems. Lead (Pb) can harm the ecosystem and humans when it exceeds the threshold. Metals are known for its ability to accumulate on the body of organisms and remain there as accumulated toxins for a long period of time. The condition of waters contaminated by various metals can have a significant effect on aquatic biionetworks, both inland and marine waters. Lead as a contaminant can last long in bodies of water before settling down or being absorbed through various physical and chemical reactions [2].

The existence of aquaculture activities in the syiah kuala sub-district also affects the condition of sea waters, for that it is necessary to pay attention to the carrying capacity of the aquatic environment, research conducted by [3] in coastal waters of Probolinggo Regency is classified as high with the ability to accommodate organic waste of 5,518,843,35 Kg / day.

According to [4], 90% of heavy metals contaminating waters will deposit in sediments. Another heavy metal that also deposits in sediment is Cadmium (Cd). It can be the benchmark for recording the accumulation of heavy metals in waters [5]. Cadmium will also undergo a process of biotransformation and bioaccumulation with living organisms [6].

2. Materials and Methods

This research was conducted in July 2020. Green mussel samples were taken in Alue Naga village. The analysis of Pb and Cd was carried out at the laboratory of Office for Research and Standardization of Aceh Industries. The site map is shown in Figure 3.1.

Figure 1. Map of research site
2.1. Research Procedure

Deciding the research point

Samples of green mussel were put in the cultivation container and at the bottom of the stream of Alue Naga. This study used simple random sampling technique. The samples have equal opportunity as they represent the population.

Sampling and sample treatment

Samples of green mussels were taken by hand. A knife was used to separate them from their substrate. They are taken from the cultivation container and from the bottom of the stream. The water at the cultivation site was also tested for its content of heavy metals. The samples were put in plastic, given a small amount of water and labeled for in-depth analysis of lead and cadmium intensity at the laboratory.

Figure 2. Illustration of cultivation container

The destruction process of lead and cadmium on green mussels (Perna viridis L.)

Samples of green mussels that had been mashed, weighed as much as 5 grams in porcelain whose weight is known. The sample was placed into a 100 mL beaker, and then 10 mL of HNO$_3$ 5N was added for heating on a hot plate. The temperature was set at 110°C. Once they dissolved and cooled off. Then they were filtered and put into a 100 mL volumetric flask. Afterwards, distilled water was added up to the mark. Then, they were measured using AAS using air-acetylene flame.

The creation of calibration curve

Standard calibration curve were obtained using the absorption of standard solutions of each element at its optimum condition. Then the linearity of the calibration curve was made using a standard solution of Pb and Cd with a concentration of 1000 ppm in a 10 mL tube for later to be put into a 100 mL volumetric flask. HNO$_3$ 5 N was added, and then diluted using
distilled water to the limit mark. The 1000-ppm solution was used as the main solution to create a standard solution. Metal standard solution was diluted as necessary. Five variations of standard solutions concentration of Pb and Cd were used, namely 0 ppm, 1 ppm, 2 ppm, 5 ppm and 10 ppm. Later, they were measured at a wavelength of 217.0 nm for Pb and 228.80 nm for Cd.

Data Analysis

The data shown on the AAS tool was the metal regression concentration of each sample. Later, it was used to calculate the level of Pb and Cd using the following formula (7):

\[
\text{Metal intensity (mg/Kg)} = \frac{C_{reg} \times P \times V}{G}
\]

Keterangan:  
- \(C_{reg}\) = regression intensity (mg/L)  
- \(P\) = Dilution factor  
- \(V\) = Solvent volume (L)  
- \(G\) = sample weight/volume (Kg)

3. Results and Discussions

Based on the results of the analysis of the concentration of heavy metals Pb and Cd in green mussel using the Atomic Absorption Spectrophotometer (AAS) is presented in table 1. The results show that the heavy metal content of cadmium (Cd) is higher in green mussels than to Pb. The metal content of cadmium in green mussels that live at the bottom of the water is <0.0004 mg/kg, while the green mussels that are cultured have heavy metal levels more than about <0.0002 mg/kg. This is due to the use of a raft cultivation system, the cultivation container is made in a water column in the form of a square chart and stored in a square fruit basket as a collector. So that the heavy metals settle in the sediment do not completely come s to the shell's body..

This is reinforced in References [8], by taking into account the construction of the container properly and correctly, a fish culture container that has a long service life will be obtained. The technical requirements that must be considered in choosing the location of a fish farming business in floating net cages include: Currents, tides, water fertility levels, free from pollution. After obtaining a location that meets technical and socio-economic requirements, planning must be carried out. One of the activities that have been carried out is the development of oyster cultivation, according to [9], oyster cultivation developed in the Tibang Alue Naga reservoir has the best growth and survival of broiler oysters, which is found in treatment A with a density of 25 ind/1500 cm²

The result of the analysis of Pb and Cd concentration on green mussel body using Atomic Absorption Spectrophotometer (AAS) is presented in table 4.1 as follows:
Table 1. The result of analysis of Pb and Cd concentration on green mussel

| Sample            | Metal | Threshold mg/Kg* | Bottom of the waters | Cultivation |
|-------------------|-------|------------------|----------------------|-------------|
| Green mussel (Pernaviridis L.) | Pb    | 0.008            | <0.0001              | <0.0001     |
|                   | Cd    | 0.001            | <0.0004              | <0.0002     |
| water             | Pb    | 0.008            | <0.0001              | -           |
|                   | Cd    | 0.001            | <0.0004              | -           |

* Quality Standard from the Ministry of Environment Decree number 51 of 2004.

Table 2. Water quality parameters

| No. | Water Quality Parameters | Unit | Result |
|-----|--------------------------|------|--------|
| 1.  | pH                       |      | 8.7    |
| 2.  | Temperature              | °C   | 29     |
| 3.  | Dissolved Oxygen         | mg/L | 4.8    |
| 4.  | Salinity                 | Ppt  | 31     |
| 5.  | Depth                    | Meter| 1.53   |
| 6.  | Brightness               | Cm   | 70     |
| 7.  | Current                  | m/s  | 17     |

The cultivation of green mussels (Pernaviridis L.) in Alue Naga reservoir is increasing due to higher market demand. It has economic value and the meat contains nutritional content that is very good for consumption. It consists of 21.9% protein, 18.5% carbohydrate, 40% water, 14.5% fat and 4.3% ash [10].

Green mussels in Alue Naga reservoir were cultivated in columns and at the bottom of the reservoir. The cultivation should pay attention to environmental aspects. Community participation in protecting Alue Naga aquatic environment is essential. Littering in the river can hinder the sustainable shellfish cultivation.

Alue Naga waters is an important area for local fishermen as it has long been used as an area for fishing, searching and cultivating green mussels and oysters. The result of the study showed that the content of Cadmium was higher than Lead on green mussels. The content of Cadmium on green mussels found at the bottom of the waters was <0.0004 mg/Kg. Cadmium content found on the cultivated green mussels was lower with <0.0002 mg/Kg. This is because the cultivation container is made in column of square shape and the mussels are kept in a square fruit basket. Thus, the heavy metal that settles in the sediment will not completely get into the mussels’ body.

Table 4.1 above showed that the content of Lead and Cadmium in green mussels had no heavy metal contamination. The content of Lead and Cadmium in mussels taken at the bottom of Alue Naga waters is <0.0001 mg/Kg and <0.0004 mg/Kg respectively, while the
content of Lead and Cadmium on mussels taken from the cultivation containers is at <0.0001 mg/L and <0.0002 mg/L respectively. The analysis result of heavy metal content showed that it did not exceed the normal threshold set by the Food and Drug Supervisory Agency.

Aquatic biota usually act as a bioindicator of pollution in the water. One of the animals that can accumulate heavy metals and is useful as bioaccumulation in waters is barnacle (balanus. sp). It is a marine biota that belongs to the crustacean class and is one of the subclasses of the cirripedia. Barnacles can accumulate heavy metals and are useful as a bio-indicator in coastal areas [11]. Barnacles (Balanus. sp) are able to adapt to their polluted or exposed habitats with heavy metals. This is due to response in its body's immune system, which is ever increasing due to increased exposure to heavy metals. This is their mechanism of self-protection to survive [12].

Table 3. The analysis results of heavy metals in waters at different locations.

| No. | Location                  | Year | Metal Weight Parameter | Source                        | Sample                  |
|-----|---------------------------|------|------------------------|-------------------------------|-------------------------|
| 1.  | Deah Glumpang, Banda Aceh | 2017 | Timbal (pb)            | Sasnitaet al.                 | Anadaragranosa and seawater |
| 2.  | Gresik, Jawa Timur        | 2014 | Timbal (Pb), Cadmium (Cd) | Eshmatet al.                 | Pernaviridis (Green Scallop) |
| 3.  | Aceh Barat, Aceh           | 2020 | Pb,Cu,Hg,As,Cd,Zn      | Ukhtyet al.                   | Shellfish               |
| 4.  | Krueng Raya, Aceh Besar    | 2016 | Timbal (Pb)            | Astuti, et al.                | Oyster                  |
| 5.  | Lhokseumawe, Aceh Utara   | 2017 | Hg, Cd, Pb, Cu, Zn     | Komarawidjajaet al            | Water                   |
| 6.  | Batam                      | 2019 | Cd, Cu, Pb             | Amelia et al                 | Anadara sp., Pernaviridis, Oysters |
| 7.  | Krueng Aceh, Banda Aceh    | 2018 | Timbal (Pb), Cadmium (Cd) | Hadiet al                    | Water andSediment       |
| 8.  | Aceh Singkil, Aceh         | 2018 | Cu, Cd                 | Ampunet al                    | Sediment                |
| 9.  | Lamnyong, Banda Aceh       | 2015 | Pb, Cd, Zn             | Sarong et al                  | Oyster                  |

The content of heavy metals both lead and cadmium in other organisms in other areas also got similar results as in Lamyoeng [13], Deah Glumpang, Banda Aceh [14], Krueng Raya, Aceh Besar [15], Lhokseumawe [16], including some areas in Indonesia such as Batam [17] and Ngemboh waters, Gresik, East Java [10].

The relationship between lead and cadmium concentrations in sediment generally follows a distribution pattern, the farther away from the coast, the lower the Pb concentration in the sediment [10]. According to the theory [18], the maximum limit of lead (Pb) contamination related to green mussel cultivation is 1.5 mg/kg and the maximum limit of cadmium (Cd) contamination is <1.0 mg/kg in bivalve, molluses and sea cucumbers. The high
levels of cadmium and lead metals taken from the bottom of the waters and in aquaculture containers on the surface other than shellfish are taken larger body size, so that the ability to absorb metals is very high and the community activities tend to dispose of industrial waste and household waste to the sea.

According to the theory of Indonesian National Standard, the upper Lead contamination limit in food is 1.5 ppm and the maximum Cadmium contamination limit is 1.0 ppm. The high intensity of Cadmium and Lead taken at the bottom of the waters and in aquaculture containers other than shellfish are taken as adults (larger body size) so that the ability to absorb metals is likely to be high.

The temperature factor affects the concentration of heavy metals in the water column and sediment. The colder the temperature, the easier it is for heavy metals to stay in the sediment. Meanwhile, at high temperature, heavy metal compounds will dissolve in water [19]. The result of temperature measurement at the location of cultivation is 29°C. This is in accordance with the result of Pb and Cd (negative) in both sea water and green mussel.

Dissolved oxygen (DO) is an important parameter in analyzing water quality. DO rate that is usually measured in the form of concentration indicates the amount of dissolved oxygen in the water. The higher the DO rate in a body of water, the better the water quality is. If the dissolved oxygen rate is low, it means the water is polluted with 4.8 mg/L.

pH also affects the concentration of heavy metals in the waters. Higher intensity of heavy metals will result in lower pH and greater heavy metal toxicity. The pH level in Alue Naga waters is 8.7. Salinity can also affect the presence of heavy metals in a body of water. Lower salinity will cause an increase of toxic power of heavy metals and the level of accumulation of heavy metals will rise. The study shows that Alue Naga waters has a salinity rate at 31 ppt.

CONCLUSION

The content of Pb and Cd was not found in cultivated green mussels (Pernaviridis) in the containers and at the bottom of the waters of Alue Naga village using Atomic Absorption Spectrophotometer (AAS). Therefore, the green mussels are fit for human consumption since they do not exceed the quality standard for aquatic biota.
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