Depuration of heavy metals Pb and Cd content in blood cockles (*Anadara antiquata*) with different filters

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Abstract. The presence of heavy metals in the waters has a negative effect on the growth, reproduction, and survival of aquatic biota. Lead (Pb) is a toxic substance that easily accumulates in human organs and can cause health problems in the form of anemia, impaired kidney function, disorders of the nervous system, brain and skin. The limit consumption of Pb is 0.2 - 2.0 mg per day. Cadmium (Cd) is the heavy metal most commonly found in the environment, especially the water environment, and has a high toxic effect, even at low concentrations. This study aim to determine the best filter to reduce the Pb and Cd content of blood cockle (*Anadara antiquata*). The research method is experimental using a completely randomized design (CRD) with 4 treatments and 5 replications. The treatments test used *Gracillaria* sp, zeolite and activated carbon filters. The test for heavy metal content used the AAS test. The results showed that the difference of filter have an effect on the reduction of Pb and Cd content in blood cockle. Giving activated charcoal filters can decreased the Pb and Cd content higher, with an average percentage of 31.5% for Pb and 28.56% for Cd.

1. Introduction
The presence of heavy metals in the waters has a negative effect on the growth, reproduction and survival of aquatic biota. Heavy metals in the waters will drop and settle on the bottom of the water and then form sediment, and this will cause organisms that feed on the bottom waters such as shrimp, crabs and shellfish will have a great chance of being exposed to heavy metals that have been bound to the bottom and forming sediments [1].

Heavy metals in marine waters are Pb and Cd. Lead (Pb) is a toxic substance that easily accumulates in human organs and can cause health problems in the form of anemia, impaired kidney function, disorders of the nervous system, brain and skin. The toxicity of Pb will only be seen when people consume more than 2 mg of Pb per day, the threshold for Pb that can be consumed is 0.2 - 2.0 mg per day [2]. While cadmium (Cd) is the heavy metal that is most commonly found in the environment, especially aquatic environments, and has a high toxic effect, even at low concentrations [3]. Cadmium is known to have a long half-life in living organisms [4] and generally accumulates in the liver and kidneys [5].
The presence of heavy metals in the aquatic environment can be determined by using an indicator biota of heavy metal pollution. Shellfish (bivalves) are often used as biota indicators of heavy metal pollution because they are able to accumulate heavy metals from the environment, they are widely distributed, have a sedentary nature, and filter feeders [6]. One of the organisms that contain this heavy metal is a blood cockle (*Anadara antiquata*). According to Hidayat [7], blood cockle (*Anadara antiquata*) are a marine product that has high economic value as a source of fulfilling nutritional needs. However, there are dangerous heavy metal content in its shells, so that heavy metal degradation is necessary.

Shells taken from waters contaminated with heavy metals should be cleaned or depurated, the purpose of this depuration process is to reduce the risk of bacterial contaminants and some heavy metals that are harmful to human health. According to The Decree of the Minister of Fisheries and Marine Affairs No. 17/2004 [8] that the depuration process is a cleaning process using a cleaning tool with a recirculation system. The depuration method in principle is the step of purification of biota under controlled conditions [9]. This research uses a recirculation system using a recirculator device with different filters, the filters include seaweed (*Gracilaria* sp.), zeolite, and activated charcoal.

### 2. Materials and methods

#### 2.1 Tools and materials

The tools that will be used in this research are 20 aquariums with a size of 45 x 20 x 25 cm, filters, water pumps filter, small pipes, fruit baskets, wooden hooks and water quality measuring devices (thermometer, pH meter, refractometer and DO meter).

The materials that will be used in this research are sea water, *Gracilaria* sp., zeolite, activated charcoal, and blood cockle (*Anadara antiquata*) sized 3.0 - 4.0 cm, 10 shells in each aquarium [10].

#### 2.2 Heavy metal challenge test

The research will be carried out by maintaining feather shells for 3-4 days in an aquarium filled with sea water with different filters. Before start the treatment, each aquarium was given a challenge test for heavy metals Pb and Cd (each 1 ml in 10 liters of water), and allowed to be exposed for 1 day. This is done to provide the same amount of Pb and Cd in the blood cockle, so that they can be tested for decreasing the heavy metal content.

#### 2.3 Atomic Absorption Spectrophotometer (AAS) Test on Heavy Metal Content

AAS test was carried out before and after treatment to determine the initial and final heavy metal content in blood cockle. In the AAS test, 25 mg of feathers were taken. The AAS test was carried out at the Chemical Laboratory, Surabaya State University. The working principle of AAS is the amount of energy absorbed is proportional to the concentration of heavy metals in the sample [11]. The actual heavy metal concentration is calculated using the formula:

\[
\text{Actual Concentration} = \frac{D - E \times fp \times V}{W \times g}
\]

Information:
- D = Concentration of sample mg / l of AAS results
- E = Blank sample concentration mg / l of AAS results
- fp = Dilution factor
- V = Final volume of the sample solution (ml)
- W = Weight of sample (g)

#### 2.4 Research parameters

The parameter observed in the study was a decrease (retention) of lead content in mussels (*A. antiquata*). According to Prihatini and Mulyati [10] the percentage reduction (retention) of heavy
metals concentration is the difference before and after the depuration divided by the previous concentration and multiplied by 100% by the following formula:

The percentage of heavy metal retention = \( \frac{C_{\text{final}} - C_{\text{initial}}}{C_{\text{initial}}} \times 100\% \)

Information:
- \( C_{\text{initial}} \): heavy metal concentrations at the beginning of the experiment (ppm)
- \( C_{\text{final}} \): heavy metal concentrations at the end of the experiment (ppm)

### 3. Result and discussion

#### 3.1 Analysis of Pb content

The results of the analysis of the Pb content before treatment was 2,054 ppm, testing the Pb content at the beginning was intended to compare how many changes in Pb content after treatment. Data and graphs before and after treatment are presented in Figure 1.

![Figure 1. Graph of Pb content before and after treatment](image)

The results of the analysis in the graph above show that the Pb content in the blood cockle (A. antiquata) has decreased after treatment. From the graph above, it can be seen that the Pb content in P3 treatment is 1.49 ppm lower than P2 for 1.52 ppm, and P1 for 1.67 ppm. This indicates that P3 treatment (using activated charcoal filters) has the lowest Pb content.

#### 3.2 Percentage of Pb content reduction

The data from the Pb content test in blood cockle (A. antiquata) before and after treatment are then calculated to determine the percentage reduction in Pb content with the following formula:

The percentage of Pb content reduction = \( \frac{C_{\text{final}} - C_{\text{initial}}}{C_{\text{initial}}} \times 100\% \)

Information:
- \( C_{\text{initial}} \): heavy metal concentrations at the beginning of the experiment (ppm)
- \( C_{\text{final}} \): heavy metal concentrations at the end of the experiment (ppm)

Data and diagrams of the average Pb content reduction can be seen in Table 1 and Figure 2.

| Treatment                | The content of Pb ± SD |
|--------------------------|------------------------|
| P0 (without using filters) | A 15.60% ± 2.93        |
| P1 (using *Gracillaria* sp. filters) | 25.53% ± 2.41 b        |
P2 (using zeolite filters) 30.62% ± 1.46 c
P3 (using active charcoal filter) 31.50% ± 1.91 c

Description: different superscripts in the same column indicate significant differences (p <0.05)

Figure 2. Graph of Pb content reduction

Information:
P0: Without using filter
P1: Using *Gracillaria* sp Filter
P2: Using Zeolite Filter
P3: Using Active Charcoal Filter

The results of the statistical test for the percentage of Pb reduction showed that the application of activated charcoal filters showed a significantly different percentage of Pb reduction between treatments. The highest percentage reduction in Pb content was found in P3 treatment (31.5%) which was not different from P2 treatment (30.62%), but significantly different from treatment P1 (25.53%) and P0 (15.6%).

3.3 Analysis of Cd content
The analysis result of heavy metal Cd content before treatment was 2.152 ppm, testing of Cd content at the beginning was intended to compare how many changes in Cd content after treatment. Data and graphs before and after treatment are presented in Table 3 and Figure 3.

Figure 3. Graph of Cd content before and after treatment
The results of the analysis in the graph above show that the Cd content in blood cockle (A. antiquata) after treatment has decreased. From the graph above, it can be seen that the Cd content in the P3 treatment is 1.65 ppm lower than P2 for 1.71 ppm, and P1 for 1.92 ppm. This shows that the P3 treatment (using activated charcoal filters) has the lowest Cd content.

3.4 Percentage of Cd content reduction

The data on the results of the Cd content test in blood cockle (A. antiquata) before and after treatment are then calculated to determine the percentage reduction in Cd content with the following formula:

\[
\text{The percentage of Cd content reduction} = \frac{C_{\text{final}} - C_{\text{initial}}}{C_{\text{initial}}} \times 100\%
\]

Information:

C\text{initial}: heavy metal concentrations at the beginning of the experiment (ppm)

C\text{final}: heavy metal concentrations at the end of the experiment (ppm)

Data and diagrams of the average Cd content reduction are presented in Table 2 and Figure 4.

| Table 2. The average of Cd content reduction |
|---------------------------------------------|
| Treatment                          | Cd content ± SD |
|---------------------------------------|-----------------|
| P0 (without using filters)            | A 16.03% ± 2.58 |
| P1 (using Gracillaria sp. filters)    | 18.77% ± 1.84 b |
| P2 (using zeolite filters)            | 26.75% ± 1.82 c |
| P3 (using active charcoal filter)     | 28.56% ± 1.29 c |

Description: different superscripts in the same column indicate significant differences (p <0.05)

![Graph of Cd content reduction](image)

Figure 4. Graph of Cd content reduction

Information:

P0: Without using filter
P1: Using Gracillaria sp. Filter
P2: Using Zeolite Filter
P3: Using Active Charcoal Filter

The results of the statistical test for the reduction in Cd metal showed that the application of activated charcoal filters showed a significantly different percentage of Cd reduction between
treatments. The highest percentage reduction in Cd content was found in P3 treatment (28.56%), not different from P2 treatment (26.75%), but significantly different from P1 (18.77%) and P0 (16.03%) treatment.

3.5 Discussion

3.5.1 Analysis of Pb content

From this study, initial data were obtained in the form of A. antiquata samples, the result that there was a Pb content of 2.054 ppm in the blood cockle before depuration. Other data obtained before treatment, that is water sample data before treatment, the Pb contained in the water sampled from the experimental aquarium was 2.233 ppm. Data of water sample after treatment is also be a supporting data, for P1 treatment is 1.943 ppm, P2 is 1.882 ppm, P3 is 1.802 ppm. Water sample data is needed to find out how much lead content is in the water to be used as a medium for blood cockle (A. antiquata). The Decree of the Minister of Fisheries and Marine Affairs No. 17 /2004 [8] concerning the Shell Sanitation System in Indonesia, has stipulated the Shell Quality Standard for live shellfish species, and their processed products for direct consumption. In relation to the threshold for heavy metals, shellfish and processed products to be consumed must meet the requirements, including the maximum content of mercury (Hg), cadmium (Cd) and lead (Pb), respectively 0.5; 1.0; and 1.5 mg / kg net weight.

To reduce the Pb content in A. antiquata, a depuration process was carried out through four treatments and five replications with a completely randomized design. From these data, it is obtained that there is a significant difference in the treatment of different filters, meaning that with different filters there are differences in the results of depuration than not using filters.

Giving a difference filter was carried out for 3 days and the results of giving activated charcoal filters in general tended to have a higher reduction in Pb content with a percentage of 31.5% compared to zeolite filters, which is 30.62% and Gracillaria sp filter, which is 25.53%. This shows that the difference in the filter on the reduction of Pb content in blood cockle (A. antiquata) is more effective in reducing blood cockle compared to those without filtering which average is only 15.6%.

3.5.2 Analysis of Cd content

From this research, initial data were obtained in the form of A. antiquata samples, the result that there was a Cd content of 2.152 ppm in the blood cockle before depuration. Other data obtained before treatment, that is water sample data before treatment, Cd contained in the water sampled from the experimental aquarium was 2.301 ppm. Water sample data after treatment is also be a supporting data, for P1 treatment is 2.083 ppm, P2 is 1.967 ppm, P3 is 1.853 ppm. Water sample data is needed to find out how much lead content is in the water to be used as a medium for blood cockle (A. antiquata). The Decree of the Minister of Fisheries and Marine Affairs No. 17 /2004 [8] concerning the Shell Sanitation System in Indonesia, has stipulated the Shell Quality Standard for live shellfish species, and their processed products for direct consumption. In relation to the threshold for heavy metals, shellfish and processed products to be consumed must meet the requirements, including the maximum content of mercury (Hg), cadmium (Cd) and lead (Pb), respectively 0.5; 1.0; and 1.5 mg / kg net weight.

To reduce the Cd metal content in A. antiquata, a depuration process was carried out through four treatments and five replications with a completely randomized design. From these data, it is obtained that there is a significant difference in the treatment of different filters, meaning that with different filters there are differences in the results of depuration than not using filters.

Giving different filters was carried out for 3 days and the results of the treatment of activated charcoal filters generally tended to have an average reduction in Cd content with a percentage of 28.56% higher than that of zeolite filters, which is 26.75% and Gracillaria sp filter, which is 18.77%. This shows that the difference in the filter on the reduction of Cd content in blood cockle (A. antiquata) is more effective in reducing blood cockle compared to those without filtering which average is only 16.03%.
4. Conclusion

The depuration process using different filters had a significant effect on the Pb and Cd content of blood cockle (*A. antiquata*). Giving activated charcoal filters in this research decreased the Pb and Cd contents higher with an average percentage of 31.5% for Pb and 28.56% for Cd. Compared using zeolite filters, *Gracillaria* sp filters, and without using filters.

5. References

[1] Payung F L 2013 *Studi Kandungan dan Distribusi Spasial Logam Berat Timbal (Pb) pada Sedimen dan Kerang (Anadara sp.) di Wilayah Pesisir Kota Makassar* (Makasar: Universitas Hasanudin)

[2] Suksmirri 2008 *Dampak Pencemaran Logam Timah Hitam (Pb) Terhadap Kesehatan* (Padang: Universitas Andalas)

[3] Almeida J A, Barreto R E, Novelli L B, Castro F J, and Moron S E 2009 *Neotrop Ichtyol* 7, 103-108

[4] Patrick L 2003 *Toxic Metals part II Altern Med Rev*

[5] Flora S J S 2009 *Metal J Med Sci* 2, 4-26

[6] Metian M, Hedouin L, Barbot Q, Teyssie J L, Fowler S W, and Goudard F 2005 *Bull Environ Contam Toxicol* 75, 89-93

[7] Hidayat T 2011 *Profil Asam Amino Kerang Bulu (Anadara antiquata)* (Bogor: Institut Pertanian Bogor)

[8] Keputusan Menteri Kelautan dan Perikanan Nomor: KEP.17/MEN/2004 *Sistem Sanitasi Kekerangan* Kementerian Kelautan dan Perikanan

[9] Gabr H R and Gab-Alla A 2008 *Oceanologia* 50(1), 83-93

[10] Prihatini W and Mulyati A H 2013 (Bogor: Universitas Pakuan)

[11] APHA (American Public Health Association) 2005 *Standard method for the examination of water and wastewater ed.21th* (Washington DC: American Public Health)