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Utilization of activated carbon of various charcoal types as absorbent in green shellfish (*Perna viridis*, Linnaeus, 1758) contaminated by lead heavy metal

Vidya Yustindriarini^{1,*}, Zahidah Hasan², Herman Hamdani², Asep Sahidin²

¹Student Faculty of Fisheries and Marine Science, Padjadjaran University, Jatinangor 45363, West Java, Indonesia

²Lecturer, Faculty of Fisheries and Marine Science, Padjadjaran University, Jatinangor 45363, West Java, Indonesia

*E-mail address: yustindriarini@gmail.com

ABSTRACT

Aims of the research are to determine the type of activated carbon with high absorption rate in absorbing heavy metals of lead in green shells. This research used experimental method with complete randomized design then analyzed used analysis of variance and duncan test to see the decrease of lead in green shells by using different charcoal filters. The results showed that the highest decrease in green shell was by using coconut shell activated filter are 0,28 with a decrease percentage of 36,51%. The best lead decrease in water maintenance coconut shell activated filter treatment are 0,33 ppm. The coconut shell activated charcoal has a low ash content compared to other types and large pore charcoal size. Factors that supporting the metal absorption by charcoal include ash content on charcoal, charcoal pores, carbon concentration and pH concentration. Water quality measurements were measured in the morning and evening as supporting parameters in the study. Water quality measurements are in a range that can still be tolerated by green shells. Based on these results it can be concluded that the use of coconut shell activated charcoal is the best type of charcoal in lowering lead in green shells.

Keyword: Activated Carbon, Green Shell, Lead, *Perna viridis*, *Skeletonema*

1. INTRODUCTION

Increasing the number of industries and residents has an impact on increase the level of river water contamination. In rivers that located in big cities, the input of contamination sources cannot be known (non point source pollution) because the waste contamination is carried by the run off in the watershed to the larger river. Usually the amount of contamination in the estuary will be high because it comes from various sources and accumulated.

The increase amount of heavy metals, especially lead in the water caused damage to the water themselves. Lead metal that enter the water will be run into sedimentation, dilution and then absorbed by aquatic organisms. Heavy metal contamination, especially lead in the environment is a serious problem because lead metal that found in the meat of fish and shellfish has a high level of toxicity and is accumulative in the human body that consumes it.

As with other fishery products, shellfish sometimes have a problems with metal pollution, especially lead. Green mussel often as used as biofilter or filter organisms that able to improve quality in water environmental because of its nature green shells is filter feeder and sesil (sedentary life) so organic and inorganic materials such as metals can be absorbed easily. High heavy metal concentration is often found in green mussels because green mussels can live in waters with high levels of lead pollution. Lead heavy metal can enter the body of the green mussel through the feeding habit and respiration. Jakarta Bay is one of the locations of shellfish cultivation because of the abundant availability of organic material. The cultivation of green mussels carried out in Jakarta Bay is indicated by heavy metal contamination because the Jakarta Bay is the estuary of the rivers that cross over densely populated and industrial areas. According the levels of heavy metals in water, especially Muara Angke and Muara Dadap, have an amount that exceeds the quality standards based on PP No. 82 of 2001. The results of the analysis of green mussel samples sourced from the Bay of Jakarta show that lead concentration in green mussels is 33.64 ppm and the results of the analysis are above the threshold set by the Food and Drug Supervisory Agency (BPOM).

In this regard, it is necessary to make an effort to reduce the heavy metal concentration of lead in the body of green shells so that the negative effects caused by heavy metals lead to humans that consume them can be prevented. Heavy metal contamination can be reduced one of them by treatment using activated carbon. Activated carbon is basically made from various carbon-containing materials such as wood, sawdust, rice husk and coconut shell. Activated carbon can be used as an absorbent to absorb heavy metal lead. This study aims to determine the type of activated carbon with the highest absorption rate in absorbing heavy metal lead in green shells.

2. MATERIALS AND METHODS

The research was carried out at the Fish Quarantine Center, Quality Control and Safety of Jakarta I Fisheries Products (BBKIPM I Soekarno-Hatta) and Laboratory of Fish Quarantine Standard Test, Cipayang Quality Control (BUSKIPM) from February to March 2018.

2. 1. Methods

This study used experimental methods by testing changes caused by independent variables and dependent variables. The independent variable is green mussel and the dependent

variable is lead metal concentration. The study was conducted with 5 treatments and 3 replications and then analyzed using variance analysis and further testing of duncan to see a comparison of the decrease in lead concentration in green mussels using different charcoal filters.

These treatments are:

- A0 : No filter (control)
- A1 : Wood activated charcoal filters.
- A2 : Chaff activated charcoal filters.
- A3 : Coconut shell activated charcoal filter.
- A4 : Coconut shell activated charcoal non filter.

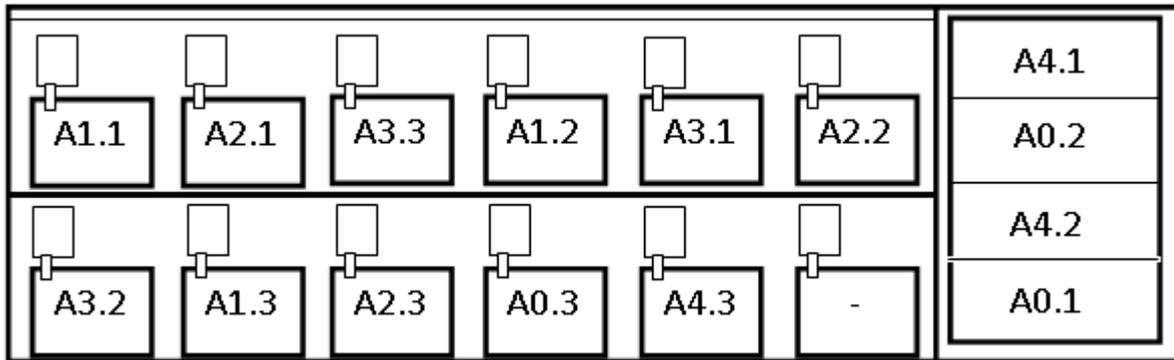


Figure 1. Layout of aquarium research

There is a picture of the difference in treatment of activated charcoal with filters and without filters

(a)

(b)



Figure 2. With filters (a), without filters (b)

2. 2. Tools and materials

The tools and materials used Aquarium as a place for maintenance of green shells, filters for filtering impurities and contamination of lead in seawater, PVC pipes for filtering media, digital scales for weighing activated charcoal, label paper and stationery to record the results of analysis, measuring instruments water quality (pH meter, DO meter, refractometer and thermometer), atomic absorption spectrophotometer (AAS) as a lead concentration gauge, activated charcoal wood, chaff and coconut shell as absorbent material on the filter, *Skeletonema* sp as a feed for green mussels, sea water as maintenance media and green shells as test samples.

2. 3. Procedure of research

Preparation of tools and materials

The first step is to clean the aquarium using liquid soap followed by drying in the sun. Water that is used as a medium for living green mussels was previously treated, which is deposited first in a water reservoir overnight and given aeration. Aquariums are filled with 15 liters of sea water with a salinity range of 25 ppt – 35 ppt (part per thousand). Then a water pump and a different char filter are installed in each aquarium. Green mussel samples were obtained from fishermen in Muara Dadap.

Maintenance of green mussels

Green mussels that used are measure between 5-7 cm will be maintained in a 50×30×30 cm³ aquarium for 6 days with a density of 15 individual for an aquarium. Maintenance media will be chipped every three days to reduce dirt on maintenance media. During maintenance, green mussels are fed three times a day, namely in the morning, afternoon and evening in the form of *Skeletonema* sp.

AAS test for heavy metal content

Green mussel samples and the seawater maintenance were tested using AAS. Tests were carried out before and after the treatment to determine the concentration of initial and final heavy metals in green mussels and sea water. Testing of lead heavy metals using atomic absorption spectrophotometry (AAS) will be carried out at the Fish Quarantine Standard Test Laboratory, Cipayung Quality Control (BUSKIPM). The working principle of AAS is the amount of absorbed energy proportional to the sample.

The actual heavy metal concentration is calculated using the following equation:

$$\text{The actual concentration} = \frac{D - E \times Fp \times V}{W}$$

note:

- D = Sample concentration μ /l from the results of reading the AAS
- E = Concentration of sample sheet μ /l from the results of reading the AAS
- Fp = Dilution factor
- V = Final volume of prepared sample solution (ml)
- W = Sample weight (gr)

Research Parameters

The parameters observed in this study were the percentage decrease in lead content in green mussels (*Perna viridis*) and water measured using AAS. According to the percentage of decrease in heavy metals is the difference in the concentration of heavy metals after and before being absorbed divided by the previous concentration multiplied by 100% by the following formula:

$$\text{Percentage of heavy metals} = \frac{C_{\text{start}} - C_{\text{end}}}{C_{\text{start}} \times 100\%}$$

Note:

C_{start} = Initial concentration of heavy metals

C_{end} = The final heavy metal concentration of the experiment

Water Quality Measurement

Water quality was measured to determine the condition of the maintenance media and its changes using a thermometer, pH meter, refractometer and DO meter with measured variables including water temperature, pH, salinity and oxygen dissolved in water. Water quality measurements are carried out once every day during the research.

2. 4. Data analysis

The data obtained were analyzed by comparing the percentage reduction in concentrations of lead heavy metals in green mussels and then analyzed using Anova (Analysis of Variants). If there is a difference between treatments then proceed with the duncan multiple distance test with a 95% trust level.

3. REDUCTION OF PB ON GREEN SHELLFISH

Based on Figure 1, the average value of the lowest lead concentration was in treatment A3 (coconut shell activated charcoal filter) which was 0,28 ppm. The treatment of A1 (wood activated charcoal filter) and A2 (chaff activated charcoal filter) concentration still exceeds the threshold set which is 0.30 ppm then in A4 treatment, the decrease in concentration is below the threshold set by SNI 2009 which is 0.29 ppm. This is because the absorbent material used in A4 treatment is same type of charcoal that is coconut shell activated charcoal. This is supported by the statement, that coconut shell activated charcoal has a better value of effectiveness when compared to chaff activated charcoal.

Using the coconut shell activated charcoal as an absorbent to reducing lead in green mussels can occur because of the extensive coconut shell activated pores so that ions of lead can be absorbed into activated charcoal. The surface area of activated charcoal pores affects the number of active sites (the part to receive metal ions) that are available and will affect the length of time needed to achieve equilibrium time.

Other than that, coconut shell activated charcoal has a lower ash content than other types of activated charcoal. The ash content is very influential on the quality of activated charcoal itself. Excessive ash can cause clogging of charcoal surface area decreases.

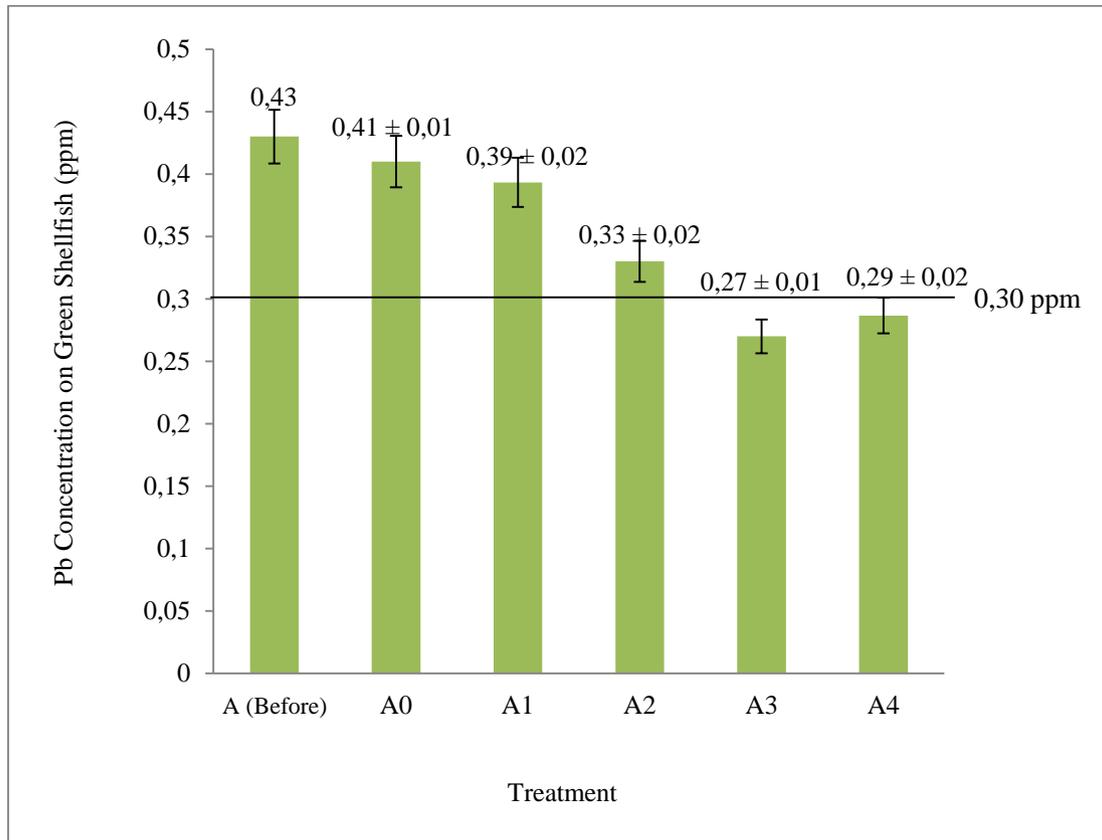


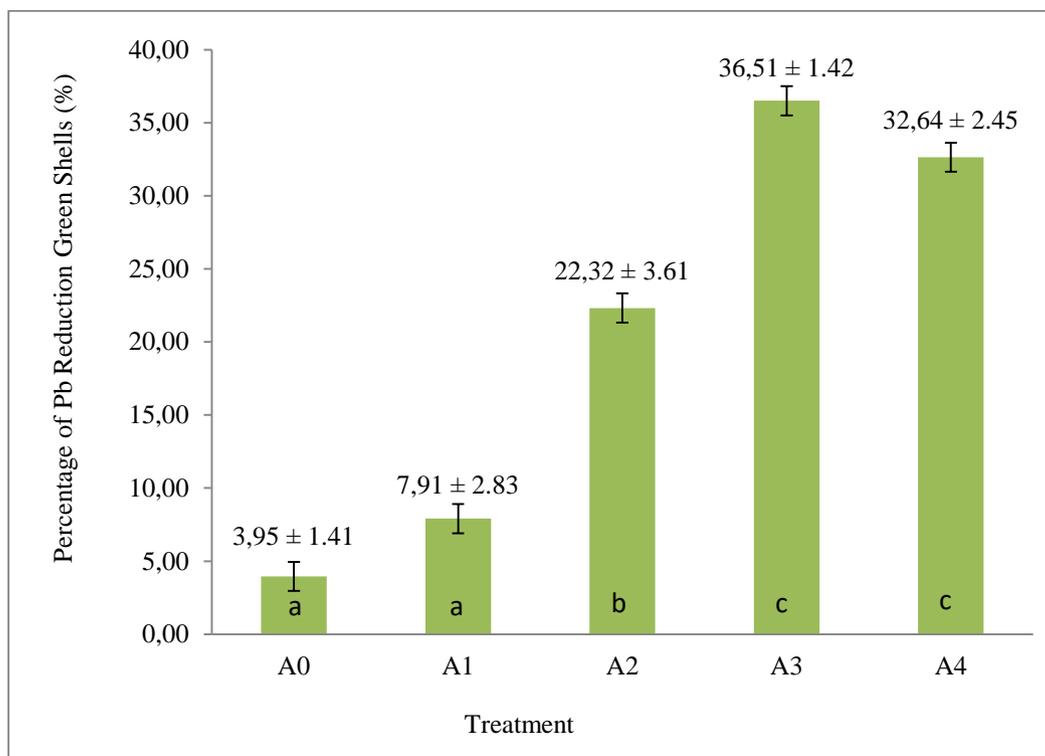
Figure 3. Lead Concentration Chart on Green Shells

3. 1. Decrease of Percentage in Pb Concentration on Green Shellfish

Based on Figure 2, the highest percentage of lead reduction occurred in treatment A3, which is $36,51\% \pm 1,41$ and the lowest decrease occurred in treatment A0 are $3,95\% \pm 1,41$. Based on the calculation of the percentage of lead, the ability to absorb charcoal on green mussels is known to be less than 50%. According to the effectiveness of coconut shell activated charcoal to absorbing lead metal is 70,4%. This can occur because activated charcoal has not reached its maximum point in the absorption of lead metal. According to the ability of activated charcoal as a metal remover is influenced by pH, contact time and carbon concentration.

The wood active charcoal is absorbent which absorbs lead at least 3,95%. The low absorption rate in this type of charcoal is due to the wood material used does not come from the same type of plant. The different types of plants are very influential because each plant has its own absorption capacity. The best type of wood to be activated charcoal is wood that has low (dry) and hard water content. In his study stated that the activated carbon of teak wood in the form of powder used as an absorbent of Pb(II) metal ions has an absorption capacity of 1,28 ppm with an absorption percentage of 62,32%.

Based on Figure 2, coconut shell charcoal is superior type of charcoal in reducing lead compared to chaff type charcoal. The mechanism of absorption of metal ions by activated charcoal is ion exchange.



note: different letter subscripts in each bar show differences real between treatments using the duncan test ($p < 0,05$)

Figure 4. Graph of Percentage Reduction in Lead on Green Shells

The ion exchange that occurs in each type of charcoal is different. The type of chaff charcoal can be used as an absorbent in reducing lead metal but has a disadvantage compared to coconut shell activated charcoal. Weakness of chaff activated charcoal is of high ash content. Stated that the value of chaff activated charcoal ash was 7,36% while coconut shell activated charcoal was 4,61%. The ability of activated charcoal as absorbent is not the same as each other, therefore an absorption is not necessarily good for other absorption processes. The difference in pore particle size and activation level can affect the optimization of used active charcoal.

3. 2. Decrease Pb in the Water

Based on the graph of the decrease in lead concentration in water (Figure 3) the P3 treatment produced the lowest lead concentration value of 0,33 ppm and the P0 treatment produced the highest concentration value of 0,48 ppm. This concentration is still classified as higher than the threshold set by the Minister of Environment Decree No. 51 year 2004.

The high concentration of lead in maintenance water shows that sea water sourced from Tanjung Pasir waters has previously been exposed to lead. The value of lead concentration in seawater that exceeds this threshold is related to several factors including the load of contamination input on water bodies and climate factors. In general, the entry of lead metal into the sea is during the rainy season with high rainfall, many heavy metals either in dissolved from sediment carried from land to sea through the river flow.

The concentration of lead in maintenance water in P1 treatment (wood charcoal active filter) and P2 (chaff activated charcoal filter) was higher than P3 treatment (coconut shell activated charcoal filter). This is due to the different pores of charcoal and ash content of each type are also affected by the gap between charcoal (porosity). The size of wood charcoal used P1 treatment is the same as each charcoal but has a more tenuous inter-charcoal gap compared to P2 treatment (chaff activated charcoal filter) and P3 (coconut shell activated charcoal filter). The gap between the gaps influences the slow slowness of water entering and exiting through the filter so that it will affect the speed of charcoal in absorbing lead.

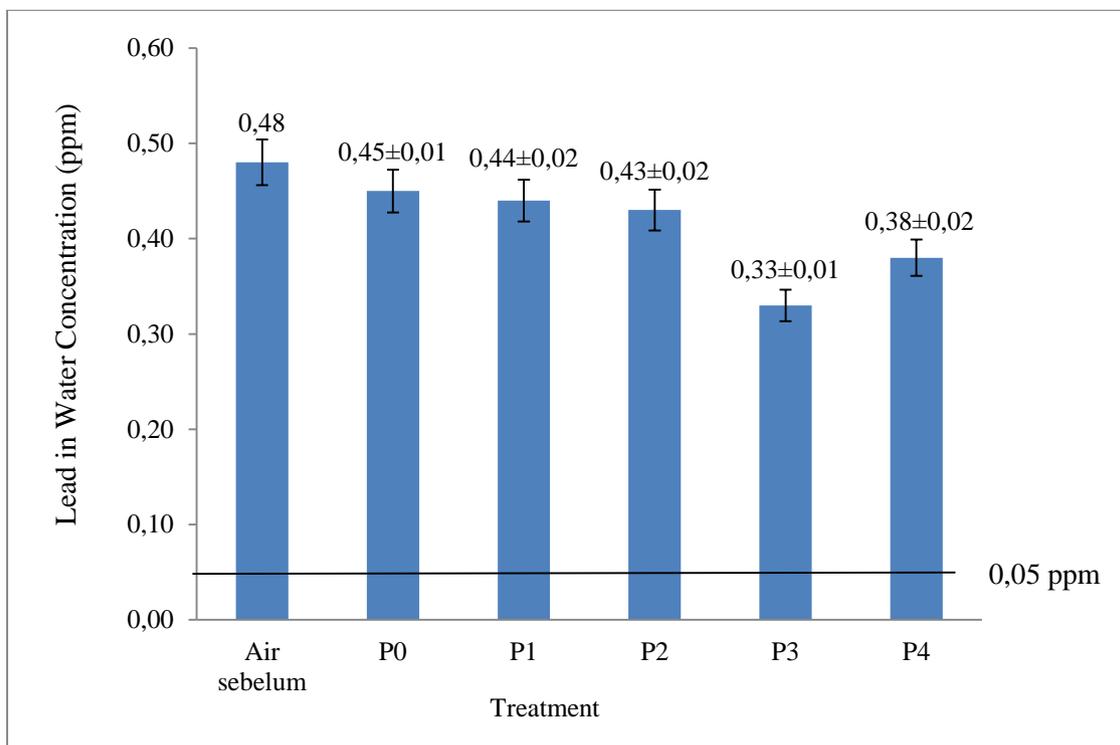


Figure 5. Graph of Decreased Lead Concentration in Water

Based on Figure 3, lead concentration in P4 treatment was higher than the same P3 treatment using coconut shell activated charcoal as absorbent. The difference in concentration between treatment P3 and P4 is thought to be influenced by filter media used in P3 treatment. The dissolved lead ions contained in the maintenance water will enter the filter with the help of a water pump so that dissolved lead metal can be easily absorbed and enter the charcoal pores, then lead metal will be trapped in the filter. While in P4 treatment that does not use filters, lead metal contained in water is only partially absorbed by charcoal through its pores and lead absorption process takes longer.

3. 3. Water Quality

Water quality is measured as a supporting parameter in the study. Water quality measurements in this study include measurement of temperature, pH, dissolved oxygen and salinity (Table 1)

Table 1. Range of Water Quality Parameters

Parameter	Time	Unit	Range	Average	Standard Deviation
Temperature	Morning	°C	27,3 – 28,4	28,2	0,3
	Evening		28,5 – 30,4	29,4	0,3
pH	Morning	-	6,5 – 7,8	7,3	0,4
	Evening		7,0 – 8,2	7,6	0,5
DO	Morning	mg/l	6,8 – 7,9	7,1	0,4
	Evening		6,5 – 7,4	7,0	0,5
Salinity	Morning	ppt	31 – 32	32	0,3
	Evening		30 – 32	32	0,5

Temperature is one of the most important physical factors in an aquatic environment. Changes in water temperature will affect the physical and chemical processes of waters, as well as for aquatic biota. An increase temperature can cause increased speed of metabolism and respiration of aquatic biota then increasing oxygen consumption. Temperature increases not only increase the metabolism of aquatic biota but also can increase the toxicity of heavy metals in the waters.

The temperature range values during the study measured in the morning were 27,3-28,4 °C and the temperature range in the afternoon was 28,5-30,4 °C. According to the temperature range that can be tolerated by a marine biota ranges from 20-35 °C. Whereas based on Minister of Environment Decree (2004) the temperature for marine aquatic biota ranges from 27-30 °C.

The level of acidity (pH) is a measure of hydrogen ion concentration and shows the condition of water. Based on the measurement of pH values during observation ranged from 6,5 to 7,8 in the morning and 7,0 to 8,2 during the day. At low pH, free ions of heavy metals released into the water column affect the toxicity of a chemical compound such as metals. The range of pH values during the day is greater than in the morning due to photosynthetic activity and respiration that occur during the day. The more CO₂ produced from respiration results in the pH of the water will increase. In general, sea water is relatively more alkaline around 8,0, but seawater organisms are able to adapt to a wide pH range between 6-8.

The concentration of dissolved oxygen and biological oxygen demand is the most important factor because its existence is closely related to biota so that it is considered as a waters productivity index. The results of dissolved oxygen measurements during the study in the morning ranged from 6,8 to 7,9 mg/l while the measurement results in the afternoon were 6,5 to 7,4 mg/l. The concentration of dissolved oxygen will affect heavy metal toxicity, if the dissolved oxygen concentration is high, heavy metal toxicity decreases while if the dissolved oxygen is low, heavy metal toxicity increases.

According to dissolved oxygen levels of less than 4 mg/l can have an adverse effect on aquatic organisms in them and can cause death. Based on the Minister of Environment Decree (2004) the quality standards of dissolved oxygen in good waters are worth above 5 mg/l.

The range of water salinity observed for 6 days in the morning is in the range of 31-32 ppt. While for the afternoon it ranges from 30-32 ppt. According to the optimum salinity of shellfish ranged from 27-33 ppt. So that in research conducted salinity has reached the optimum value for the growth of green mussels. Salinity is one of the factors that influence the level of heavy metal toxicity. Decreasing salinity in the waters causes greater heavy metal toxicity. Water salinity tends to change due to the presence of evaporation factors.

4. CONCLUSIONS AND SUGGESTIONS

4. 1. Conclusions

Based on the results of the research that has been done, the following conclusions can be drawn:

- 1) Using activated charcoal has an effect on reducing lead concentration in green mussels, especially the use of activated coconut shell charcoal with the highest percentage reduction of 36.51% using filters and 32.64% unfiltered.
- 2) Using coconut shell activated charcoal can reduce lead concentration in sea water with the highest concentration value of 0.33 ppm.

4. 2. Suggestions

- 1) Based on the results of the study, the use of coconut shell activated charcoal as a filter or without filter can be used as an alternative in reducing lead in both green mussels and sea water. The use of charcoal filters as a medium to reduce lead concentration is recommended because it is easier to clean and last longer than unfiltered charcoal.
- 2) Using of activated coconut shell charcoal as an indirect absorbent can also minimize the adverse effects of lead on humans who will consume green shellfish

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