The Design of Filtration System Using Coconut Shell Charcoal for Domestic Wastewater Purification

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The Design of Filtration System Using Coconut Shell Charcoal for Domestic Wastewater Purification

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Abstract— *Water pollution is a sanitation problem that will always demand attention and the sustainable solution. As one of the river's pollutants, blackwater requires good treatment techniques so that it can be discharged into the body of water and does not cause environmental or health problems. One of the vest purification techniques is the filtration method by using materials that are cheap and easy to obtain, such as coconut shell charcoal. Charcoal has great potential due to its ablility to remove suspended solids and bind chemical pollutants. This study aims to apply the concept of blackwater purification using coconut shell charcoal filtration method, as well as to determine the most optimal blackwater waste discharge in reducing turbidity. Observations were made on the turbidity variable (NTU) which was recorded at each residence time of 0 to 9 days. The result of regression analysis demonstrates that the thickness of the charcoal filter layer and the discharge of wastewater have a significant effect on reducing the turbidity level of the treated blackwater. Thus, it can be concluded that coconut shell charcoal is very potential to be used as a filter in blackwater treatment. Blackwater is best be purified with 30 cm of charcoal filter layer and 9 days of residence time.*

Keywords— *Blackwater, Filtration, Communal wastewater treatment plant.*

I. INTRODUCTION

One of the crucial basic needs for human life is clean water. The water sanitation and waste management in Indonesia, especially in East Java, requires serious attention from various parties. The lag in the field of sanitation development has triggered various problems, including decreasing the quality of groundwater and surface water (river), air pollution to decreasing the level of public health which ultimately weakens the competitiveness of the nation. It has been revealed in various media that pollution of groundwater in various cities reaches 80%, where about 75% of the river has been polluted. In order to avoid increasingly worsening environmental and public health problems. Bappeda (The agency of planning and regional development) East Java, which is now changed into the Environmental Agency (BLH) develop the program for wastewater treatment by promoting the application of communal wastewater treatment and water pollution control.

The communal WWTP is useful for processing domestic wastewater until its output meets the quality standard so that it no longer pollutes the environment. However, the experience that occurred in Malang City proves that the construction and delivery of sanitation facilities such as WWTP, even though it has gone through a process that seems good, but in reality will not function optimally in the next few years. The lessons learned from the experience of community failure in managing communal WWTPs in Malang City are due to the introduction of a non-sustainable management system (closing cycle), and if this management system is not immediately applied, it is almost certain that failure after failure will occur in East Java and even throughout Indonesia, because all of them do not have a sustainable management system. If the example of the preservation of communal IPAL management cannot yet be demonstrated, the MDGs (Millennium Development Goals) in the form of improved sanitation facilities in Indonesia which should reach 70% in 2015 will be difficult to realize.

Sustainability (Sustainability) is the process of determining the achievement of the balance of fruit three aspects, namely: 1) economic development; 2) improvement of community resources (HR), and 3) strengthening the environment at the local level. The process towards sustainability can be done by testing, developing and disseminating procedures for developing the economic level of the community in such a way that the ecosystem gets protection due to an increase in living standards (ICLEI, IDRC and UNEP 1996).

The economic development of communal IPAL management communities, even local people should be able to be improved. While this effort towards it is still not done. Wherever communal WWTPs are built, there have not been any efforts that have led to the idea of improving the community's economy due to the existence of the WWTP. Currently, there are many developments in *Sanimas* program (community sanitation) in several cities in East Java (for example: in Blitar, Batu and Kepanjen). The system applied is levied for people who use the communal WWTP facilities in the form of usage fees. In reality, this system cannot work effectively due to the inability of the managers to withdraw contributions if those who use toilet or bathroom facilities are neighbors, friends or even their own families. Things like this reduce the sustainability of this facility. The good goal of obtaining funds for the care of communal WWTPs cannot be achieved, especially to improve the economy of the community. One of the best communal wastewater plant that is used as a pilot is the IPAL Komunal Tlogomas, Malang.

This processing is carried out on liquid waste containing waste materials which can be separated mechanically directly without the addition of chemicals or through biological destruction. Physical processing of liquid waste can be done by filtration and sedimentation (Manurung et al., 2004). Sedimentation is a solid-liquid separation process by depositing suspended particles in the presence of gravity. According to Kagaya et al., (1999) as cited in Wulandari (2018), waste treatment by sedimentation is the process of

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deposition of organic compounds in waste without any treatment. However, sedimentation processing is not efficient to use, because the process is slow, especially if the waste is in sufficiently large quantities even though the cost is relatively cheap. Filtration is a solid-liquid separation process through a filter (filter). Filtration is one form to produce high-efficiency waste solids. When compared with the processing of sedimentation, filtration requires a relatively expensive cost, besides that the effectiveness of the membrane rapidly decreases because the pores are likely to be covered by organic particulates.


Figure 1. The condition in IPAL Komunal Tlogomas

By far, researchers have seen that there has been no further processing related to efforts to improve the quality of wastewater entering the river bodies. Based on the condition of the area surveyed, the facilities and resources in processing waste are only functioned functionally and do not pay attention to system improvement and optimization of existing resources. Thus, it is necessary to improve the design of the blackwater waste treatment system at WWTP to improve the quality of external water so that it is suitable to be dumped into rivers or reused as agricultural water. Previous research conducted by Wulandari (2018) combined filter materials including gravel, sand and charcoal for the purification of blackwater treatment. The study found that the three materials are greatly promising to be used as natural filter for purifying the wastewater. This study, on the other hand, focuses on the use of coconut shell charcoal as filter material in the purification of blackwater. For this reason, researchers conducted research by utilizing materials that were easily obtained at relatively affordable prices, namely coconut shell charcoal. shell charcoal has good potential to help purify wastewater because of its active carbon content (Cobb et al. 2012). This study aims to apply coconut shell charcoal as a filter material in blackwater waste treatment, which is to determine the thickness of the charcoal layer, the residence time, and the recommended maximum discharge to be able to produce good output.

II. Method

This study used an experimental quantitative method. Primary data were obtained directly from experimental activities carried out in the field, namely the Communal wastewater plant of Tlogomas Malang (IPAL Komunal Tlogomas, Kota Malang).


Figure 2. Blackwater


Figure 3. Coconut shell charcoal

The variables observed are discharge variation and the residence time as an independent variable, as well as the level of turbidity as the dependent variable. The method of data analysis is Regression with linear and exponential equations processed on the SPSS 21 program. The design of the filter plant was made on a laboratory scale by constructing a filter box measuring of 25 x 60 cm. In addition to the filter box, the equipments used in this study include wiremesh 18, frame and turbidity meter. The materials used include blackwater as research sample, and coconut shell charcoal as the filter material. Coconut shell charcoal filter was made with a thickness of 30 cm. This thickness was determined in the previous research.

III. Result and Discussion

A. The Decrease of Blackwater Turbidity

In this study, the design of a blackwater purification installation was previously tested in preliminary research. The final concept of charcoal filter design is shown in Figure 4. The filter was made from wiremesh box filled with coconut shell charcoal with an average particle diameter of 2 mm. The blackwater collected from morning and evening samples, while the residence time of blackwater in the filtration system ranged from 1 to 9 days.

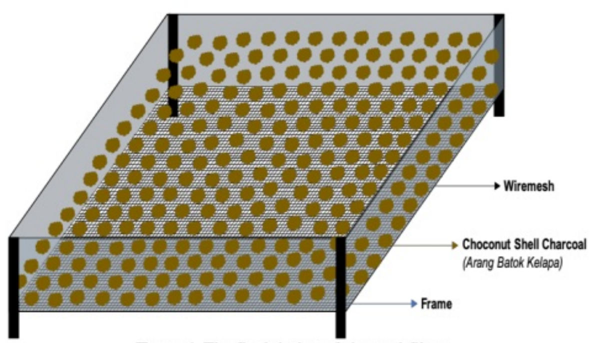

Figure 4. The final design of charcoal filter

Measurements of turbidity level were carried out on samples that have not been filtered to determine the initial turbidity levels, during the filtering process according to residence time (1-9 days), and after the series of process was completed. The results of the application in the field can be seen in table 1. Based on the measurement results, the initial turbidity level of blackwater was 1000 NTU. In addition, the maximum turbidity level based on the Government Regulation (PP) is 25 NTU.

TABLE 1. The decrease of turbidity level of blackwater

Volume (liter/day)	Turbidity Level (NTU)		Residence Time (Day)
	Morning sample	Afternoon sample	
100	1000	950	0
	560	700	1
	480	550	2
120	390	470	3
	280	320	4
	150	225	5
	125	190	6
140	100	160	7
	35	45	8
	22	26	9

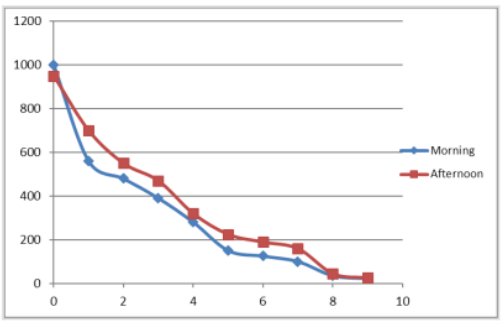

Figure 5. Turbidity level from the treatment charcoal filter 30 cm

It can be seen that the initial turbidity of blackwater waste before processing reaches greater than 1000 NTU in blackwater taken in the morning, and 950 NTU in blackwater taken in the afternoon. Filtering with a single filter from the first day to the 9th day shows that the blackwater turbidity level continues to decline to reach 22 NTU in the morning blackwater sampling, and 26 NTU at the blackwater sampling in the afternoon. Because it has fulfilled the requirements of the government regulation on Sanitaisi, namely 25 Ntu, the research was stopped.

B. The Effect of Charcoal Filter Thickness on the Decrease of Turbidity Level

Linear regression

Table 2 presents a summary of the results of Linear Regression analysis on blackwater data obtained in the morning, specifically related to the effect of thickness of shell charcoal with turbidity levels.

TABLE 2. The result of linear regression on the morning sample

Independent Var.	Coefficient	*P*	R^2	Equation
Charcoal filter thickness	-10,144	0,002	7,6%	Y = 717,871 – 10,144 X + e

Based on the table above, it can be seen that the results of the analysis of Linear Regression between shell charcoal and turbidity in morning processing show a regression coefficient of -10.144, with a significance value of 0.002 (<0.05). Thus, it can be stated that the thickness of shell charcoal has a significant negative effect on the turbidity of treated wastewater. In other words, the thicker the shell charcoal layer is used for filtration, the more potential it will be in reducing turbidity levels. The coefficient of determination obtained from regression analysis is 7.6%, where this number represents the effect of the thickness treatment of shell charcoal applied to the level of turbidity of treated wastewater. The rest (92.4%) is the percentage of the influence of variables or other factors, other than the thickness of the shell charcoal treatment applied. Furthermore, the results of the Linear Regression analysis (Table 6) are explained in the blackwater data obtained in the afternoon, specifically related to the effect of thickness of shell charcoal with turbidity levels.

TABLE 3. The result of linear regression on the afternoon sample

Independent Var.	Coefficient	*p*	R^2	Equation
Charcoal filter thickness	-9,380	0,002	8,2%	Y = 746,300 – 9,380 X + e

Based on the table above, it can be seen that the results of the analysis of Linear Regression between shell charcoal and turbidity in afternoon processing show a regression coefficient of -9.380, with a significance value of 0.002 (<0.05). Thus, it can be stated that the thickness of shell charcoal has a significant negative effect on the turbidity of treated wastewater. In other words, the thicker the shell charcoal layer is used for filtration, the more potential it will be in reducing turbidity levels. The coefficient of determination obtained from regression analysis is 8.2%, where this number represents the effect of the thickness treatment of shell charcoal applied to the turbidity level of treated wastewater. The rest (91.8%) is the percentage of influence of variables or other factors, other than the thickness of the shell charcoal treatment applied.

Non-Linear regression (Exponential)

Table 4 presents a summary of the results of the Exponential Regression analysis on blackwater data obtained in the morning, specifically related to the effect of thickness of shell charcoal with turbidity levels.

TABLE 4. The result of exponential regression on the morning sample

Independent Var.	Coefficient	*p*	R^2	Equation
Charcoal filter thickness	-0,033	0,000	13,1%	$Y = 823{,}924^{-0{,}033\,X} + e$

Based on the table above, it can be seen that the results of the Exponential Regression analysis between shell charcoal and turbidity in morning processing show a regression coefficient of -0.033, with a significance value of 0.000 (<0.05). Thus it can be stated that the thickness of shell charcoal has a significant negative effect on the turbidity of treated wastewater. In other words, the thicker the shell charcoal layer is used for filtration, the more potential it will be in reducing turbidity levels. The coefficient of determination obtained from regression analysis is 13.1%, where this number represents the effect of the thickness treatment of shell charcoal applied to the level of turbidity of treated wastewater. The rest (86.9%) is the percentage effect of variables or other factors, other than the thickness of the shell charcoal treatment applied. Furthermore, a summary of the results of the Exponential Regression analysis on the blackwater data obtained in the afternoon is explained, specifically related to the effect of thickness of shell charcoal with turbidity levels.

TABLE 5. The result of exponential regression on the afternoon sample

Independent Var.	Coefficient	p	R^2	Equation
Charcoal filter thickness	-0,029	0,000	12,4%	$Y = 855{,}090^{-0{,}029 X + e}$

Based on the table above, it can be seen that the results of the Exponential Regression analysis between shell charcoal and turbidity in afternoon processing show a regression coefficient of -0.029, with a significance value of 0.000 (<0.05). Thus, it can be stated that the thickness of shell charcoal has a significant negative effect on the turbidity of treated wastewater. In other words, the thicker the shell charcoal layer is used for filtration, the more potential it will be in reducing turbidity levels. The coefficient of determination obtained from regression analysis is 12.4%, where this number represents the effect of the thickness treatment of shell charcoal applied to the level of turbidity of treated wastewater. The rest (87.6%) is the percentage effect of variables or other factors, other than the thickness of the shell charcoal treatment applied.

C. The Effect of Blackwater Volume on the Decrease of Turbidity Level

Linear regression

Table 6 presents a summary of the results of Linear Regression analysis on blackwater data obtained in the morning, specifically related to the effect of water discharge with turbidity levels.

TABLE 6. The result of linear regression on the morning sample

Independent Var.	Coefficient	p	R^2	Equation
Blackwater volume	4,566	0,002	7,5%	Y = -20,275 + 4,566 X + e

Based on the table above, it can be seen that the results of the analysis of Linear Regression between water discharge and turbidity in morning processing show a regression coefficient of 4.566, with a significance value of 0.002 (<0.05). So, it can be stated that water discharge has a significant positive effect on the turbidity of treated wastewater. In other words, the higher the water discharge used, the higher the turbidity level. The coefficient of determination obtained from the regression analysis is 7.5%, where this number represents the effect of the treatment of applied water discharge on the turbidity level of treated wastewater. The rest (92.5%) is the percentage of the influence of variables or other factors, apart from the treatment of water discharge applied. Furthermore, the results of the Linear Regression analysis on blackwater data obtained in the afternoon are explained, especially related to the effect of water discharge with turbidity levels.

TABLE 7. The result of linear regression on the afternoon sample

Independent Var.	Coefficient	p	R^2	Equation
Blackwater volume	3,731	0,006	6,3%	Y = 122,675 + 3,731 X + e

Based on the table above, it can be seen that the results of the analysis of Linear Regression between water discharge and turbidity in afternoon processing show a regression coefficient of 3.731, with a significance value of 0.006 (<0.05). So, it can be stated that water discharge has a significant positive effect on the turbidity of treated wastewater. In other words, the higher the water discharge used, the higher the turbidity level. The coefficient of determination obtained from the regression analysis is 6.3%, where this number represents the effect of the treatment of applied water discharge on the turbidity level of treated wastewater. The rest (93.7%) is the percentage of the influence of variables or other factors, other than the treatment of water discharge applied.

Exponential regression

Table 8 presents a summary of the results of the Exponential Regression analysis on blackwater data obtained in the morning, specifically related to the effect of water discharge with turbidity levels.

Based on the table above, it can be seen that the results of Exponential Regression analysis between water discharge and turbidity in morning processing show a regression coefficient of 0.013, with a significance value of 0.000 (<0.05). So, it can be stated that water discharge has a significant positive effect on the turbidity of treated wastewater. In other words, the higher the water discharge used, the higher the turbidity level. The coefficient of determination obtained from regression analysis is 10.1%, where this number represents the effect of the treatment of applied water discharge on the turbidity level of treated wastewater. The rest (89.9%) is the percentage of the influence of variables or other factors, other than the treatment of water discharge applied. Furthermore, the results of the Exponential Regression analysis on the blackwater data obtained in the afternoon are explained, especially related to the effect of water discharge with turbidity levels.

TABLE 8. The result of exponential regression on the morning sample

Independent Var.	Coefficient	p	R^2	Equation
Blackwater volume	0,013	0,000	10,1%	$Y = 89{,}863^{0{,}013 X + e}$

TABLE 9. The result of exponential regression on the afternoon sample

Independent Var.	Coefficient	p	R^2	Equation
Blackwater volume	0,010	0,002	7,7%	$Y = 145{,}536^{0{,}010 X + e}$

Based on the table above, it can be seen that the results of Exponential Regression analysis between water discharge and turbidity in afternoon processing show a regression coefficient of 0.010, with a significance value of 0.002 (<0.05). So, it can be stated that water discharge has a significant positive effect on the turbidity of treated wastewater. In other words, the higher the water discharge used, the higher the turbidity level. The coefficient of determination obtained from the regression analysis is 7.7%, where this number represents the effect of

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the treatment of applied water discharge on the turbidity level of treated wastewater. The rest (92.3%) is the percentage of the influence of variables or other factors, other than the treatment of water discharge applied.

IV. Conclusion

Based on the results, it can be concluded that the filtration method using coconut shell charcoal is able to reduce the turbidity level of blackwater. The best result was obtained from the treatment of 30 cm charcoal thickness with 9 days of residence time. In addition, the best final results from each samples (morning and evening samples) were 22 and 26 NTU, respectively. Those results have met the standard. Therefore, the use of coconut shell charcoal for blackwater purification is highly recommended. On the other hand, further studies are suggested to investigate the effect of coconut shell charcoal as filter material on decrease of other parameters.

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