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THE EFFECT OF SAND FILTER AND WETLAND RESIDENCE TIME ON THE DECREASE OF BLACKWATER PARAMETERS

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ABSTRACT

The effectivity of blackwater treatment is influenced by the methods and processes applied. Due to its high pollutant content, blackwater treatment requires a series of processes and a longer processing time. One aspect that has been a problem so far is the cost, hence the technology must be developed in order to find the applicable and efficient method that can be applied by the community. Sand is a natural material that can be used as a filter, along with gravel and charcoal. In addition to the low price, these three materials are also easy to obtain. The use of filter materials can be refined through the wetland system by utilizing aquatic plant, such as Vetiver grass (Vetiveria zizanioides). In other words, blackwater is processed physically and biochemically. Based on the findings, the combination of stratified filtration method and wetland system can reduce the levels of TSS, TDS, BOD, COD parameters, and stabilize the pH. The effect of the sand thickness of the filter and the residence time of the blackwater in wetland tube is an interesting material to discuss.

Key words: Sand filter, Residence time, Wetland, Blackwater.

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1. INTRODUCTION

Wastewater from domestic activities is one the main source of environmental pollution, especially in the river ecosystem. Thus, the high volume of waste must be supported by adequate sanitation infrastructure and appropriate processing techniques. Improper handling of wastewater can lead to a decrease in environmental quality and cause various diseases for humans [3]. Wastewater treatment is considered important because it supports the continuity and sustainability of natural resources, that is if wastewater can be reused for certain purposes based on its specifications [4]. One type of wastewater that requires serious handling is that blackwater is due to its high organic matter content and various pathogenic bacteria. Generally, blackwater waste is processed by means of being stored in a septic tank and distributed to sewage systems then through the processing process to obtain an output that is deemed to be feasible to flow into the river.

According to the previous studies, the most commonly mentioned method is filtration with various types of materials, as well as the application of constructed wetland systems by utilizing various types of plants that have the potential as remediator agents. Previously, the use of gravel and sand as a blackwater waste filter material has shown promising results [5]. Other ingredients that can also be used are charcoal. With its active carbon content, charcoal can remove the odor and turbidity of the wastewater [6]. Other sources state that the use of charcoal is very good for waste treatment because it works both physically and chemically. Besides that, it is easy to obtain or even can be made by yourself, and the cheap price makes charcoal the right solution in processing blackwater waste in developing countries [7].

Constructed wetland can be applied to improve the filtration process with the filter material mentioned above. Wetland can be made by utilizing potential plants for remediation of wastewater, such as Cattail (Typha angustifolia) [10] [11]. Cattail is known for its high tolerance to pollutants and is able to reduce organic and inorganic pollutants. Constructed wetlands consist of three main characteristics, which are flooded and support the life of aquatic plants, have a growing medium of plants in the form of soil, and are saturated with water [12].

This study applies a combination of stratified filter methods and artificial wetlands. The focus of the observation is on measuring the parameters of pH, temperature, TSS (Total Suspended Solids), TDS (Total Dissolved Solids), BOD (Biological oxygen demand) and COD (Chemical oxygen demand) during the processing. The measurement data will be analyzed statistically to find out the potential methods used to improve the quality of blackwater. Processing results are expected to be able to meet class IV water standards, namely water for agricultural irrigation purposes.

2. METHODS

2.1. Stratified Filter Construction

This study uses a model of blackwater waste treatment with a scale of 1: 200. The waste filter is made by arranging filter material in reverse from clean water treatment, ie from coarse to fine material. The arrangement starts from gravel, charcoal, and then cast sand. The consideration of this compilation pattern is the filtering principle that starts from rough material first, where this process will be played by gravel. Furthermore, the process continued with filtering fine material and purifying water with charcoal followed by sand to filter out impurities that are still contained in blackwater waste. The stratified filter model scheme is shown in the following figure:

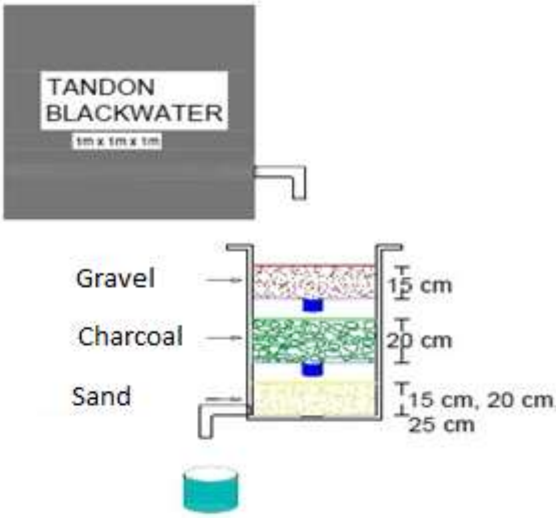

Figure 1. Stratified filter

2.2. Wetland Construction

The application of the wetland system is very important to obtain processing results that meet the standard of agricultural water. Wetlands are made on a lab scale by utilizing aquatic plants as blackwater waste remediation agents. The type of plant used is Vetiver Root (*Vetiveria zizanioides*). This method is expected to be able to maximize the process of backwater waste treatment after going through the screening process with stratified filters.

Figure 2. Constructed wetland with Vetiver grass (*Vetiveria zizanioides*)

2.3. Parameter Measurement

Measurement of the characteristics of blackwater is carried out before the start of the processing process, after going through a stratified filtration process, and during the residence time in a wetland tub. The observation interval of blackwater in wetland tubs is every two days, namely the second, fourth, and sixth days. The wastewater samples were obtained from communal septic tanks in Tlogomas Village, Malang City, and taken as much as 120 liters for processing and then measured the decrease in content. Water quality parameters observed were pH, temperature, TSS (Total Suspended Solids), TDS (Total Dissolved Solids), BOD (Biological Oxygen Demand), and COD (Chemical Oxygen Demand). Measurement of water quality parameters is carried out in the laboratory using the standard method of measuring instruments from the laboratory.

2.4. Data Analysis

Research data includes water quality parameter data observed during the blackwater treatment process. The data of all parameters are then processed by Factor analysis to formulate all parameters into one variable, to be further analyzed by the Multiple Regression analysis method. Multiple regression analysis was carried out to determine the effect of the treatment of sand thickness and length of stay in the wetland to reduce water quality parameters. The results of the analysis will show the significance of the treatment applied to the magnitude of the effect and the effect of reducing the parameters in each treatment unit applied. The data analysis process is carried out using the SPSS program.

3. RESULT AND DISCUSSION

3.1. Blackwater Parameters

The water quality reference basis used in this study is Government Regulation No. 82 of 2001, namely in class IV water or water for agricultural purposes. Processing results are declared feasible to be used again for irrigation activities if the final level of parameters does not exceed the specified threshold. In general, the results of the study are presented in table 1 below:

Table 1. Blackwater parameters during treatment

Parameter	Initial Level	Sand Thickness (cm)	After Filtration	Residence time in wetland			Standard
				2-Day	4-Day	6-Day	
pH	3.62	15	9.41	8.9	8.6	8.1	5-9
		20	8.36	8.9	8.8	8	
		25	11.31	8.7	8	8.71	
Temperature (°C)	27.5	15	24.97	25.92	25.87	25.1	21
		20	25.39	26.00	25.8	25	
		25	27.69	26.00	25	25.71	
TSS (mg/L)	877	15	110	60	58	50	400
		20	110	45	40	35	
		25	110	30	20	9	
TDS (mg/L)	766.67	15	3200	1238	1235	1210	2000
		20	5900	1300	1210	1000	
		25	6620	900	800	790	
BOD (mg/L)	375	15	166	142	140	130	12
		20	135	145	140	120	
		25	119	110	100	91	
COD (mg/L)	482	15	173	205	203	190	100
		20	195	210	200	150	
		25	175	140	125	105	

Wastewater is identical to high pollutant levels so it needs to be carried out in stages, namely by a stratified filtration method and then proceed with a wetland system. Table 1 above presents data on the characteristics of blackwater at the beginning (input) to the end (output) of a series of processing processes applied. Overall, the best treatment combination to get the best outcome is sand thickness of 25 cm and residence time in the wetland for 6 days. In the pH parameter, it can be seen that the condition has met the IV water standard. Similar with TSS and TDS. on the other hand, BOD and COD still do not meet class IV water standards. This condition indicates that decreasing levels of BOD and COD requires a longer process in the wetland tube because it involves a biochemical remediation process. Even so, the results obtained from this study are still better than the results of processing in WWTP or existing field conditions, so that the model can be applied by the community. Of course, the subsequent application requires additional residence time in order to obtain results that are in accordance with standards. Stratified filtration methods and wetlands with *Vetiveria zizanioides* show promising results. In addition, the material used in making filter models is also easy to obtain at low prices.

3.2. Regression Analysis

Multiple regression analysis is carried out to determine the contribution of sand thickness treatment and residence time in the wetland to improving the quality of wastewater. Improved water quality can be seen from how much the parameter levels are reduced through the treatment applied. The results of Multiple Regression analysis are as follows:

Table 2. Result summary of Regression analysis

Variable	Coef	Equation	Sig.	R Square
Sand thickness	-0.178	Water quality = 3.562 – 0.178 X1* + e_1	0.15	59.5%
Residence time	-0.292	Water quality = 1.169 – 0.292 X2* + e_2	0.164	25.6%
Sand thickness	-0.178	Water quality = 4.731 –0.178 X1* – 0.292 X2* + e_3	0.003	85.1%
Residence time	-0.292			

The results of the analysis between the influence of sand thickness and the residence time of wastewater in the wetland on water quality parameters showed a coefficient that was negative. Sand thickness has the potential to reduce blackwater wastewater parameters by 0.178 per unit, with an effect of 59.5%. The residence time in the wetland has the potential to reduce the level of wastewater parameters by 0.292 per unit, with an effect of 25.6%. In other words, the thicker layer of sand used in the filtration process, and the longer the residence time applied, the better in reducing pollutant content in blackwater wastewater. Furthermore, simultaneous testing showed a significance value of 0.003 with an influence of 85.1%. So it can be stated that the combination of sand thickness treatment and residence time in the wetland is able to give a significant influence on the decrease in water quality parameters. Both descriptively and inferential statistical analysis, the results show that the treatment applied shows promising outcomes and is even better than the methods applied in the field. With the addition of wetland time, the physical model of waste treatment will be able to produce better outcomes and can be used directly for irrigation purposes.

4. CONCLUSION

Based on the results of the study, the following conclusions were formulated:

- Processing of physical models of waste treatment with stratified filtration and wetlands using Vetiver plants can increase pH up to 8.1, the temperature is in the normal range (25-27 oC), TDS decreases to reach 9 mg / L, TDS levels actually rise to 790 mg / L, BOD dropped to 91 mg / L, and COD dropped to 105 mg / L.
- Regression Equations obtained from the analysis of processing data with Vetiver plants are Y = 4.731 -0.178 X1 * - 0.292 X2 * + e3 (X1 = thickness of sand, X2 = time of wetland).

SUGGESTION

Based on the results of the study, a number of suggestions were formulated for the next researcher as follows:

1. Change the thickness of the gravel filter and shell charcoal.
2. Combine Vetiver plants with other plants.
3. Extend residence time in both filters and wetlands.
4. Perform a backwash to rinse dirt if the filter will be reused.

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