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APPLICATION OF STRATIFIED FILTER AND WETLAND TO STABILIZE THE TEMPERATURE AND pH OF BLACKWATER

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ABSTRACT

A Constructed wetland is a suitable wastewater treatment method for developing countries since it is inexpensive and easy to implement. Blackwater treatment can be maximized with the combination of stratified filtration method and wetland system using Vetiver grass and Cattail plants. This research aimed to examine the effectivity of the combination method to improve the quality of wastewater based on the parameter of temperature and pH. Blackwater flows into the stratified filter consisting of gravel, charcoal, and sand material, then flows into wetland tube with the residence time of 2-day, 4-day, and 6-day. The result of water quality measurement will be compared with the quality standard based on the government regulation.

Key words: Blackwater, Wetland, Temperature, pH.

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1. INTRODUCTION

Water is a crucial natural resource for human life, thus it requires proper management in order to maintain the sustainability [1]. One type of waste that often contaminates the river is blackwater, which mostly comes from domestic activities. At least 50-70% of the pollution in river come from anthropogenic wastes [2]. Ongoing waste disposal regardless of environmental carrying capacity can lead to the contamination. This occurs when a load of waste received by the river exceeds the *self-purification* of natural ecosystem [3].

Blackwater is a type of wastewater derived from human feces, hence it has a high content of organic materials and pathogenic bacteria. When blackwater is discharged into the river directly without any treatment, it can cause the disruption to the river ecosystems and health problems for humans. The impact begins when blackwater waste contaminates raw water sources for daily needs [4].

Commonly, blackwater treatment is generally done by using septic tank as the container, or by channeling the black water into the sewage system and then processed in wastewater treatment plant (IPAL). This processing can be accomplished using efficient and easy-to-use methods, such as filtration methods and the use of constructed wetland. Both methods have been widely researched and developed to be applicable, especially in developing countries.

Gravel is one of the filter materials that can be easily obtained. Gravels with a diameter of 2-3 cm are known to be able to filter oil and decrease the level of organic matter contained in waste. The combination of gravel and sand can be used for water purification [5]. In addition, earlier research also explained that charcoal can be used to filter out pollutants which can result in clear and odorless output [6]. Carbon content in charcoal makes it a potential material for wastewater treatment. Both physical and chemical parameters of wastewater can be improved by the use of charcoal [7]. These three filter materials are inexpensive and easy to obtain.

In order to get better results, wastewater that has been through the filtration process can then be processed using wetland. Constructed wetland can be made by utilizing aquatic plants to reduce the pollutants. Based on the previous research, Vetiver grass (*Vetiveria zizanioides*) has been shown to improve the quality of wastewater by reducing the organic or inorganic materials, stabilizing pH, and reducing dissolved and suspended solids [8] [9]. Another plant that is also potential for wastewater treatment is Cattail (*Typha angustifolia*) [10] [11]. Constructed wetlands are made exactly like the natural wetland, which consists of soil and water [12]. This condition is aimed to support the survivability of the plants, hence it can contribute to decompose the pollutants optimally.

This research applies the combination method of stratified filter and constructed wetland using Vetiver grass and Cattail. The assessment of wastewater quality is focused on the parameters of temperature and pH. Data of the parameters will be compared with the quality standards for agricultural water (class IV) from the government.

2. METHOD

2.1. The Planning of Wastewater Plant and Stratified Filter

The model of wastewater treatment plant was planned with a scale of 1: 25, which is not the same as field condition. The preparation of the filter materials refers to the earlier study conducted by Adhibaswara *et al*. [5], started from coarse to the fine material (gravel, charcoal, and then sand). It is also based on the theoretical consideration that the crude material (gravel) is able to filter suspended solids, then continued with charcoal to filter out the dissolved solids and sand to maximize the process.

Figure 1 Filter materials (Gravel 12,5 mm, Charcoal 2 mm and Sand 2 mm)

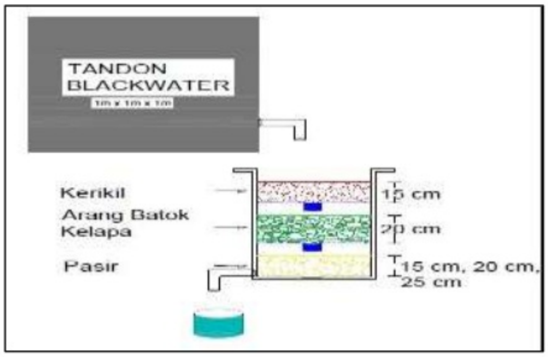

Figure 2 Stratified Filter

2.2. Wetland Construction

Two kinds of plantwere used as the remediation agent for blackwater treatment, namely Vetiver grass (*Vetiveria zizanioides*) and Cattail plant (*Typha angustifolia*). *Wetlands* were constructed by using boxes by the size of 90 x 60 x 30 cm, which then filled with 60% soil and 40% water to provide the media for the plants. Vetiver grass and Cattail plant were then planted on the wetland and left for one month until the condition is fully recovered before being used for blackwater treatment.

Figure 3 Constructed Wetland

2.3. Parameter Measurement

The measurement of temperature and pH was done three times at 2-day, 4-day and 6-day residence time. The blackwater material was obtained from a communal septic tank in Tlogomas, Malang City. The amount of blackwater required for this research was 1000 liters. The measurement of temperature and pH parameters was performed directly at the experimental station. The measurement tool for temperature was a thermometer, and for pH was using pH meter.

2.4. Data Analysis

The research data was analyzed descriptively to determine the improvement of wastewater quality based on the temperature and pH level. The data of both parameters will be compared with the quality standard of Grade IV water based on the Government Regulation number 82 year2001, namely the water for agricultural purposes. It is important to know whether the processing method applied is capable of producing a decent water output or not. In addition, the results of data processing will also show which treatment is more effective in improving the quality of wastewater.

3. RESULT AND DISCUSSION

Blackwater contains high level of organic material, hence the condition tends to acid. pH is a chemical parameter that reflects the organic matter contained in a waste. The combination method of stratified filter and wetland using Vetiver grass (*Vetiveria zizanioides*) and Cattail plant (*Typha angustifolia*) are expected to stabilize the temperature and pH of blackwater. Based on the standard for grade IV water, the required water temperature is 21°C, and for pH is 5-9 [13].

3.1. Veriver Grass

The presentation of the results begins with observation data of wastewater temperature on the Vetiver treatment system. The following table describes the data of blackwater temperature in each treatment stage, including the initial temperature, after the filter process, and in each residence time in wetland tube.

Table 1 Temperature of blackwater in each treatment stage (Vetiver grass)

Sand thickness (cm)	**Initial temperature (°C)**	**Temperature In filter (°C)**	**Temperature of *blackwater* in each residence time in wetland (°C)**			**Standard (°C)**
			2-day	**4-day**	**6-day**	
15	26.047	24.97	25.92	25.87	25.1	21
20	26.047	25.39	26.00	25.8	25	
25	26.047	27.69	26.00	25	25.71	

Temperature is a physical parameter that is influenced by many factors, including the external factors outside the treatment process itself. The initial temperature of blackwater before the treatment was 26.047°C, while the final temperature after the treatment (residence time 6-day) 6 days was 25 °C. In accordance with the standard, the temperature was not yet eligible to be discharged into the river or used for irrigation water. The temperature of wastewater can be influenced by external factors, such as the sunlight and air temperature. In this case, the measurement time also affects the level of temperature obtained. In the filtration process, the wastewater temperature decreased 1°C, especially on the treatment of sand thickness 15 and 20 cm. Meanwhile, on the sand thickness of 25 cm, the temperature of the wastewater rose 1°C. Temperature has a correlation with the metabolism of organisms in decomposing the organic matter [14]. a 1°C temperature increase (sand thickness 15 and 20 cm) at the residence time 2-day indicated the presence of symbiotic microbial activity to decompose organic matter contained in blackwater waste. As the theory says that the root area of Vetiver grass is a habitat for various decomposing organisms that will simultaneously help decomposition of organic pollutants. The data of temperature parameters are visually illustrated through the following graphs:

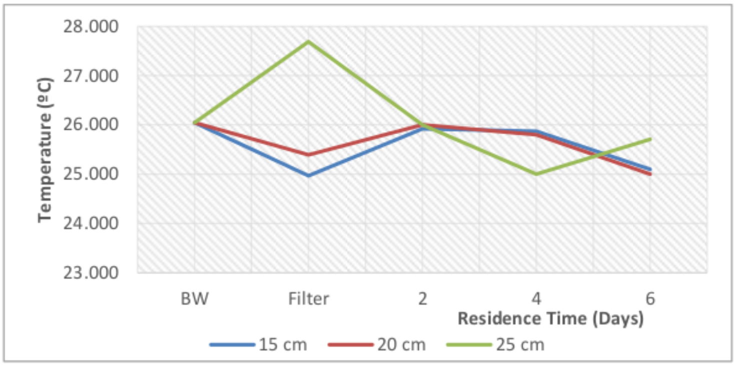

Figure 4 Dynamics of blackwater temperature in each treatment stage (Vetiver grass)

Furthermore, the result of pH measurements of blackwater during the treatment is displayed in the following table:

Table 2 pH of blackwater in each treatment stage (Vetiver grass)

Sand Thickness (cm)	Initial pH	pH in filter	pH level of blackwater in each residence time in the wetland			Standard
			2-day	4-day	6-day	
15 cm	6.28	9.41	8.9	8.6	8.1	5-9
20 cm	6.28	8.36	8.9	8.8	8	
25 cm	6.28	11.31	8.7	8	8.71	

It is generally observed that the pH of the treated blackwater waste, almost all of its processes have met the required quality standards for agricultural water. However, it is seen that the pH of wastewater has increased, from an average of 6.28 to 8.1, 8, and 8.71. In other words, the initial pH of the effluent before it is treated tends to be acidic and then rises in the normal range of pH to the prevailing water of 7 to 8.5 [14]. The treatment of stratified filter results in waste outcomes with varying pH levels. At 15 cm thickness, obtained pH value 9,41, sand thickness 20 cm with waste pH 8.36, and sand thickness 25 cm with pH 11,31. This condition describes the amount of filtered organic material in the filtration process, so the pH of the wastewater tends to rise up to the alkaline condition. For a clearer picture, blackwater pH during processing can be seen in the following graph:

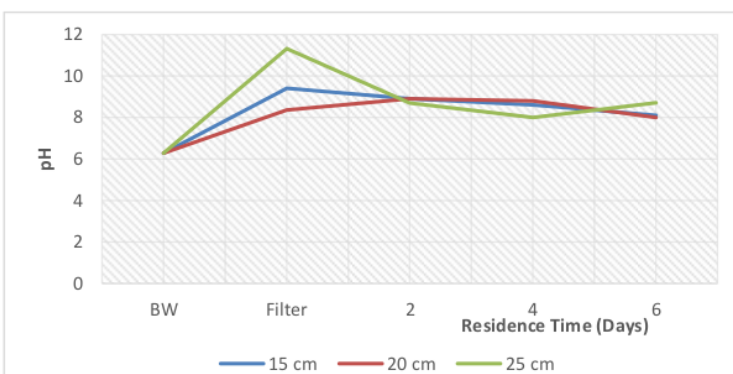

Figure 5 Dynamics of pH of blackwater during the treatment (Vetiver grass)

The characteristics of Vetiver root is wide and complex, with the length up to 3 - 4 meters and forms a large volume coverage. This condition is a good habitat for symbiotic bacteria and fungi, and simultaneously for man ecological system to process the pollutants. In addition, Vetiver plants have the ability to absorb large amounts of pollutants without affecting their growth rate [15]. Previous research conducted by Dyamanagowdru and Lokeshappa [16], showed the result that wastewater treatment with wetland system at residence time of 4 and 6-day showed a quality improvement in pH and electrical conductivity up to 96%. Initially, pH ranged from 6 - 7.2, then after treated with wetland system using vetiver plant rose to 7,1 - 8,5. Meanwhile, in study from Pongthornpruek [17], the final pH value obtained from Vetiver system treatment was 7.68 - 8.22, from previously 6.82 to 7.45.

3.2. Cattail Plant

The following table presents the data of black water temperature from the combination treatment of stratified filter and wetland system using Cattail plant (*Typha angustifolia*):

Table 3 Temperature of blackwater during the treatment (Cattail plant)

Sand Thickness (cm)	Initial Temperature (ºC)	Temperature in filter (ºC)	Temperature of *blackwater* in each residence time in the wetland			Standard (ºC)
			2-day	4-day	6-day	
15	26.047	24.97	26.80	26.04	25.2	21
20	26.047	25.39	26.00	26	26	
25	26.047	27.69	26.00	25	26.17	

Blackwater treatment with stratified filter and wetland using Cattail plant showed the same result as the previous treatment with Vetiver grass, where the final temperature range obtained does not meet the quality standard for agricultural water. On the treatment of sand thickness 15 and 20 cm, blackwater temperature decreased from the previous 26.047 ºC to 24.97 and 25.39 ºC. As in the stratified filter terraced with 25 cm sand thickness, wastewater temperature rose to 27.69 ºC. The final result with the lowest temperature was on the combination treatment of 15 cm sand thickness and residence time in wetland for 6 days (25.2ºC). Figure 5 below presents a visualization of the dynamics of blackwater temperatures during the treatment with stratified filter and wetland using Cattail plant.

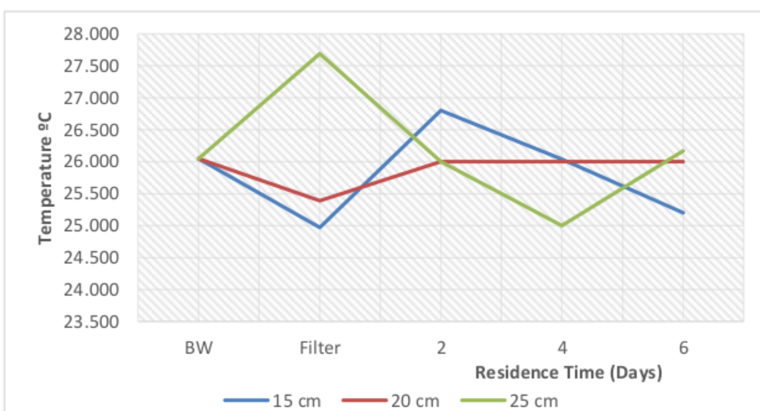

Figure 6 Dynamics of temperature of blackwater during processing (Cattail Plant)

The results of pH measurements on the wetland with Cattail plants also showed similar results with the previous result from Vetiver grass. Overall, the pH of black water was within the standard required for agricultural water, but there was an improvement in water quality based on the rise of pH level. The data of blackwater treatment on pH parameter is presented in the following table:

Table 4 pH level of blackwater in each treatment stage (Cattail plant)

Sand Thickness (cm)	Initial pH	pH in filter	pH level in each residence time			Standard
			2-day	4-day	6-day	
15	6.28	9.41	8.7	8.7	8	5-9
20	6.28	8.36	8.8	8.5	8	
25	6.28	11.31	8.0	8	9.02	

Table 4 shows that the average initial pH of the blackwater was 6.28 and risen to 8 after flowing through the entire treatment process. Thus, it can be stated that the raw blackwater was tended to be acid, but the condition has been processed to be a relatively neutral pH. In the stratified filter treatment with sand thickness of 25 cm and the residence time of 6 days, the final pH level was 9.02, which was the highest one. To provide a clearer picture of the process of pH change, the following graph is presented as a transformation from the table above:

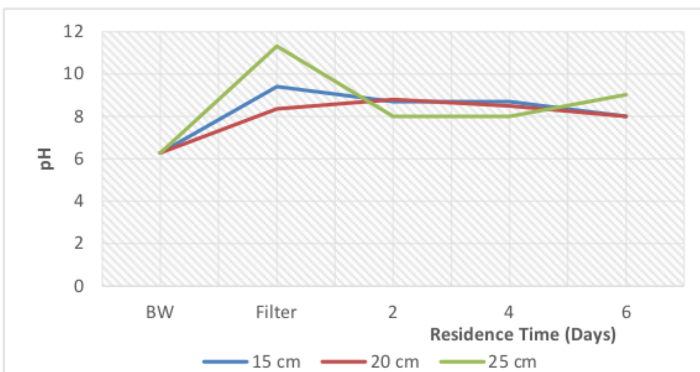

Figure 7 Dynamics of pH of blackwater during processing (Cattail Plant)

Cattail plants are known for their ability to tolerate the contaminated conditions. Based on their morphology, Cattails have a heavy fibrous root system that supports the absorption of large contaminants. In addition, one of the advantages of using Cattail plant for remediation is the ease of obtaining the plant, as it is commonly found in the natural wetlands in Indonesia [18]. Arivoli and Mohanraj [19] carried out the research about wastewater treatment using Cattail plant. The results showed that the pH of wastewater tended to be constant at HRT 12, 24 and 36 days, ranging from 7.5 to 7.8. Furthermore, the research from Pongthornpruek[17] also used wetland system with Cattail plant. The result demonstrated that the final pH level of wastewater ranged from 6.59 to 7.90, from previously 6.82 to 7.45.

4. CONCLUSIONS

It can be concluded that the temperature of wastewater treatment output was still not meet the standard for agricultural purposes (21 ºC). In this study, the temperature of the wastewater is more affected by the external factors, such as sunlight and air temperature. Regarding the parameters of pH, wastewater, both before and after processing, were already in the range of the standard (5-9). However, the results of this study indicate that water quality has increased, showed by the rise of pH level from 6 to 8-9. In other words, the pH of raw blackwater has turned into neutral or normal.

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