Quality Improvement Of Blackwater Using Filter Materials And Cattail

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Abstract: This study aimed to improve the quality of blackwater by using a physical model consisting of 2 processes; stratified filters and wetland. The stratified filtration method utilized gravel, charcoal, and sand as the filter materials, meanwhile, the wetland system utilized the Cattail plant (Typha Angustifolia). Blackwater quality improvement was observed at the intervals of 2 days, 4 days and 6 days, and included parameters of pH, temperature, TSS, TDS, BOD and COD. The method of data analysis was Multiple Linear Regression. Generally, the final result showed that the blackwater quality was improved and met the standard of grade IV water quality (water for agricultural purposes). Furthermore, the equation of Regression analysis obtained was, Water Quality (Y) = 4.693 - 0.176 X1 * - 0.294 X2 * + e6 (X1 = sand thickness, X2 = residence time). This means that every 1 cm thickness of the sand layer contributes to the improvement of water quality by 0.176. In addition, each application of 1 day residence time in the wetland tube has the potential to increase the water quality by 0.294 units. Therefore, the use of filter materials and Cattail plants has been proven to be effective for pollutant removal in blackwater.

Keywords: Blackwater, Stratified filter, Constructed Wetland, Cattail.

1. Introduction

Increasing volume of wastewater is not always supported by the availability of proper environmental sanitation infrastructure. Wastewater requires adequate treatment as it can cause serious impacts on the environment and humans. These impacts include polluting the sources of raw water used to meet the needs of clean water [1] and can cause various health problems for humans. Water management is crucial to be done so the wastewater can be reused for another purpose and support the sustainability of the environment [2]. Blackwater is a type of wastewater that must be well processed before being disposed to any environment due to its high content of pathogenic bacteria and other pollutants. Blackwater waste treatment is generally carried out in a septic tank or directly distributed to sewage systems to be processed in a domestic wastewater treatment plant (WWTP). Several solutions have been developed to improve the quality of the output of blackwater treatment, such as by using the filtration method, or using wetland system, separately. Prior studies have shown that the use of filter materials such as gravel and sand can be used for water purification [3]. In addition, charcoal can also be used as a color cleaner and odor removal as it contains active carbon [4]. Charcoal is a filter material that is very suitable for water treatment because it can reduce various physical and chemical pollutants and is cheap and easy to obtain [5]. Constructed wetland can be applied to complement the filtration process. Wetland can be made by utilizing potential plants for wastewater remediation, such as Cattail (Typha angustifolia) [6][7]. Cattail is known for its high tolerance to pollutants and is able to reduce organic and inorganic pollutants. Constructed wetland consist of two main characteristics; requires water to support the life of aquatic plants and requires soil for the growing medium of the plants [8]. This research aimed to improve the quality of blackwater by implementing the combination methods of stratified filtration and constructed wetland system. This study focused 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 treatment process. The measurement data will be analyzed statistically to find out the potential combination method that can be suggested for blackwater treatment. The processing result is expected to meet the standard of grade IV water quality, namely water for irrigation in agricultural activities.

2. Methods

2.1 Constructing the Model of Stratified Filter

The first stage of blackwater treatment process is by filtering the suspended solids. This study applied the stratified filtration method using three filter materials. Filter materials were arranged from coarse to fine (the opposite of clean water filtration), started from gravel on the top layer, charcoal on the middle, and concrete sand on the bottom. This is based on the consideration that coarse material (gravel) is capable of filtering suspended solids, then continued with charcoal to filter dissolved solids and sand to filter out dirty water that flows slowly.

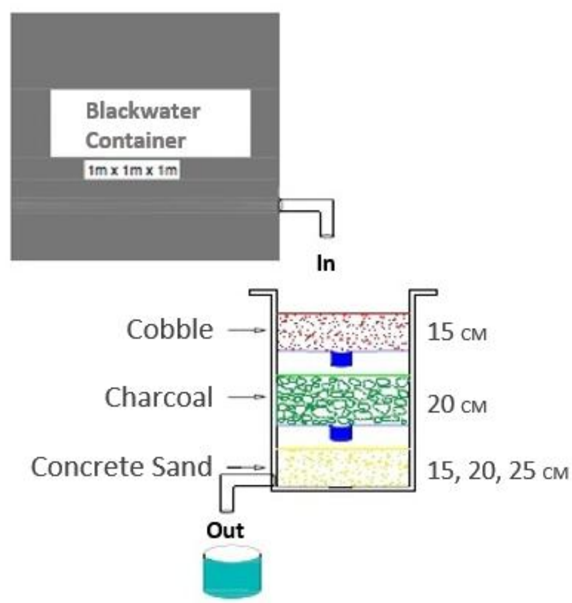

Fig. 1. *The model of stratified filter*

2.2 Constructing the Wetland System

In this study, the researcher applied the constructed wetland systems planted with Cattail (Typha angustifolia) as the remediation agent. This method is expected to reduce the pollutants so that the water quality can be improved. The principle of waste water treatment mechanism was by flowing the blackwater that has been previously processed with the filter into the wetland and then settled for 2 days, 4 days and 6 days. Specifically, the concept of the constructed wetland is displayed by figure 2.

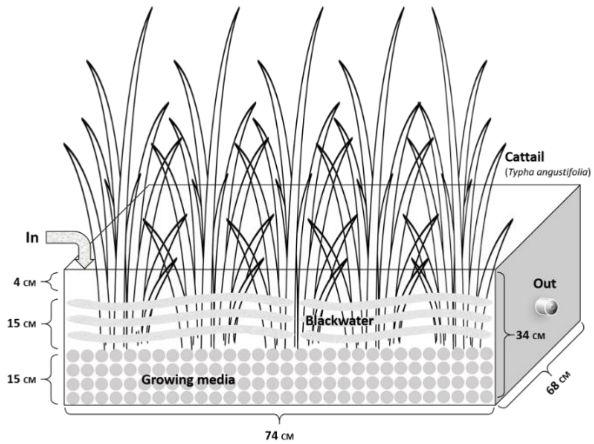

Fig. 2. *The concept of constructed wetland*

Fig. 3. *Wetland system using Cattail (Typha angustifolia)*

2.3 Measuring the Parameters of Water Quality

Blackwater samples were observed 3 times at the observation time of 2-day, 4-day, and 6-day. Wastewater samples were obtained from the communal septic tank in Tlogomas Village, Malang City. The amount of blackwater taken for the experiment was 120 liters. Measurement of water quality parameters was carried out in the laboratory using the standard method from the laboratory.

TABEL 1

THE MEASUREMENT OF WATER QUALITY PARAMETERS

Parameters	Tools / Method
pH	pH Meter
Temperature	Thermometer
TSS (Total Suspended Solids)	TSS Meter (Horiba)
TDS (Total Dissolved Solids)	TDS Meter (Horiba)
BOD (Biological Oxygen Demand)	Titration (Sodium thiosulfate)
COD (Chemical Oxygen Demand)	Titration (Ferrous ammonium sulfate)

2.4 Data Analysis

The research data were analyzed using Multiple regression analysis to determine the effect of the stratified filter with the variation of sand layer thickness, as well as the application of wetland system with varying the residence time on the decrease of water parameters. Before testing with multiple regression analysis, Factor analysis was obtained for combining all the water parameters into one variable. Data were processed by using SPSS program.

3. Results and Discussion

3.1 Characteristic of Processed Blackwater

Wastewater is known with its high content of various pollutants. Thus, the treatment process using stratified filter and wetland system is expected to improve the water quality so the wastewater can be reused for agricultural watering needs. The standard of water for irrigation is based on the Government Regulation No. 82 Year 2001 [9]. The results (Table 2) obtained will reflect the ability of each treatment combination, thus the conclusion on the best treatment can be formulated.

TABLE 2

CHARACTERISTICS OF BLACKWATER DURING THE FILTRATION AND REMEDIATION PROCESS

Parameters	Initial Level	Sand Thickness (cm)	After Filtration	Parameter levels during the residence time in wetland tube			Standard
				2-day	4-day	6-day	
pH	3.62	15	9.41	8.7±0.1	8.7±0.05	8±0.11	5-9
		20	8.36	8.8±0.0	8.5±0.05	8±0	
		25	11.31	8.0±0.1	8±0.05	9.02±0	
Temperature (°C)	27.5	15	24.97	26.80±0.28	26.04±0.36	25.2±0.11	21
		20	25.39	26.00±0.39	26±0.39	26±0.40	
		25	27.69	26.00±0.48	25±0.41	26.17±0.33	
TSS (mg/L)	877	15	110	56±3.46	55±2.51	50±2.30	400
		20	110	40±3.51	35±2.64	30±5.03	
		25	110	25±2.08	20±3.05	0±3.05	
TDS (mg/L)	766.67	15	3200	1120±25.50	1110±27.22	1100±41.06	2000
		20	5900	1100±37.51	825±13.05	800±50.36	
		25	6620	800±19.67	750±23.79	700±49.16	
BOD (mg/L)	375	15	166	140±0.57	135±0.57	130±3.78	12
		20	135	180±4.58	175±2.51	160±1	
		25	119	150±0.57	100±1.52	57±3.46	
COD (mg/L)	482	15	173	210±3.60	200±4.50	160±4.50	100
		20	195	240±2.51	231±5.19	200±1.73	
		25	175	180±5.77	120±5.03	96±7.02	

Table 1 presents data on the characteristics of blackwater from the initial level of water parameters (input) until the end of the process (output). Generally, the best final result is obtained from the combination of 25 cm sand thickness and 6 days of residence time in the wetland tube. The lowest level of water parameters obtained from each treatment was below the standard of grade IV water, although this does not apply to the BOD parameters. This shows that the treatment to reduce BOD levels requires a longer process, especially on the residence time in the wetland tube. Nevertheless, the results obtained from this study are still better compared to the current WWTP at IPAL Komunal Tlogomas, Malang City, hence the treatment model can be applied by the community. Besides being able to produce promising outcomes, the materials used in the preparation of physical models of waste treatment are also easy to obtain.

3.2 Regression Analysis

Table 3 displays the summary of the result of Regression analysis.

TABLE 3

RESULT SUMMARY OF REGRESSION ANALYSIS

Variable	Coef.	Equation	Sig.	R Square
Sand Thickness	-0.176	Water quality = 3.516 – 0.176 X1* + e_4	0.017	57.9%
Residence Time	-0.294	Water quality = 0.732 – 0.294 X2* + e_5	0.161	26.0%
Sand Thickness and Residence Time	-0.176 -0.296	Water quality = 4.693 – 0.176 X1* – 0.294 X2* + e_6	0.004	83.9%

The result of regression analysis demonstrated the negative coefficient. This shows that the treatment of sand thickness and residence time in wetland tube can reduce the water quality parameters. The simultaneous test showed the significance value of 0.004, with R Square of 83.9%. Hence, the applied treatment has a significant effect on the improvement of water quality, with 83.9% influence. This finding is explained in more detail from the regression equation, Y = 4.693 - 0.176 X1 * - 0.294 X2 * + e6 (X1 = sand thickness, X2 = residence time). This reveals that every 1 cm of sand thickness layer contributes the decrease of water parameter by 0.176. In addition, each application of 1 day residence time in the wetland tube contributes the decrease of water parameters by 0.294. Thus, the use of filter materials for filtration process and Cattail plant for wetland system has been proven to improve the quality of blackwater.

4. Conclusions

Based on the results, the conclusions of this study are:

1. The application of combination method using stratified filter and wetland system can improve the quality of blackwater. In fact, it is better than the current method used at IPAL Komunal Tlogomas, Malang. The final pH level was 8, the temperature was in the normal range (25-27ºC), TSS was completely removed (0 mg/L), TDS was 700 mg/L, BOD 57mg/L, and the final COD level was 96 mg/L.
2. Regression equation obtained was Y = 4.693 - 0.176 X1 * - 0.294 X2 * + e6 (X1 = sand thickness, X2 = Residence time).

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