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Determining the Maximum Discharge of Blackwater in the Treatment Using Wetland System

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Abstract- *This study aimed to determine the maximum discharge in the application of wastewater treatment design for blackwater. The design adopted the wetland system to reduce the level of suspended solids (TSS) and dissolved solids (TDS). Wetlands were made on a lab scale and planted with Vetiver grass (Vetiveria zizanioides) and Cattail (Typha angustifolia) as remediation agents. 120 liters of Blackwater were obtained from the Communal WWTP Tlogomas, Malang City. Data were obtained from selected parameter observations during the residence time in wetland bath for 2 days, 4 days and 6 days. The method of data analysis was using Regression analysis for determining the maximum discharge of blackwater that can be maximally processed with the treatment plant. The results showed that the levels of TSS and TDS decreased along with the increase in residence time of blackwater in the wetland. The lowest TSS and TDS levels were 0 mg/L and 700 mg/L, respectively. Both levels were obtained from the data of 6 days of residence time in wetland using Cattail. Furthermore, the results of the regression analysis with quadratic graphs suggested that the maximum discharge for TSS and TDS removal with Vetiver grass were 204.22 liters/day and 208.08 liters/day, respectively. In addition, in the wetland system using Cattail, the maximum discharge for TSS and TDS removal were 199.19 liters/day and 208.01 liters/day, respectively.*

Keywords- *Blackwater, Cattail, Maximum discharge, Wetland.*

I. INTRODUCTION

Nowadays, the global demand for water is increasing for various purposes, meanwhile, the quality of existing water does not always comply with its designation standards. Humans need water for various activities, such as drinking, bathing, washing, farming, and industrial activities. According to Hawkins et al. [1], the availability of clean water requires consistent fresh water sources and the carrying capacity of effective and sustainable wastewater treatment technologies. This processing technology is not always in accordance with the capabilities of developing countries, thus it becomes a challenge to be solved by utilizing technology that is cost-efficient but still effective in improving water quality.

Wastewater from anthropogenic activities, especially blackwater, requires proper processing before being discharged or reused. Blackwater is wastewater originated from human waste (feces) which contain various pollutants that can be harmful to the environment. In the worst case, blackwater can contaminate the sources of clean water and cause health issues in human and disrupt the ecosystem [2][3]. Commonly, blackwater is accommodated in septic tanks or directly channeled into sewage systems for further treatment. If the processing effort is not carried out.

Prior studies have presented various interesting findings regarding the wastewater treatment system. One of the most common methods that have been widely studied is the wetland system. Naturally, wetlands have an important role in maintaining environmental quality and supporting biodiversity [4][5]. In wastewater management practices, wetlands are artificially constructed in various scales to serve as the media of wastewater remediation. A constructed wetland can be planted with various types of aquatic plants, such as Vetiver grass (*Vetiveria zizanioides*) and Cattail (*Typha angustifolia*). The potential of Vetiver grass for remediation agent in wetland system had previously been studied by Dyamanagowdru and Lokeshappa [6] and Yeboah et al. [7]. Meanwhile, the wetland system using Cattail had been investigated by Rani et al. [8] and Weragoda et al. [9].

This study applied a constructed wetland system to improve the quality of backwater that has been initially treated with a filtration system. The result was expected to meet the standards of water for agricultural needs. However, the presentation in this paper focuses on the maximum discharge of blackwater that can be processed with the treatment plant, optimally. The maximum discharge is crucial information so that the blackwater treatment plant can be applied widely by the community. The main consideration in preparing the blackwater treatment plant was the ease of its application in Indonesia which is a developing country, especially in Malang City. Therefore, the design was made as simple as possible and utilized the materials that are easily obtained with relatively cheap prizes. The community can re-apply the method by reconstructing the design and considering the maximum discharge of blackwater.

II. METHOD

A. Constructing the Wetland System

In this study, we applied an artificial wetland system as described in Figure 1. Wetlands were constructed by utilizing aquatic plants as blackwater remediation agents; Vetiver grass (*Vetiveria zizanioides*) and Cattail (*Typha angustifolia*). Those plants were chosen since they are relatively easy to obtain in Indonesia, especially in Malang city in which the research was conducted. It is also to make it more possible to be re-applied by the community. This method was expected to remove the level of suspended and dissolved solids in blackwater. The principle of blackwater treatment was by flowing blackwater into the wetland bath for the residence time of 2 days, 4 days and 6 days. 120 liters of Blackwater were obtained from the Communal WWTP Tlogomas, Malang City.

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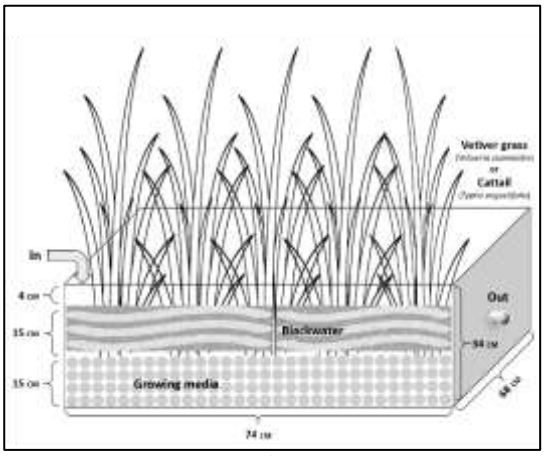

Fig. 1. The design of constructed wetland


Fig. 2. Wetland system using Cattail plants

B. Measuring the Parameters

The parameters of water quality were including Total Suspended Solid (TSS) and Total Dissolved Solids (TDS). The measurements of the parameters were obtained 3 times regarding the blackwater residence time; 2 days, 4 days and 6 days. The method of TSS and TDS measurement was using Horiba water quality meter and using the unit of mg/L. The measurement was conducted in the Laboratory of Water Engineering, Brawijaya University.

C. Data Analysis and Determination of the Maximum Discharge

Research data were analyzed and presented descriptively by finding the average level of each parameter after the residence time of 2 days, 4 days and 6 days. Furthermore, the determination of the maximum discharge of blackwater that can be processed by the treatment plant was by using Regression analysis, which was by looking at the result of the quadratic curve from the regression analysis between the data of blackwater discharge and the water quality parameters. Data analysis was processed in Microsoft Excel.

III. Result and Discussion

A. Results of Blackwater Processing

The results of blackwater processing on TSS parameter are displayed in the following table:

TABLE 1. The average of TSS level of blackwater from each residence time

Initial Level (mg/L)	Blackwater Discharge (L)	The Average of TSS Level (mg/L)					
		Vetiver grass			Cattail		
		2-day	4-day	6-day	2-day	4-day	6-day
877	200	70.0	58.0	50.0	50.0	55.0	50.0
	220	65.0	56.0	48.0	50.0	57.0	46.0
	240	60.0	52.0	46.0	56.0	60.0	50.0
	180	45.0	40.0	35.0	40.0	35.0	30.0
	210	43.0	38.0	34.0	43.0	39.0	20.0
	230	42.0	36.0	32.0	47.0	34.0	24.0
	240	30.0	20.0	11.0	25.0	20.0	6.0
	250	25.0	15.0	10.0	26.0	14.0	2.0
	260	23.0	12.0	9.0	22.0	16.0	0.0

Based on the results of measurements, it can be seen that the TSS levels of blackwater have decreased with the addition of the residence time in the wetland bath. The lowest TSS level obtained from the wetland system with Vetiver grass (*Vetiveria zizanioides*) in the 6-day residence time with 260 L, which was 9.0 mg/L. In addition, in the wetland system using Cattail plants, the lowest TSS level was 0 mg/L, or in other words, the suspended solids are completely removed. These levels were obtained at a residence time of 6 days with an initial discharge of 260 L. Overall, it can be seen that the longer the residence time applied, the lower the TSS level. Compared to the standard based on the Regulation of Indonesian Government No. 82 [10], the lowest TSS levels obtained in this study have met the standards (< 400 mg/L) for agricultural water. Furthermore, the average of TDS levels of processed blackwater is displayed in Table 2.

TABLE 2. The average of TDS level of blackwater from each residence time

Initial Level (mg/L)	Blackwater Discharge (L)	The Average of TDS Level (mg/L)					
		Vetiver grass			Vetiver grass		
		2-day	2-day	2-day	2-day	2-day	2-day
766.67	200	1255.0	1235.0	1210.0	1146.0	1110.0	1100.0
	220	1245.0	1201.0	1206.0	1171.0	1162.0	1055.0
	240	1238.0	1213.0	1207.0	1120.0	1122.0	1018.0
	180	1300.0	1210.0	1000.0	1100.0	825.0	800.0
	210	1234.0	1229.0	969.0	1025.0	844.0	775.0
	230	1238.0	1243.0	923.0	1061.0	850.0	703.0
	240	900.0	800.0	734.0	800.0	750.0	798.0
	250	814.0	722.0	766.0	785.0	703.0	756.0
	260	898.0	749.0	790.0	761.0	720.0	700.0

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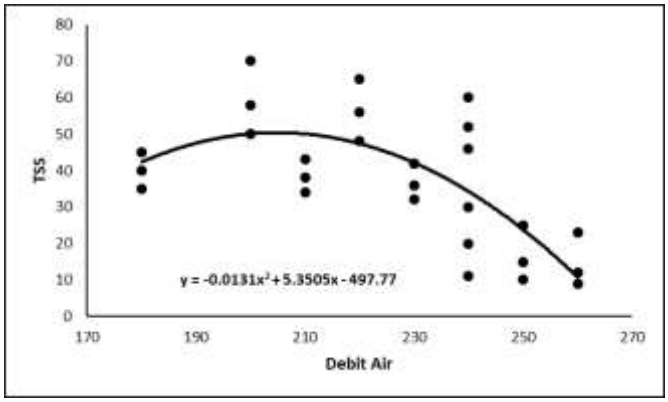
The observation result of the TDS parameter illustrates the same findings as the TSS data, where the lowest levels obtained at the longest residence time. Based on Table 2, it can be seen that the lowest TDS level from the wetland system using Vetiver grass was at the 6-day residence time with 240 L discharge, which was 734 mg/L. On the other hand, in the wetland system using Cattail plant, the lowest TDS level was obtained at the 6-day residence time with 230 L discharge, which was 703 mg/L. In accordance with the standard regulated by the Indonesian Government No.82 year 2001, the lowest levels of TDS obtained from this wetland system have met the standard (< 2000 mg/L) for agricultural purposes.

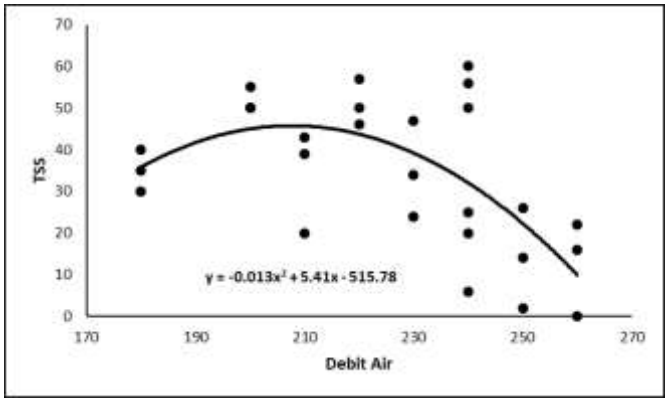
B. Determination of Maximum Discharge

The results of the Regression analysis to determine the maximum discharge of blackwater are described as follows:

1. TSS (Total Suspended Solids)



a. Vetiver grass

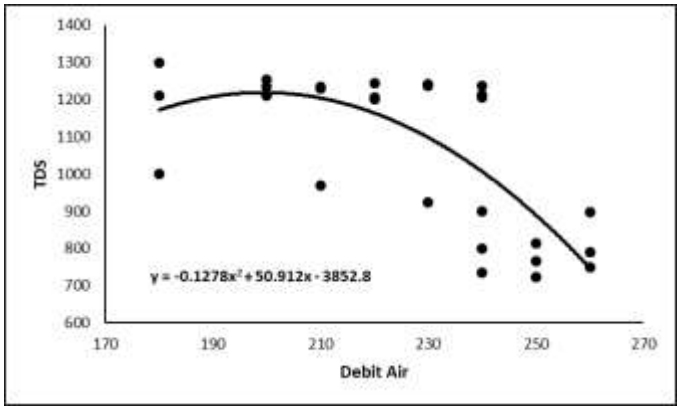


b. Cattail

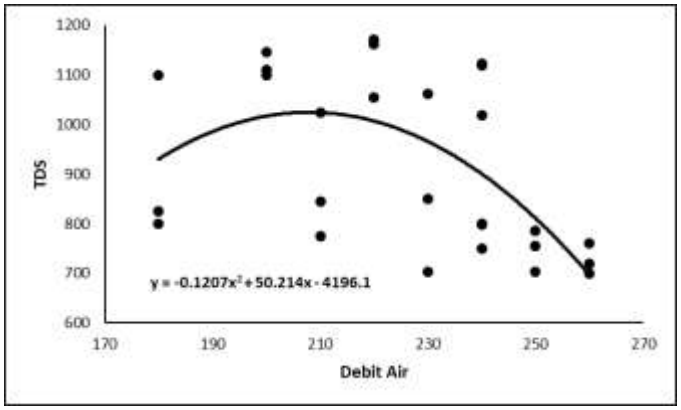
Fig. 3. The quadratic curve of blackwater discharge and TSS data

The results demonstrated that the wetland system using Vetiver grass (*Vetiveria zizanioides*) had the maximum blackwater discharge of 204.22 liters/day with a maximum TSS level of 48.563 mg/L. If the amount of blackwater processed exceeds the maximum discharge, there will be a decrease in TSS level. In addition, the treatment using Cattail plant (*Typha angustifolia*) obtained the maximum discharge of blackwater was 208.08 liters/day with maximum TSS level of 47.068 mg/L. Therefore, If the amount of blackwater processed exceeds the maximum discharge, the blackwater processing might no longer optimal in removing the TSS level.

2. TDS (Total Dissolved Solids)



a. Vetiver grass



b. Cattail

Fig. 4. The quadratic curve of blackwater discharge and TDS data

In the wetland system using Vetiver grass (*Vetiveria zizanioides*), the results of the analysis on the effect of blackwater discharge on TDS level showed a maximum discharge of 199.19 liters/day with a maximum TDS level of 1217.668 mg/L. In other words, if the amount of blackwater processed exceeds the maximum discharge, there will be a decrease in the value of the TDS parameter. Furthermore, in the Wetland system using Cattail plants (*Typha angustifolia*), the maximum discharge of blackwater was 208.01 liters/day with a maximum TDS level of 1026.444 mg/L. If the amount of blackwater processed exceeds the maximum discharge, the blackwater processing might not be optimal.

IV. CONCLUSION

It can be concluded that the maximum discharge for blackwater treatment using wetland system with Vetiver grass (*Vetiveria zizanioides*) was 204.22 liters/day for TSS parameter and 208.08 liters/day for TDS parameter. In addition, the wetland system using Cattail plants (*Typha angustifolia*) obtained a maximum discharge of 199.19 liters/day for TSS and 208.01 liters/day for TDS parameter. Future studies are suggested to implement longer residence time in wetland bath and investigate other parameters besides

TSS and TDS. Researchers can also use other types of plants that are potential to be used as blackwater remediation agents.

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