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Batik Industry Wastewater Treatment using Constructed Wetland in Sidoarjo Regency

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Abstract

Batik is one of the industrial potentials of Indonesia, which is experiencing rapid growth in various regions. Besides providing economic benefits, the batik industry also harms the environment. One of the processing methods that can be used as a solution is the Constructed Wetland (CW) method. This method is appropriate because it doesn't require high processing and maintenance costs and the process is simple and uses local resources. The purpose of this study was to measure the efficiency of batik industry wastewater treatment in reducing the pollutant load with the CW system so that the waste discharged into the environment can be declared safe. The parameters studied were COD, and TSS with the Hydraulic Retention Time for 10, 20, and 30 days. The results of the analysis of the initial content obtained a COD value of 1832,02 mg/L and a TSS value of 300 mg/L. Based on the results of the research that has been done, the results obtained for the removal of COD and TSS at 10 days HRT were 92.698% and 83.33%, then HRT 20 days of 94.603% and 86.67%. and then HRT 30 days of 96.138 % and 93.33%.

Keywords: *Batik Liquid Waste; Constructed Wetlands; COD; Hydraulic Retention Time; TSS.*

Introduction

Sidoarjo is one of several regencies that are considered to have quite rapid industrial development. Sidoarjo has experienced a significant industrial development rate, besides that labor is easy to obtain, Sidoarjo district has experienced a strategic industrial area (Maryantika & Lin, 2017). One of the industries that are often encountered in the Sidoarjo district is the textile industry in the form of batik, which can be found in Jetis Batik Village. The village is known for producing written batik with motifs typical of Sidoarjo, which has long been known as a producing area for written batik cloth, and Jetis written batik has been around since 1675. This written batik was brought by Mbah Mulyadi, a descendant of the King of Kediri (Rizky Satrya W & Trilaksana, 2015).

Batik is a craft that has high artistic value and has been part of Indonesian (especially Javanese) culture for a long time (Kusumaningtyas, 2011). Batik is also a wealth of Indonesian cultural heritage that has been recognized by the world. In 2009, The *United Nations Educational, Scientific, and Cultural Organization* (UNESCO) give International recognition of Indonesian batik as a humanitarian heritage for oral and intangible culture/ *Masterpieces of the Oral and Intangible Heritage of Humanity*. But in its manufacture, batik produces a negative impact that is not small. Industry batik including industry textiles Which most Lots uses water in the production process, as a result, the resulting liquid waste reaches 80% of the whole amount of water used in batik (Bambang Suharto et *al* ., 2013). In the process of making batik, dyeing waste is produced which consists of dyes and other chemicals including heavy metals (Rizky Satrya W & Trilaksana, 2015).

In more detail, the content of dyes in liquid waste usually has a high concentration and also contains synthetic materials that are difficult to dissolve or are difficult to degrade. The waste generated from the batik industry is liquid waste containing levels of BOD, COD, TSS, dyes, fats, and oils. Because the pollutants contained in the batik industrial wastewater generally contain suspended solids, organic matter, and heavy metals, if discharged directly into the environment without prior treatment it will potentially cause pollution to rivers, reduce water quality and affect the local ecosystem (Ernastin Maria, 2018). However, under these conditions, some MSMEs in Kampung Batik Jetis Sidoarjo do not have a wastewater treatment plant (IPAL). Disposal of batik waste that has not been properly managed has resulted in pollution of the Sidokare River (the river around Kampung Batik Jetis Sidoarjo) which harms public health. Therefore, effective waste treatment is needed.

One of the cheap, easy, and applicable waste treatment methods is the Constructed Wetland system. *Constructed Wetland* (CW) is a natural wastewater treatment system that utilizes microbes and plants which are supported by mechanisms of sedimentation, filtration, gas transfer, adsorption, chemical reactions, and biological activity (Cahyana, 2020). *The Constructed Wetland* (CW) used in this study consists of *Subsurface Flow* (SSF) *and Free Water Surface*

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(FWS). Meanwhile, the types of vegetation used are water hyacinth (*Eichornia crassipes*) and reeds (*Imperata cylindrica*l). Water hyacinth also shows great potential for pollutant processing, especially due to its high capacity to absorb nutrients and heavy metals arising from waste (Sabioni et al., 2019). This was proven in a study conducted by Rukmi *et al.* (2013) where using *laundry waste* can reduce detergent levels by 19.63%, BOD levels by 37.24%, and COD levels by 20.39%. Whereas in research conducted by Ernastin Maria (2018) using batik industrial waste but using *Typha latifolia* and *Canna Indica L plants* can reduce the pollutant load of each parameter, respectively BOD 92.5% and 93%, then chromium 21, 6% and 22.4%.

Based on the explanation above, we took the initiative to carry out developments from previous research, namely to find out the effectiveness *of constructed wetlands* in reducing COD and TSS content with variations in HRT for 10, 20, and 30 days.

Research methods

This research is experimental and was carried out offline for 4 months in the biotechnology laboratory of the ITS Industrial Chemical Engineering department. The experimental approach was carried out using research/experiments on a laboratory scale to design and study "Batik Industrial Wastewater Treatment using *Constructed Wetland* in Kampung Batik Jetis, Sidoarjo Regency". The implementation method used there are 5 stages, namely:

1. *Pretreatment* Stage
   In this research, the first thing that was done was the *pretreatment stage*. At that stage, start preparing the batik industrial wastewater, water hyacinth vegetation, and substrate in the form of gravel, soil, and sand. After that, acclimatization to the water hyacinth vegetation so that it can adapt well before the plants enter the reactor.
2. *The Constructed Wetland* Design Stage
   In this process, designing the reactor to be used, namely *the Constructed Wetland* with two types, namely *Horizontal Flow Sub-Surface Flow* (HSSF) and *Free Water Surface* (FWS). By preparing 2 reactors in the form of a beam, then filling the substrate in the reactor, then removing the acclimatized vegetation, and preparing the *inlet* and *outlet reservoirs* with the pipe hoses.
3. Batik Industry Waste Processing Stage with *Constructed Wetland*
   Experiments were carried out by entering batik industrial wastewater into the *constructed wetland reactor* in series, namely entering reactor 1 (HSSF) and then entering reactor 2 (FWS) with variations in Hydraulic Residence Time (HRT) for 10, 20, and 30 days. After that, take the water in the *outlet* reservoir for analysis with predetermined parameters, namely COD and TSS.
4. Results Analysis Stage
   After experimenting, an analysis was carried out in the form of predetermined parameters, namely the COD and TSS tests based on PERMENLHK No. 16 of 2019 concerning Quality Standards for Textile Industry Wastewater.
5. Stage of Reporting and Drawing Conclusions
   After analyzing the research, conclusions can be drawn from the research that has been done, and then making a report. The conclusion drawn is the effectiveness *of the constructed wetland* in reducing COD and TSS levels in the wastewater of the batik industry in Kampung Batik Jetis, Sidoarjo.

Results and Discussion

1. Waste Characteristics

The Waste Characteristics Test aims to determine the amount of pollutant contained by the parameters of the textile industry wastewater quality standards in PERMENLHK No. 16 of 2019.

Table 1. Characteristics of Batik Industry Liquid Waste

No.	Parameter	Unit	Analysis results	Quality standards
1	COD	mg/L	1832,025	150
2	TSS	mg/L	300	50

Source: Analysis Results, 2023

results for the characteristics of the batik industrial wastewater can be seen in **Table 1**. The COD and TSS values of batik industrial wastewater were 1832.025 mg/L and 300 mg/L. This value far exceeds the textile industry wastewater quality standards in PERMENLHK No. 16 of 2019. Therefore, it is necessary to treat waste that can reduce the pollutant load and not endanger the surrounding environment.

2. Variation of Hydraulic Residence Time (HRT) 10 Days

Because there were 2 reactors in this study, a 10-day hydraulic residence time (HRT) variation was carried out for each reactor. In more detail, the HRT variable was carried out for 10 days in reactor 1, followed by 10 days in reactor 2. The results showed that in the variation of hydraulic residence time (HRT) 10 days the removal of COD and TSS content can be seen in Figure **1**.

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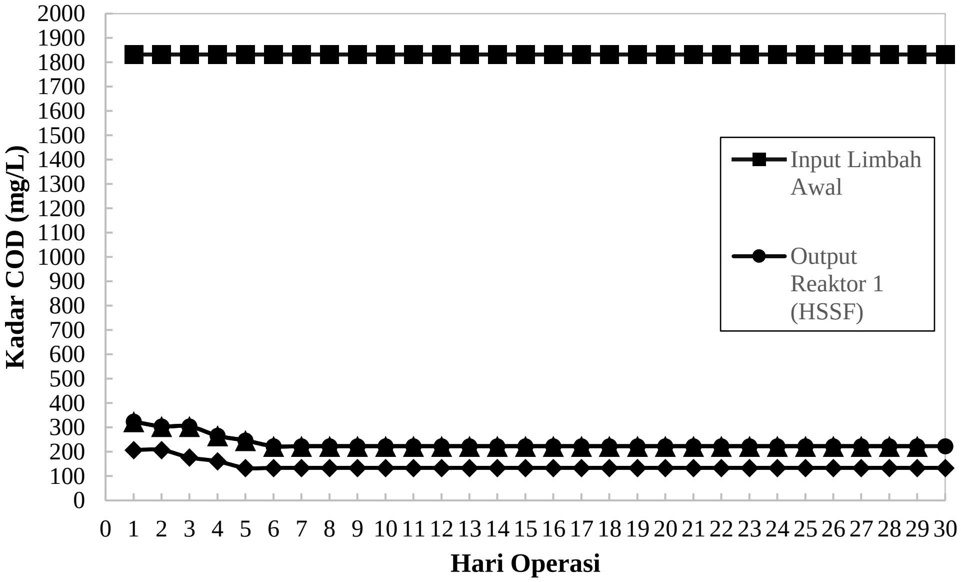
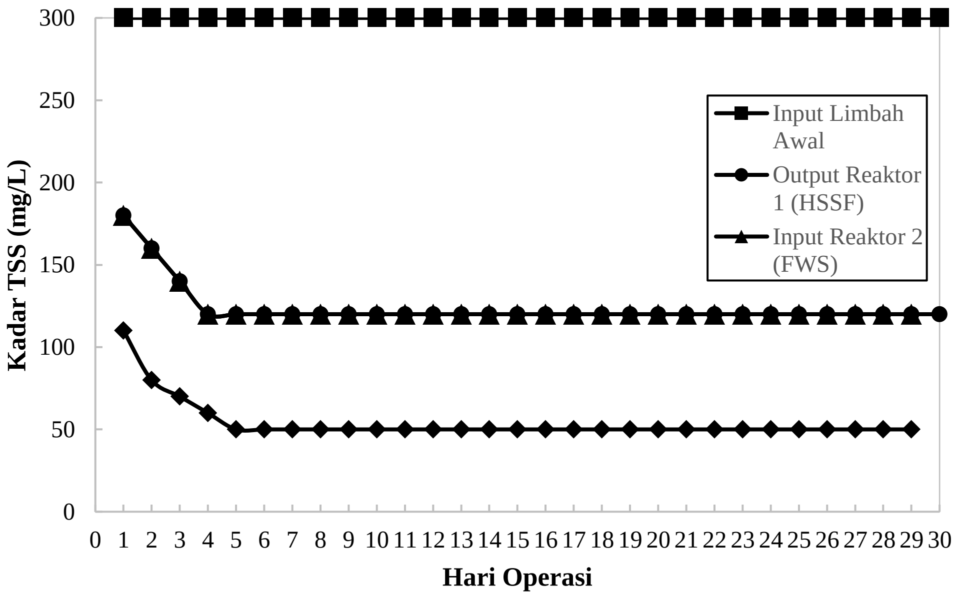


(a)



(b)

Figure 1. Effect of 10-Day HRT Variation on COD and TSS (a) COD (b) TSS reduction. *Note:* ■ = Initial Waste *Input* , ● = Reactor 1 *Output* (HSSF), ▲ = Reactor 2 *Input (FWS)* , ◆ = *Output* Reactor 2 (FWS)

COD and TSS tests are carried out every day, to find out in detail the reduction in pollutant content. From **Figure 1** (a), it can be seen that the initial waste COD content (before entering the reactor) was 1832.025 mg/L, and after exiting reactor 1 (HSSF) was 222.944 mg/L. Then the waste goes back into reactor 2 (FWS) and can be output with a COD content value of 133.766 mg/L. From these results, it can be concluded that *the Constructed Wetland* with 2 reactors and a 10-day HRT variation can effectively reduce the COD content with a *removal efficiency* of 92.698% and by applicable quality standards.

Meanwhile, from Figure 1 (b), it can be seen that the value of the initial waste TSS content is 300 mg/L, and after exiting reactor 1 (HSSF) is 120 mg/L. After that, the waste returns to reactor 2, and the output obtained is a TSS content of 50 mg/L. Therefore, the removal of TSS content with *Constructed Wetland* is quite effective, with *a removal efficiency* of 83%, and is by the applicable quality standards.

3. Variation of Hydraulic Residence Time (HRT) 20 Days

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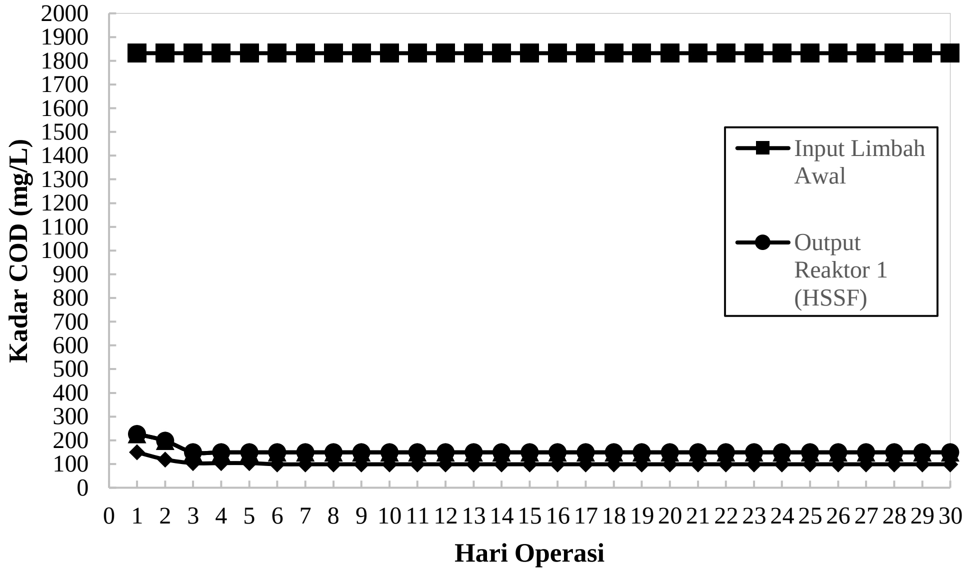
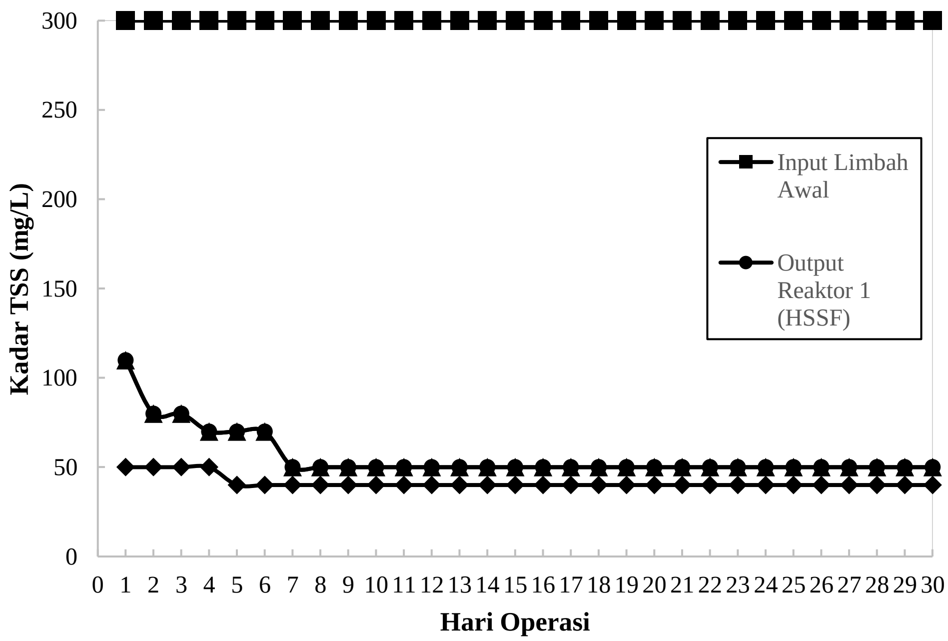
The same as the 10-day HRT variation, because in this study there were 2 reactors, the 20-day hydraulic residence time (HRT) variation was carried out for each reactor. In more detail, the HRT variable was carried out for 20 days in reactor 1, followed by 20 days in reactor 2. The results showed that in the 20-day hydraulic residence time (HRT) variation, the removal of COD and TSS content can be seen in Figure 2.



(a)



(b)

Figure 2. Effect of 10-Day HRT Variation on COD and TSS Reduction (a) COD (b) TSS. *Note:* ■ = Initial Waste *Input* , ● = Reactor 1 *Output* (HSSF), ▲ = Reactor 2 *Input (FWS)* , ◆ = *Output* Reactor 2 (FWS)

From Figure 2 (a), it can be seen that the initial waste COD content (before entering the reactor) was 1832.025 mg/L, and after exiting reactor 1 (HSSF) was 149.276 mg/L. Then the waste goes back into reactor 2 (FWS) and can be output with a COD content value of 98.871 mg/L. From these results, it can be concluded that *the Constructed Wetland* with 2 reactors and a 20-day HRT variation can effectively reduce the COD content with a *removal efficiency* of 94.603% and is by applicable quality standards.

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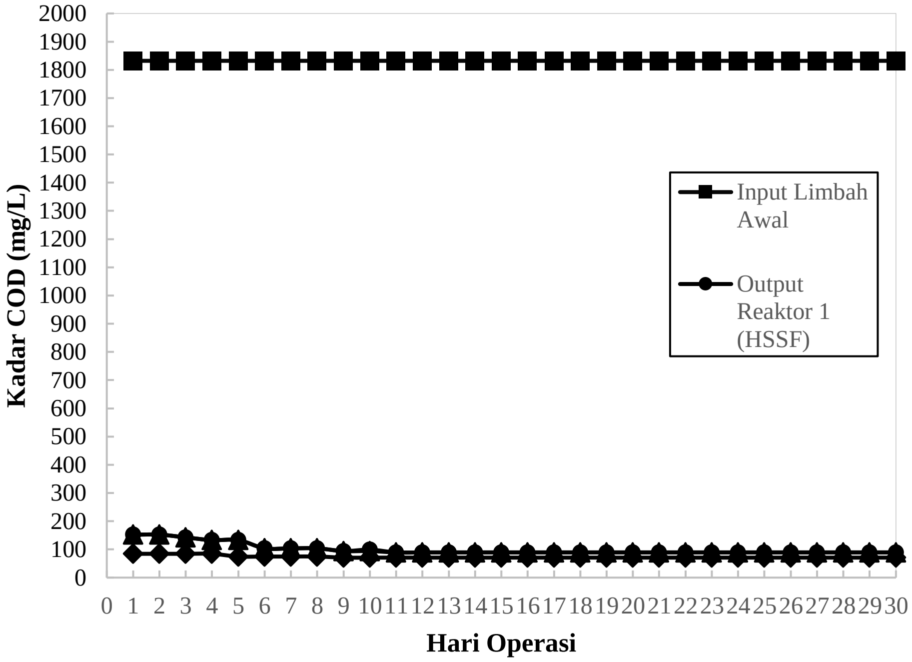
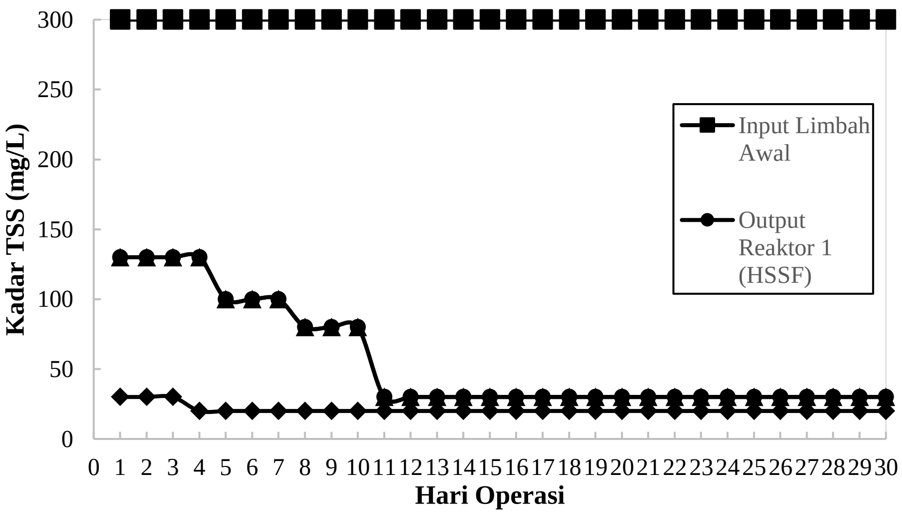
Meanwhile, from Figure 2 (b), it can be seen that the value of the initial waste TSS content is 300 mg/L, and after exiting reactor 1 (HSSF) is 50 mg/L. After that, the waste returns to reactor 2, and the output that is obtained is a TSS content value of 40 mg/L. *The removal efficiency* obtained is 86.67% and by the applicable quality standards.

4. 30-Day Hydraulic Stay Variation (HRT).

The HRT variable was carried out for 30 days in reactor 1, followed by 20 days in reactor 2. The results showed that in the 30-day hydraulic retention time (HRT) variation, the removal of COD and TSS content can be seen in Figure 3.



(a)



(b)

Figure 3 . Effect of 10-Day HRT Variation on COD and TSS Reduction (a) COD (b) TSS. *Note:* ■ = Initial Waste *Input* , ● = Reactor 1 *Output* (HSSF), ▲ = Reactor 2 *Input (FWS)* , ◆ = *Output* Reactor 2 (FWS)

Figure 3 (a) shows the value of the COD content of the initial waste (before entering the reactor) of 1832.025 mg/L, and after exiting reactor 1 (HSSF) is 89.177 mg/L. Then the waste goes back into reactor 2 (FWS) and can be output with a COD content value of 70.761 mg/L. From these results, it can be concluded that *the Constructed Wetland* with 2 reactors and a 20-day HRT variation can effectively reduce the COD content with a *removal efficiency* of 96.138% and is by the applicable quality standards.

Meanwhile, from Figure 2 (b), it can be seen that the value of the initial waste TSS content is 300 mg/L, and after exiting reactor 1 (HSSF) is 30 mg/L. After that, the waste returns to reactor 2, and the output obtained is a TSS content of 20 mg/L. *The removal efficiency* obtained was 93.33% and was by the applicable quality standards.

removal efficiency value was obtained by *Constructed Wetland* with a 30-day HRT variation, which can be concluded that the longer the HRT, the lower the value of the pollutant content. Wu (2015) in his research also argues that HRT plays an important role in the removal of pollutants in wastewater. A collection of microbes will form in the CW and can remove contaminants along with the length of time the waste stays in the reactor.

Conclusion

Constructed Wetland has the potential to be used in the processing of batik industrial wastewater because it meets PERMENLHK industrial wastewater quality standards No. 16 of 2019 for COD and TSS levels. The highest *removal efficiency was obtained by the 30-day Hydraulic Residence Time (HRT) variation, where the longer the HRT time, the lower the pollutant content.*

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