The Effect of Material Characteristics on the Quality of Hand-crafted *Batik* Wastewater

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ABSTRACT

Batik Sidomulyo Batu City is one of the hand-crafted batik Small and Medium Enterprises (SMEs) that uses synthetic dyes. The use of dyeing technology in *batik* making process generates a large amount of wastewater, which can lead a harmful effect to the environment. To date, *Batik* Sidomulyo SME uses two types of mori cloth material before dyeing process include mori cloth with and without the mordanting process. The mori cloth with mordanting process was soaked in the alum for 24 hours before the grafting process was carried out. The purpose of this study was to analyze the quality of *batik* wastewater produced based on the characteristics of the treatment of the fabric material before the embedding process was carried out. Wastewater treatment technology uses technology transfer from Mini Wastewater Treatment Plant (WWTP) which utilizes biofilter technology using two treatment compartment including (1) separation of wax content from wastewater and (2) separation of wastewater from toxic and hazardous material waste by mixing with a coagulant. Measurements of pH, BOD, COD, TSS, and oil/fat were carried out before and after the treatment of Mini WWTP. The results showed that the pH of the wastewater generated from the mini WWTP outlet was following the quality standard of 6.86 and the total suspended solids (TSS) value of 90.16 mg/L. Meanwhile, the values of BOD, COD, and oil/fat content have been significantly reduced but still exceeded that of the quality standards, with the value of 90.16, 253.8, and 4.5 mg/L, respectively.

***Keywords**: Batik, Wastewater, Quality, WWTP*

1. INTRODUCTION

Mori cloth is a fabric made of cotton fibers from Gossypium seeds. This cloth is material for making *batik* cloth in Sidomulyo *Batik*, Batu City. In general, *mori* cloth has white color, making it easier during the *batik*'s coloring process [1]. This *mori* cloth is often used for the *batik* material due to its right thickness, softness, and density [2]. There are three types of *mori* cloth based on its softness, i.e. primissima *mori* cloth (first quality), prime *mori* cloth (second quality), and blue *mori* cloth (third quality). These types of *mori* can be chosen based on the necessity and user's demand [3]. In the *batik* coloring process, *Batik* Sidomulyo SME uses synthetic dyes as coloring agent. A synthetic dye is a chemical colorant mostly used by *batik* craftsmen because it is easy to find, easy to use, faster time to coloring process, and more economical. However, there are also many disadvantages from using synthetic dyes, in particular, in can lead to detrimental effect of environmental pollution if the wastewater is not properly treated [4]. Furthermore, the coloring process on the fabric also depends on the mordant substance used as a color binder.

The mordant substances are mixed with the fabric during the mordanting process. Mordanting is an early process for coloring the fabric. This process is for removing wax remains, starch, oils, even dirt left during the looming process. The fabric is soaked into an alum solution and then boiled [5]. The mordanting process usually uses a color binder. There are many type of color binders such as lime ($CaCO_3$), alum ($Al_2(SO_4)_3$), and *tunjung* ($FeSO_4$). Using different color binders may result in different colors in each fabric [6]. Based on its purpose, mordanting can fix the liquid wastewater characteristics.

Batik Sidomulyo is one SME producing hand-crafted *batik* located in Agrotourism City, Batu City. Batu City's potential as one travel destination can be utilized for developing and preserving local heritage, such as hand-written *batik* from *Batik* Sidomulyo.

Agrotourism development plays a key role in preserving resources, local heritages, as well as in increasing the revenue of the local community. *Batik* Sidomulyo has a distinctive characteristic in motifs taken from local heritages such as ornamental plants and cut flowers. Therefore, Sidomulyo's hand-crafted *batik* development has huge potentials as a locally featured product.

Hand-crafted *batik* with local heritage motifs is one of the souvenir choices from Batu City. *Batik* as a souvenir has the potential to be preserved and developed as a featured product, considering *batik* has been included in one of the heritages approved by UNESCO. *Batik* has motifs and characteristics for each region because in general *batik* motifs are a representation of local cultures. *Batik* making starts from drawing the motifs on the fabric, implementing wax, coloring, sagging, and finishing. In the *batik* coloring process, *Batik* Sidomulyo SMEs have implemented coloring technology and resulted in wastewater. The coloring dyes used could be natural dyes, synthetic dyes, or a combination of both. The advantages of natural dyes are that it has a distinctive color as well as the wastewater is relatively nontoxic and may reduce the negative impact on the environment. On the other hand, synthetic dyes have color variations because it can be combined into a new color beyond natural dyes. However, the wastewater caused by synthetic dyes has a certain compound that is more dangerous than natural dyes. Accumulation of synthetic dyes on the environment can cause detrimental effects to human health and ecosystems. Using both type of dyes still produce highly toxic wastewater, which may pose harm to the environment. Aside from coloring dyes agents, other materials such as the fabric type or the wax also influenced the contents of the wastewater. Therefore, wastewater treatment is needed before disposal.

Textile-based agroindustry, hand-crafted *batik* is one of the industries that still have limitations regarding the wastewater from the coloring process. *Batik* making process, which each have their contaminants, lead to the complexity of wastewater treatment, resulted in wastewater containing water, color/dyes residue, water glass, and wax from the wax application process [7]. Various types of wastewater contain substances that could cause degradation and turn into carcinogenic compounds, causing bad odor and murky water. Several parameters used to control and monitor the wastewater quality include BOD, COD, TSS, oils, and pH. Those five parameters have a maximum limit that has to be fulfilled before the wastewater effluents are discharge into the environment. Adjusting each parameter's value is for reducing environmental issues that could be caused by wastewater from the process of making *batik*. A study by Suprihatin [8] shows that using alum coagulant in large amounts is proven to decrease the COD rate.

One of the solutions and efforts for managing the wastewater from hand-crafted *batik* SMEs is by implementing the wastewater treatment plant (WWTP). The use of WWTP is expected to decrease the harmful pollutants in the wastewater before it discharged into the environment. This research aimed to investigate the impact of the *batik* production method on the quality of wastewater, as well as to identify the impact of WWTP technology application on the effluent quality of the treated wastewater. The research explored the wastewater generated from two production process, i.e. *mori* cloth that treated with and without the mordanting process. The results obtained from this research are expected to improve the quality of the *batik* industry's wastewater in Sidomulyo *Batik*, thus reducing the negative impact on the environment. This research is also expected to produce wastewater effluents that meet with that of standard values from the East Java Governor Regulation No 72 Year 2013.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in making *batik* were *mori*, alum aluminum acetate, wax, and natural dyes. *Mori* is a plain white cloth used as the basis cloth for making *batik*, alum and aluminum acetate are materials used for the mordant process and wax is a material used to cover the surface of the *mori* according to the *batik* motif. Mordant is a substance that can increase the affinity or binding between cells and dyes.

2.2. Experimental Approach and Set-up

The method for this research was Participatory Technology Development i.e. an approach that is oriented in role improvement as well as the society directly in the research as well as utilizing appropriate technology based on science and technology as well as local heritage. Designing mini WWTP was executed based on the benchmark result from the Center for Crafts and *Batik*) in Yogyakarta as well as practitioners about wastewater management technology with design as seen in Figure 1.

This research was conducted in pilot scales without any replication. The working principle from Mini WWTP consists of a wastewater management process installed with 3 compartments for collecting the wastewater, stirring, and separating the liquid and solid waste. This mini WWTP has a capacity of up to 3000 L. The tanks are 900 cm height, with diameter for tanks' bodies and lids are 690 and 400 cm.

2.3. Parameters Analysis

Batik's wastewater's quality was tested in the laboratory using parameters i.e. COD (SNI 6989.2.2009), BOD (APHA 5210. B-2017), pH (SNI 06-6989.11.2004), and TSS (APHA 2540 D-2017) rates as well as oils/grease compound (APHA. 5220 B-2017) in Jasa Tirta Malang. The quality of wastewater was the compared by using 5 wastewater quality parameters from East Java Governor Regulation No 72 the Year 2013, including BOD, COD, oils, pH, and TSS values.

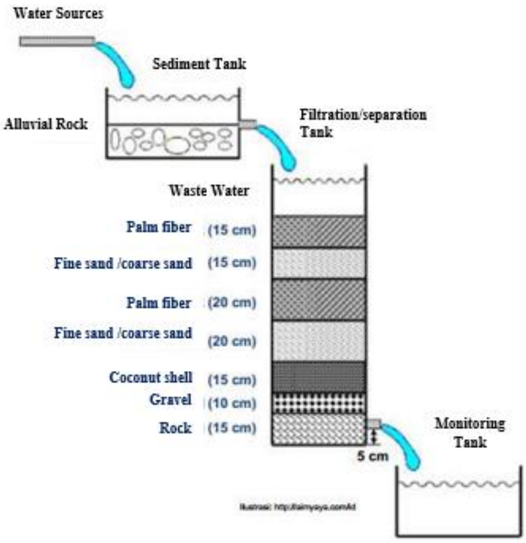

Figure 1 Mini WWTP installation design for wastewater at UKM *Batik* Sidomulyo

3. RESULTS AND DISCUSSION

3.1. Implementation of Mini WWTP

Sidomulyo's hand-crafted *batik* is one of the crafts that became icons and potential as one of the travel destinations in Sidomulyo Flower Resort Village, Batu City. *Batik* theme that raises the potential of ornamental plants, flowers, as well as local heritage that is in Sidomulyo Village is very interesting and has competitiveness potential with fellow *batik* craftsmen in Batu City. Solutions and steps that were done in the activity started from surveying *batik*'s production in *Batik* Sidomulyo SMEs. The next step was installing the Mini WWTP in *Batik* Sidomulyo SMEs using supporting devices that can be seen in Figure 2. WWTP function is important for the efficiency of wastewater treatment. The efficiency of wastewater treatment as basic depends on the amount and composition of wastewater, condition, and type of sewer network, producers, used technical and climatic equipment, and other conditions [9].

Figure 2 Mini WWTP design at UKM *Batik* Sidomulyo (top left) Place for *batik* dyeing and coloring process (top right) Tank for mixing and purifying *batik* wastewater with bacteria media and plastic ball (bottom) pump for power in the stirring process

3.2. Performance of Mini WWTP

Batik's wastewater samples were taken from 2 types of production process. Production process 1 was that the *batik* cloth colored with synthetic dyes and mordanted using alum. Production process 2 was that there were 2 *batik* cloths, one was colored with synthetic dye and mordanted using alum, while the other one was not mordanted, then both wastewater was homogenized. Both samples were analyzed for TSS (APHA 2540 D-2017), BOD (APHA 5210 B-2017), COD (SNI 6989.2.2009), oil (APHA.5220 B-2017), and pH (SNI 06-6989.11.2004), the results are presented in Table 1.

Table 1. Characteristics of *Batik* wastewater influent processing treated with mini WWTP

Parameters	1	2	Quality Standard
TSS (mg/L)	29.9	1122	Max. 50
BOD (mg/L)	49.22	11541	Max. 150
COD (mg/L)	149.9	30800	Max. 60
Oils (mg/L)	3.5	328	Max. 3
pH	6.59	8.7	6 - 9

Table 1 shows that the result of all parameters in process 1 is much lower than that of from the process 2. This means that the wastewater from treatment 1 is safer on the environment. The influent wastewater from production process 1 has a few parameters that meet the wastewater quality standard for the textile industry in accordance to East Java Governor Regulation No 72 Year 2013 i.e. in TSS, BOD, oil, and pH parameters. Much higher pollutants contained in wastewater generated from the production process 2 is possibly due to the use of synthetic dyes and chemical mordanted use [10]. In process 2, the wastewater sources were homogenized, causing the chemicals in the *batik* wastewater to accumulate and become high.

The important process in creating beautiful batik art is the coloring process. The mordanting process was used before the coloring process on batik making with natural dyes [11]. The use of mordant is for binding the colors in the fabric so the color is stronger than un-mordanted fabric. However, the mordant agent also usually consists of alum and lime which can purify water. Alum is a positively charged dispersion that will bind negatively charged particles that may cause sediments and the water to be clearer and reduce TSS in the water [9]. Furthermore, alum if it is mixed with water can result in H_2SO_4 [10]. Thus, it may cause the water mixed with alum to have a smaller pH. Alum can also decrease the BOD and COD rate in wastewater because alum's characteristics could bind negatively charged particles that have organic or inorganic characteristics, so reducing the COD values [9]. In production process 2, two wastewater sources were homogenized causing the chemicals and solids are accumulated in the wastewater to accumulate, leading to an increase in pH values. This may also be due added wastewater from the process without the use of mordanted agent.

Batik's wastewater was tested using 3 parameters i.e. physical, chemical, and biological. The characteristics of wastewater before and after treatment using mini WWTP can be seen in Tables 2, 3, and 4.

Table 2. Physical Parameters

Physical Parameters				
Parameter	Treatment	1	2	Quality Standard
TSS (mg/L)	Inlet	29.9	1122	Max. 50
	Outlet	44.8	21.20	
Removal (%)		-	98.11	

Note: 1 = wastewater generated from production process with mordanted agent of alum; 2 = combination of wastewater from production process with and without mordanted agent

After *treated* by mini WWTP, the TSS of *batik*'s wastewater from production process 2 was significantly reduced to 21.2 mg/L (or by 98.11% reduction). Despite a slight increase in TSS of wastewater from process 1, both values were lower than that of the quality standard in accordance to East Java Governor Regulation No 72 Year 2013 that stated, TSS from wastewater for the textile industry is 50 mg/L maximum. This indicated that treating wastewater from *batik* processing using mini WWTP was found to improve the wastewater effluent quality and reduce the pollutants.

Table 3. Chemical Parameters

Chemical Parameters				
Parameter	Treatment	1	2	Quality Standard
pH	Inlet	6.59	8.7	6 - 9
	Outlet	6.96	6.86	

Note: 1 = wastewater generated from production process with mordanted agent of alum; 2 = combination of wastewater from production process with and without mordanted agent

pH is one of the supporting parameters that are important to be measured, this is because pH is one of the factors that could identify the presence of organic compound decomposition by the microorganism [10]. Table 3 shows that *Batik* wastewater's pH of both samples after treated with mini WWTP were 6.96 and 6.86. The pH result is still in the range of wastewater quality standard for the textile industry in accordance to East Java Governor Regulation No 72 the Year 2013 i.e. maximum value is 6 to 9. Therefore, the mini WWTP was effective to keep the pH values of the treated *batik* wastewater close to neutral pH.

Table 4. Biological Parameters

Biological Parameters				
Parameter	Treatment	1	2	Quality Standard (mg/L)
BOD (mg/L)	Inlet	49.22	11541	Max. 50
	Outlet	44.42	90.16	
Removal (%)		9.752	99.219	
COD (mg/L)	Inlet	149.9	30800	Max. 60
	Outlet	133.1	253.8	
Removal (%)		11.207	99.176	
Oils (mg/L)	Inlet	3.5	328	Max. 3
	Outlet	2.5	4.5	
Removal (%)		28.571	98.628	

Note: 1 = wastewater generated from production process with mordanted agent of alum; 2 = combination of wastewater from production process with and without mordanted agent

The result of the biological parameters from wastewater is shown in Table 4. The BOD of *Batik* wastewater's BOD after treated with mini WWTP was decrease to 44.42 mg/L and 90.16 mg/L, for sample 1 and 2, respectively. BOD results by the wastewater quality standard for textile industry from East Java Governor Regulation No 72 the Year 2013 is 150 mg/L maximum. This indicated that mini WWTP is working effectively to remove organic pollutants contained in *batik* wastewater. The BOD removal effectiveness of wastewater from production process 1 and 2 was 9.75% and 99.22%. In sample 2, the BOD was significantly reduced as it value was almost reached 100%, while only a small reduction was found in sample.

The COD removal of *batik* wastewater sample from production process 1 and 2 sequentially were 11.21% and 99.18%. A study by Rahmawati et al. [11] reported that the COD rate could decrease up to 80.38% because the majority of an organic compound including dyes agent can be separated from *batik* industry's wastewater. The COD value generated is higher than the wastewater quality standard from the governor's regulation that stated, COD from wastewater with a maximum value of 50 mg/L. This indicated, further treatment is necessary to reduce the COD concentration. The wastewater still cannot be directly disposed to the environment.

The oil removal of *batik*'s wastewater from production process 1 and 2 was 28.75 % and 98.63%. The wastewater influent from each process has value of 3.5 and 328 mg/L. After treated with mini WWTP, the oil content reduced to 2.5 and 4.5 mg/L. The oil removal rate of wastewater from production process 1 was lower than that of the value (max. of 3 mg/L) stated in East Java Governor Regulation No 72 Year 2013. This demonstrated that mini WWTP was able to significantly remove oil content in the wastewater samples. Altough the oil removal in wastewater from production process 2 was 98.63%, further treatments are still required to ensure that the treated wastewater effluents have met the standard value for discharge.

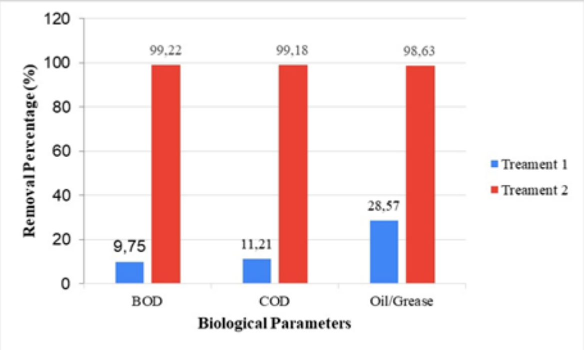

Figure 3 Efficiency biological parameter diagram

Figure 3 shows that mini WWTP has higher efficacy when treating wastewater from production process 2. Y-axis describes the removal or decreases of the effectiveness of parameters (%). Biological parameters observed were in BOD, COD, and oils removal, with the average value of 99.23%, 99.18%, and 98.63%.

3. CONCLUSION

Making the hand-crafted *batik* needs *mori* cloth, wax, synthetic and natural dyes, alum binder, and water. The production process is categorized into 2; include soaking of *mori* cloth with and without mordant agents. The implementation of Mini WWTP was found to improve the quality of wastewater effluent. Parameters values of pH (6.86) and TSS (90.16 mg/L) were in accordance to that of the standard effluent discharge. The mini WWTP was also significantly reduced BOD, COD and oil content to 90.16 mg/L, 253.8 mg/L , and 4.5 mg/L, respectively.

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