Natural dyes batik gallery with waste management in Kampung Palbatu Tebet

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Abstract. Lots of Small and Medium Enterprises uses natural dyes on their Batik process in Jakarta. Palbatu Tebet Batik village has applied Batik process with natural coloring but there is not any treatment center for the natural coloring waste. This causes environmental pollution and endangers the health of residents around there. Palbatu Batik Village requires wastewater treatment center. This research is implemented by making correlation between wastewater value and WWTP system. The highest BOD and COD value in the Natural Coloring process is 2870 mg/L and 8345 mg/L. Both of these values exceed the quality standards set by the government which are 75 mg/L and 100 mg/L. This research is to find out the right WWTP system to treat waste to meet quality standards. Of the several WWTP systems, only the Aerobic-Anaerobic system can reduce the BOD value to 5.166 mg/L and the COD value to 91.79 mg/L. The space requirements for the Aerobic-Anaerobic system are Fat Seperator, Equalization, Initial Sedimentation, Anaerobic Biofilter, Aerob Biofilter, Final Sedimentation, and Chlorination.

Keywords: Natural Dyes Batik, BOD, COD, WWTP

1. Introduction

This research was raised based on one of United Nations Habitat programme number 11 “Make cities and human settlements inclusive, safe, resilient and sustainable”. There are ten contents that supports the UN Habitat number 11 and this research emphasize on number 11.6 “By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management” [1]. Batik Gallery is one that contributes quite high wastewater. These problems generated high water pollution on a local scale. This research participated in effort to reduce water pollution in Jakarta.

Batik is a skill that has high artistic value and has become part of the culture of the nation. Batik in Jakarta known and developed together with other batik areas, namely the end of the 19th century, mostly spread around Tanah Abang which one of them is Tebet [2]. 1800’s batik in Indonesia using natural dyes made from natural ingredients, as well as coloring from plants and also from animals. Palbatu Tebet Batik Village has already established since 2011 and they have been using natural dyes as part of their batik process. Using Natural dyes as the coloring system on Batik has increase the value and quality of the batik. However, with a variety of natural coloring agents available, it does not mean that all waste is safe to be directly channeled to the waterways.
According to UU RI no.32 in 2009 Regarding the Protection and Management of the Environment, each industry or institution/business entity must be responsible for the management of waste generated from its activities [3]. The Palbatu Tebet Batik requires Wastewater Management Plant for their wastewater treatment. The creative industry sector in Indonesia must start making products with natural dyes [4] because there are many benefits to be gained when using natural dyes such as: (1) Environmentally friendly and safe for health, it is easy to decomposed so it does not cause pollution. (2) In Terms of coloring, the color obtained has the properties of soft, harmonious, matching.(3) Natural dyes usually contain distinctive aromas that appear when blended with cotton fibers, and finally batik fabrics have a higher value compared to cotton fibers.

The process of producing the natural coloring liquid for Natural dyes batik results water waste which has a quality standard that exceeds the standard Value of DKI Jakarta. For example: Indigo, Mahoni, and Jolawe has BOD of 1585, 2870, and 2430, and COD 4028, 8345, and 7650. These BOD and COD value have extremely high value. As the attachment 3: DKI Jakarta Provincial Regulation Number 122 of 2015, BOD standard Value is 75 mg/L and the COD standard value is 100 mg/L [5].

This paper aims to find: (1) to study which Wastewater Treatment Plants applied at the natural dyes batik gallery in Palbatu Tebet Village? (2) to study WWTP Space requirements that will be needed at the Natural dyes Batik Gallery in Palbatu Tebet Village.

2. The methodology

2.1. The method of study
The methodology of this research is explained on the Diagram (Figure 1). The study methodology is Literature review of the Natural dyes substance, BOD and COD Values, WWTP systems. The process of Natural Dyeing is taken from “Teknik Eksplorasi Zat Pewarna Alam di Sekitar kita untuk pencelupan bahan tekstil”[6]. WWTP systems and the space requirements is taken from “Tinjauan Permasalahan, Strategi, dan Teknologi Pengolahan” [7].

![Figure 1. The diagram of methodology](diagram)

The process of natural dyes produces liquid wastewater that has BOD, COD, and pH value. We analyze all WWTP system that commonly used, each of them has decrease percentage of BOD, and COD. The BOD, and COD value of Natural dyes will be calculated with the percentage number. If the
results value has fulfill the quality standard of DKI Jakarta, these WWTP can be used for the Batik Gallery Services. After the study find out which WWTP can be used, each of them has different room requirements. The results of the study are to know which WWTP system is fulfill the needs of the wastewater of the Natural dyes, and the space requirements for the WWTP system.

2.2. The case study.
The study selected are The Batik Palbatu Village that located on Jl. Palbatu IV, Menteng Dalam, Kec. Tebet, Jakarta Selatan, DKI Jakarta. Batik medium local business and community in these area needs a wastewater treatment center to accommodate the Natural dyes batik process. Because they are commonly do the batik process on their own house, they do not have space to do the Natural dyes by their own. Therefore, Batik Palbatu Village need a space for Natural dyes process with an adequate WWTP system.

3. Result and Discussion
3.1. The process and waste of natural dyeing

![Figure 2. Diagram of Natural Dyeing](image)

Based on the Journal, there are 7 steps on processes natural dyeing (Figure 2), these are the steps that produced wastewater that consists of BOD and COD value. Several natural dyeing processes and their BOD and COD is shown in Table 1.

| No  | Process                        | Steps                                                      | BOD (mg/L) | COD (mg/L) |
|-----|--------------------------------|------------------------------------------------------------|------------|------------|
| 1   | Batik process with one boil    | The Fabric is colored first with a light color             | 1585       | 4028       |
| 2   | Batik process with one boil    | The cloth is dyed the second time with an older color      | 1585       | 4028       |
| 3   | Batik process with one boil    | The cloth is dyed the third time with an older color       | 1585       | 4028       |
| 4   | Lasem Batik Process            | Fabric first dyed in dark color (repeated 10-20 times)     | 1585       | 4028       |
| 5   | Batik process with more than one boil | If necessary, do the coloring process again                  | 1585       | 4028       |
| 6   | Lasem Batik Process            | Fabric dyed in blue from Tarum (Indigofera tinctorial)     | 1585       | 4028       |
| 7   | Batik process with one boil    | After all motifs are colored, the wax is drawn, the fabric is washed and drained | 2292       | 6674       |
Batik process with more than one boil

The wax in the fabric is boiled

2292 6674

Batik process with more than one boil

The wax that still attached to the fabric is boiled and then washed

2292 6674

Lasem Batik Process

The wax in the fabric is boiled

2292 6674

Lasem Batik Process

The fabric is colored in yellow from Jolawe material

2430 7650

Lasem Batik Process

The fabric is colored in red from Mahoni material (10-20 times)

2870 8345

3.2 WWTP Percentage Decrease

To find out how many decrease percentage of each WWTP, we analyze of some journal to know each decrease percentage by reducing the first value and final value of each BOD and COD, as tabulated in Table 2.

| Journal | WWTP System | BOD decrease % | COD decrease % | pH |
|---------|-------------|----------------|---------------|-----|
| Evaluasi Dan Desain Ulang Unit Instalasi Pengolahan Air Limbah (IPAL) Industri Tekstil di Kota Surabaya menggunakan Biofilter Tercelup Anaerobik-Aerobik [8] Keberlanjutan Instalasi Pengolahan Air Limbah Domestik (IPAL) berbasis masyarakat, Gunung Kidul, Yogyakarta [9] Pengelolaan Metode IPAL (Instalasi Pengolahan Air Limbah) dalam mengatasi Pencemaran Air Tanah dan Air Sungai [10] | Aerobic-Aerobic | 99.82 | 98.90 | - |
| Pengolahan Air Limbah Industri Kecil Tekstil dengan Proses Biofilter Anaerob-Aerob Tercelup menggunakan Media Plastik Sarang Tawon [11] Pengolahan Limbah Zat Warna Tekstil Tersispersidengan Metode Elektroflotasi [12] Uji Penurunan Kandungan BOD, COD dan warna Pada Limbah Cair Pewarnaan Batik Menggunakan Scirpus grossus Dan Iris pseudacorus dengan sistem memaparan Intermittent [13] | Communal | 77.19 | 80.19 | - |
| Pengolahan Limbah Industri Kecil Tekstil dengan Proses Biofilter Anaerob-Aerob Tercelup menggunakan Media Plastik Sarang Tawon [11] Pengolahan Limbah Zat Warna Tekstil Tersispersidengan Metode Elektroflotasi [12] Uji Penurunan Kandungan BOD, COD dan warna Pada Limbah Cair Pewarnaan Batik Menggunakan Scirpus grossus Dan Iris pseudacorus dengan sistem memaparan Intermittent [13] | Anaerobic Filter | 93.93 | 89.17 | - |
| Pengolahan Limbah Industri Kecil Tekstil dengan Proses Biofilter Anaerob-Aerob Tercelup menggunakan Media Plastik Sarang Tawon [11] Pengolahan Limbah Zat Warna Tekstil Tersispersidengan Metode Elektroflotasi [12] Uji Penurunan Kandungan BOD, COD dan warna Pada Limbah Cair Pewarnaan Batik Menggunakan Scirpus grossus Dan Iris pseudacorus dengan sistem memaparan Intermittent [13] | Sludge system Anaerobic-Aerobic (Bee Hive) | 86.67 | 98.03 | - |
| Pengolahan Limbah Industri Kecil Tekstil dengan Proses Biofilter Anaerob-Aerob Tercelup menggunakan Media Plastik Sarang Tawon [11] Pengolahan Limbah Zat Warna Tekstil Tersispersidengan Metode Elektroflotasi [12] Uji Penurunan Kandungan BOD, COD dan warna Pada Limbah Cair Pewarnaan Batik Menggunakan Scirpus grossus Dan Iris pseudacorus dengan sistem memaparan Intermittent [13] | Electroflotation | 93.33 | 88.87 | - |
| Pengolahan Limbah Industri Kecil Tekstil dengan Proses Biofilter Anaerob-Aerob Tercelup menggunakan Media Plastik Sarang Tawon [11] Pengolahan Limbah Zat Warna Tekstil Tersispersidengan Metode Elektroflotasi [12] Uji Penurunan Kandungan BOD, COD dan warna Pada Limbah Cair Pewarnaan Batik Menggunakan Scirpus grossus Dan Iris pseudacorus dengan sistem memaparan Intermittent [13] | Intermittent | 96.72 | 97.69 | - |
| Nilai Parameter Kadar Pencemar sebagai penentu Tingkat Efektivitas Tahapan Pengolahan Limbah Cair Industri Batik [14] | Anaerobic and charcoal absorbent | 96.42 | 99.04 | - |
| Konsep Desain Instalasi Pengolahan Air Limbah Skala Komunal Dalam Rangka Puriifikasi Kualitas Air Sungai di Jakarta [15] | Activated Sludge | 87.50 | 82.50 | - |
| Konsep Desain Instalasi Pengolahan Air Limbah Skala Komunal Dalam Rangka Puriifikasi Kualitas Air Sungai di Jakarta [15] | Rotating Biological Contractor | 72.50 | 82.50 | - |
| Konsep Desain Instalasi Pengolahan Air Limbah Skala Komunal Dalam Rangka Puriifikasi Kualitas Air Sungai di Jakarta [15] | Trickling Filters High Rate Stone Media | 72.50 | 70.00 | - |
| Konsep Desain Instalasi Pengolahan Air Limbah Skala Komunal Dalam Rangka Puriifikasi Kualitas Air Sungai di Jakarta [15] | Trickling Filters High Rate Plastic Media | 75.00 | 75.00 | - |
| Prototype Unit Pengolahan Limbah (Activated Sludge Biosand Filter Reactor) Untuk Menurunkan kadar Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) dan Total Suspend Solid(TSS) [16] | Activated sludge biosand Filter Reactor | 89.21 | 85.29 | - |
In addition to the processes in Table 2, several membrane-based clarification of textile wastewater processes were considered [24-28], but not recommended due to economic aspects.

### 3.3 Discussion on the relationship between the Natural Dyes process, Waste and WWTP System

After found out the BOD, and COD value of the Process, Do the calculation of the Process value with the Decrease Percentage of WWTP to find out the right WWTP.

| Journal                                                                 | WWTP System     | BOD decrease % | COD decrease % | pH     |
|-------------------------------------------------------------------------|-----------------|----------------|----------------|--------|
| Pengolahan Limbah Cair Industri Minuman Ringan [17]                     | Oxidation Ditch | 96.88          | 96.00          |        |
| Evaluasi Pengolahan Air Limbah dengan Sistem Extended Aeration di Rumah | Extended        | 25.17          | 62.45          |        |
| Sakit “x” Semarang [18]                                                 | Aeration        |                |                |        |
| Studi Penurunan Kadar BOD, COD, TSS dan pH Limbah Pabrik Tahu          | Step aeration   | 93.80          | 68.15          |        |
| Menggunakan Metode Aerasi Bertingkat [19]                              | Activated Sludge| 44.35          | 17.77          |        |
| Efektivitas Lumpur Aktif Dalam Menurunkan Nilai BOD dan COD pada      | Batch           | 92.33          | 98.73          |        |
| Limbah Cair UPT LAB. Analitik Universitas Udayana [20]                  |                 |                |                |        |
| Penurunan BOD dan COD Limbah Cair Melalui Proses Adsortsi Secara Batch | Anaerobic       | 98.81          | 98.81          |        |
| dengan menggunakan Kombinasi Sistem Anaerobik-Aerobik                  | Aerobic 2       | 98.1          | 98.81          |        |
| pada Pabrik Tahu “DUTA” Malang [22]                                    | Anaerobic       | 96.91          | 98.97          |        |
| Pengolahan Limbah Cair Industri Batik sebagai Salah satu                | Aerobic 3       | 96.91          | 98.97          |        |
| Percontohan IPAL Batik di Yogyakarta [23]                               |                 |                |                |        |

From Table 3, we can conclude that Aerobic-Anaerobic systems 1 and 2 can reduce the entire value of BOD and COD from Natural dye process waste up to quality standard. Aerobic-Anaerobic system 3 and Oxidation Ditch System can only reduce 10 out of 12 waste to the quality standard. Intermittent system can only reduce 6 out of 12 waste to the quality standard. Besides five systems above, other Waste Treatment Systems cannot reduce the BOD value of Natural Dye Waste up to the BOD standard.
Table 4. Final COD value Calculation

| No | COD Value (mg/L) | Standard COD Value (mg/L) | Aerobic-Anaerobic 1 (mg/L) | Aerobic-Anaerobic 2 (mg/L) | Aerobic-Anaerobic 3 (mg/L) | Batch (mg/L) | Intermittent (mg/L) | Activated Sludge (mg/L) |
|----|------------------|--------------------------|----------------------------|---------------------------|---------------------------|--------------|--------------------|-----------------------|
| 1  | 4028             | 100                      | 44.308                     | 47.93                     | 41.48                     | 51.15        | 93.04              | 79.35                 |
| 2  | 4028             | 100                      | 44.308                     | 47.93                     | 41.48                     | 51.15        | 93.04              | 79.35                 |
| 3  | 4028             | 100                      | 44.308                     | 47.93                     | 41.48                     | 51.15        | 93.04              | 79.35                 |
| 4  | 4028             | 100                      | 44.308                     | 47.93                     | 41.48                     | 51.15        | 93.04              | 79.35                 |
| 5  | 4028             | 100                      | 44.308                     | 47.93                     | 41.48                     | 51.15        | 93.04              | 79.35                 |
| 6  | 4028             | 100                      | 44.308                     | 47.93                     | 41.48                     | 51.15        | 93.04              | 79.35                 |
| 7  | 6674             | 100                      | 73.41                      | 79.42                     | 68.74                     | 84.75        | 154.16             | 131.47                |
| 8  | 6674             | 100                      | 73.41                      | 79.42                     | 68.74                     | 84.75        | 154.16             | 131.47                |
| 9  | 6674             | 100                      | 73.41                      | 79.42                     | 68.74                     | 84.75        | 154.16             | 131.47                |
| 10 | 6674             | 100                      | 73.41                      | 79.42                     | 68.74                     | 84.75        | 154.16             | 131.47                |
| 11 | 7650             | 100                      | 84.15                      | 91.03                     | 78.79                     | 97.155       | 176.71             | 150.70                |
| 12 | 8345             | 100                      | 91.79                      | 99.30                     | 85.95                     | 105.98       | 192.76             | 164.39                |

From Table 4, data concludes that Aerobic-Anaerobic systems 1, 2 and 3 can reduce the entire value of COD from Natural dye process waste up to quality standard. Aerobic-Anaerobic system 3 and Oxidation Ditch System can only reduce 10 out of 12 waste to the quality standard. Intermittent system can only reduce 6 out of 12 waste to the quality standard. Besides 5 systems above, other Waste Treatment Systems cannot reduce the BOD value of Natural Dye Waste up to the BOD standard. According to Tables 3 and 4 above, only Aerobic-Anaerobic system meets the needs of waste treatment in the natural coloring process.

3.4 Room Requirements for the Natural Dye WWTP system

From the conclusion of the selection of the WWTP system that has been carried out above, the appropriate system used to treat natural coloring liquid waste is the Anaerobic-Aerobic system. The space needed for the process of the Batik Natural Dyes with Anaerobic-Aerobic WWTP system is as follows:

- Size of Fat Seperator Tub: 6.5 m x 1.5 m x 2.4 m Area: 9.75 m²
- Size of Equalization Tub: 8.4 m x 6.4 m x 3 m Area: 53.76 m²
- Size of Initial Sedimentation Tub: 6.2 m x 2 m x 2.5 m Area: 12.4 m²
- Size of Biofilter Anaerob Tub: 4.2 m x 2 m x 2.5 m Area: 8.4 m²
- Size of Biofilter Aerob Tub: 5.4 m x 2 m x 2.5 m Area: 10.8 m²
- Size of Final Sedimentation: 1.5 m x 2 m x 2.5 m Area: 3.0 m²
- Size of Chlorination Tub: 0.3 m x 0.3 m x 0.4 m Area: 0.09 m²
- Total Area: 98.2 m²
4. Concluding Remarks
The study of the connection between Natural Dye waste contents and the WWTP system selected are as follows:
- The largest BOD and COD value on natural dyes Batik process are 2870 mg/L and 8345 mg/L
- WWTP system that can reduce the value of BOD and COD of natural dyes is an anaerobic-aerobic system with a percentage decrease in BOD 99.82 %, and COD 98.90%
- Space requirements for Aerobic-Anaerobic systems are: Fat Separator Tub, Equalization Tub, Initial Sedimentation Tub, Anaerobic Biofilter Tub, Aerob Biofilter Tub, Final Sedimentation Tub, and Chlorination Tub with total area 98.2 m².

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