Batik Pemalang Organic Wastewater Composition and Simple Electrocoagulation-Filtration Treatment

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Abstract. Wastewater produced by batik industry in Cibelok Village, Pemalang that is disposed straight into the sewage will increase the concentration of Biochemical Oxygen Demand (BOD), ammonia (NH3), Chemical Oxygen Demand (COD), chromium (Cr), lead (Pb), watercolour, acidity (pH), and dissolved oxygen (DO). Disposed batik wastewater without treatment will contaminate the environment, mainly its water and soil. The main purpose of this research is to reduce the concentration of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), ammonia (NH3), chromium (Cr), lead (Pb), watercolour, acidity, and dissolved oxygen (DO) by treating batik Cibelok's waste and not contaminate the surrounding environment. Laboratory test results on batik waste in COD, BOD, ammonia, chromium, lead, colour, and acidity (pH). These results are not in accordance with the 2014 Waste Water Quality Standard Number 5 by the Regulation of the Minister of Environment of the Republic of Indonesia. Alternatives that have been done to treat Cibelok Village's batik waste is to lower dangerous substances concentration through electrocoagulation and filtration. The processes could lower COD level around 57.6%, ammonia 98%, chromium 85%, and BOD 67%. Reducing the concentration of the substance makes the batik waste safer and environmentally friendly when it's finally disposed to the sewage.

1. Introduction

Batik industry in Pemalang Regency, Central Java is experiencing very rapid growth. Batik, as a distinctive Indonesian commodity, has become one of the livelihood sectors for the community. Unfortunately, batik production process produces large volumes of organic waste [1]. This caused by the resulting waste in the form of coloured liquid. The amount of waste is increasing because of industries and households that produce batik grows along with the increasing market demand.
Batik waste produced by industry is liquid waste that has various kinds of impacts, both on health and the environment. Parameters used as a reference to determine the level of "unhealthy" of batik wastewater include: DO (Dissolved Oxygen), BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), phosphorus intensity, intensity of heavy metals, CO2 content, pH, nitrogen, inorganic and organic suspended solids, and total solids both inorganic and organic \[2,3\]. In addition, an easy parameter to observe using the senses regarding the level of "unhealthy" of this waste is the presence of a pungent odour, turbid color and tend to be concentrated.

Various methods, both conventional and modern, have been developed by researchers to overcome and reduce the negative impact of wastewater. Techniques that have been developed include degradation using microbial \[3,4\], using photocatalyst techniques \[5,6\], utilization of activated carbon \[7\], Fenton activity \[8\], ozone technology \[9\], ultraviolet light energy \[10\], and electrocoagulation techniques \[11-13\]. Among these methods, electrocoagulation is the most suitable choice to be applied in solving the waste problem from the batik industry in Pemalang district. This is because the technique is simple, does not require a lot of chemicals, is economical and can be applied to organic or inorganic waste. Besides, this technique has been proven to work well to reduce pollutants in the case of textile waste \[14\].

In this research study, plate electrodes (aluminum) used for electrocoagulation method will be combined with a filtration system in hopes of obtaining optimal results. To test the success rate, the treatment results were verified using instruments so that the parameter analysis of the "health" level of Pemalang batik was obtained.

### 2. Materials and Methods Research

#### 2.1 Reagent and materials

Some materials are used in the coagulation and filtration process. In the coagulation process, aluminium plates, cables and crocodile clamps are used. In the filtration process using gravel, sand, coconut shell, palm broom, zeolite, and gauze.

For batik liquid waste testing materials used reagents from Hanna Instruments. The reagents used in the analysis are Ammonia MR (HI-93715A-0 and HI 93715B-0), Chromium VI HR (HI 93723-0), Dissolved Oxygen (HI 93732A-0, HI 93732B, and HI, 93732C-0), Oxygen Request for MR (HI 93754B-25).

#### 2.2 Research Methods

![Figure 1 Schematic wastewater batik treatment](image-url)
The schematic for the formation of wastewater batik treatment is shown in figure 1. The research method starts with collecting batik waste samples from Cibelok, Pemalang. The research process is through two stages, namely electrocoagulation and filtration.

The results obtained from data collection in the form of primary data obtained from laboratory tests on batik liquid waste in Cibelok, Pemalang. Sampling was carried out directly on the batik industry which at that time carried out the production process located in Cibelok, Pemalang. The parameters to be analyzed are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), chromium (Cr), ammonia (NH₃), lead (Pb), watercolour, acidity, and dissolved oxygen (DO). Analysis of these parameters is carried out following standard analysis procedures.

2.3 Optical characterisations of wastewater batik

The COD (Chemical Oxygen Demand) analysis of the samples to quantify the number of organics in water. In testing The COD (Chemical Oxygen Demand) is heated using HANNA Instruments (HI 839800 COD Reactor 2008 series). Analysis of colour water, ammonia, chromium, DO, BOD, using HANNA Instruments (HI 83099 COD and Multiparameter Photometer). The PH analysis of batik liquid waste by PIXMA.

3. Results and Discussion

3.1 The quality of batik wastewater

Treatment of Pemalang batik wastewater has been carried out using electrocoagulation method is shown in figure 2. Treatment can take place because of chemical reaction of the electrolysis mechanism of the electrodes. Systematic work of principle electrocoagulation's is by neutralizing the charge of a negatively charged colloidal cationic hydrolysis product and combining impurities in amorphous hydroxide deposits. The process that occurs in the aluminium electrode is explained as in the following scheme [15]:

\[
\begin{align*}
\text{Al} & \rightarrow \text{Al}^{3+} + 3e^- \quad \text{(anode)} \quad (1) \\
2\text{H}_2\text{O} + 2e^- & \rightarrow \text{H}_2 + 2\text{OH}^- \quad \text{(cathode)} \quad (2)
\end{align*}
\]
Batik waste from Cibelok Village has been tested for its organic content. Laboratory test parameters show the results of the Quality Standards based Wastewater Quality Standards 2014 number 5 on the Regulation of the Minister of Environment of the Republic of Indonesia. Data considered by Table 1.

| Parameter              | Highest level (mg/L) | Highest pollution load (kg/ton) |
|------------------------|----------------------|---------------------------------|
| BOD₅                   | 60                   | 5                               |
| COD                    | 150                  | 15                              |
| Chromium (Cr)          | 1.0                  | 0.1                             |
| Ammonia Total (NH₃-N)  | 8.0                  | 0.8                             |
| pH                     | 6.0-9.0              | 6.0-9.0                         |

This study aims to measure the batik wastewater content in Cibelok Pemalang Village, and the results are described in Table 2.

| Parameter           | Results (mg/L) |
|---------------------|----------------|
| BOD                 | 4750           |
| COD                 | 10600          |
| DO                  | 4950           |
| Chromium (Cr)       | 17800          |
| Ammonia Total (NH₃-N)| 60             |
| pH                  | 10             |

In Table 2 it can be explained that the results of the Cibelok Village batik waste test exceed the specified quality standards. The result of color water is very concentrated, namely 81200 PCU. So treatments are carried out to reduce levels of metal content in waste. In Figure 3 gives a picture of the color change in wastewater that has gone through the electrocoagulation and filtration process. Sample 1 is a pure sample of batik waste before the treatment process, sample 2 is the result of preliminary coagulation, sample 3 is the result of advanced coagulation, while sample 4 is the result of advanced coagulation combined with the filtration process. The electrocoagulation and filtration processes have produced more evident water quality than the real batik wastewater at number 1.
Figure 3. Colour of water

The results of color water testing is shown in Table 3. Sample 1 (before treatment), sample 2, sample 3 and sample 4 (through the process of coagulation and filtration). Tested using HANNA Instruments (HI 83099)

| Parameter       | Results  |
|-----------------|----------|
| Color Water 1   | 81200    |
| Color Water 2   | 34700    |
| Color Water 3   | 9900     |
| Color Water 4   | 9600     |

3.2 COD (Chemical Oxygen Demand) Analysis

Figure 4 shows the COD testing process in a laboratory using HANNA Instruments HI 839800. The test results in Table 4 testing batik waste before processing is very high at 10600 mg / l.

| Parameter | Results (mg/L) |
|-----------|----------------|
| COD 1     | 10600          |
| COD 2     | 1700           |
| COD 3     | 1500           |
| COD 4     | 1500           |

The decrease in COD content of samples 2-4 is influenced by the coagulation process in which the process of accumulating metal particles. Filtration also has a big effect because it filters out the lumps that are leftover from the coagulation process.
3.3 DO (Dissolved Oxygen) Analysis

One of the most important parameters in quality analysis is DO (Dissolved Oxygen). Dissolved oxygen is needed by biota for breathing, the metabolic process of marine biota [4]. DO content that is too low can cause fish to die. Whereas DO that is too high is also very dangerous for the environment including the increasingly rapid corrosion process on metals [5].

Figure 5 shows the DO (Dissolved Oxygen) laboratory testing process. According to qualitative data it appears that sample 1 looks clearer than the other samples. Whereas the test sample which has a lower DO is DO 2, seen from Table 5.

| Parameter | Results (mg/L) |
|-----------|----------------|
| DO 1      | 5000           |
| DO 2      | 4450           |
| DO 3      | 4850           |
| DO 4      | 4850           |
3.4 BOD (Biological Oxygen Demand)

BOD (Biological Oxygen Demand) defines a lot of oxygen needed by bacteria to stabilize organic matter that can be broken down carried by aerobes. It can also be explained that BOD is the amount of oxygen in milligrams needed by microorganisms to decompose biochemically organic substances in 1 liter of water for 5x24 hours at 20°C [6].

| Parameter | Results (mg/L) |
|-----------|----------------|
| BOD 1     | 4750           |
| BOD 2     | 2050           |
| BOD 3     | 1600           |
| BOD 4     | 1600           |

Based on Table 6. The test results for knowing the BOD results. The highest BOD yield was in the BOD 1 sample. The BOD 4 sample results showed the lowest decrease compared to other samples.

3.5 Ammonia MR and Chrom (Cr) HR

Ammonia MR and Chrom (Cr) HR tests are very important parameters in wastewater testing. Table 7 results show the results of reduced ammonia content in wastewater.

| Parameter | Results (mg/L) |
|-----------|----------------|
| Ammonia 1 | 60             |
| Ammonia 2 | 32             |
| Ammonia 3 | 1              |
| Ammonia 4 | 0              |

Table 7 shows the results of the chrome test. Samples 1-4 show a significant reduction.

| Parameter | Results (mg/L) |
|-----------|----------------|
| Chromium 1| 17800          |
| Chromium 2| 11900          |
| Chromium 3| 3400           |
| Chromium 4| 1500           |

3.6 Quality wastewater analysis

Overall the results of the test showed that the results were still less than the standard quality of Indonesian waste. Even so, the results of water quality testing are said to be better than waste without coagulation and filtration processes, shown on Table 9.
| Parameter                  | Before treatment (mg/l) | After treatment (mg/l) |
|----------------------------|------------------------|------------------------|
| COD                        | 10600                  | 1500                   |
| DO                         | 5000                   | 4850                   |
| BOD                        | 4750                   | 1600                   |
| Ammonia MR Chrom (Cr)HR    | 60                     | 0                      |
| pH                         | 10                     | 9                      |
| Color water                | 81000 pcu              | 9600 pcu               |
| pH                         | 10                     | 9                      |

4. Conclusion

The reduction and testing of the content of batik waste have been successfully carried out. This research is to reduce the concentration of ammonia (NH\textsubscript{3}), chromium (Cr), Chemical Oxygen Demand (COD), watercolour, acidity, Biochemical Oxygen Demand (BOD), and dissolved oxygen (DO) by treating batik Cibelok's waste and not contaminate the surrounding environment. The processes could lower COD levels around 57.6%, ammonia 98%, chromium 85%, and BOD 67%. Reducing the concentration of the substance makes the batik waste safer and environmentally friendly when it's finally disposed to the sewage.

References

[1] Puspitasari E 2018 January Treatment of wastewater batik by electrochemical coagulation using aluminium (Al) electrodes. In *IOP Conference Series: Materials Science and Engineering* 299(1) p 012081 IOP Publishing

[2] Gaur N, Narasimhulu K and PydiSetty Y 2018 Recent advances in the bio-remediation of persistent organic pollutants and its effect on environment. *Journal of cleaner production* 198 pp 1602-1631

[3] Muchtasjar B Hadiyanto H & Izzati M 2019 August Microbial degradation of batik waste water treatment in Indonesia. In *IOP Conference Series: Earth and Environmental Science* 314(1) p 012020 IOP Publishing

[4] McMullan G, Meehan C, Conneely A, Kirby N, Robinson T, Nigam P and Smyth W F 2001 Microbial decolourisation and degradation of textile dyes. *Applied microbiology and biotechnology* 56(1-2) pp 81-87

[5] Sutanto H, Wirboso S, Nurhasanah I, Hidayanto E and Hadiyanto H 2016 Ag doped ZnO thin films synthesized by spray coating technique for methylene blue photodegradation under UV irradiation. *International Journal of Chemical Engineering*

[6] Sutanto H, Wirboso S, Hidayanto E, Nurhasanah I and Hadiyanto H 2015 Synthesized of Double Layer Thin Film ZnO/ZnO: Ag by Sol-Gel Method for Direct Blue 71 Photodegradation *Reaktor* 15(3) pp 175-181

[7] Yasin Y, Hussein M Z and Ahmad F H 2007 Adsorption of methylene blue onto treated activated carbon *Malaysian Journal of analytical sciences* 11(2) pp 400-406

[8] Kantar C, Oral O and Oz N A 2019 Ligand enhanced pharmaceutical wastewater treatment with Fenton process using pyrite as the catalyst: Column experiments *Chemosphere* 237, p 124440

[9] Von Sonntag C and Von Gunten U 2012 Chemistry of ozone in water and wastewater treatment *IWA publishing*
[10] Ibrahim N, Zainal S F F S and Aziz H A 2019 Application of UV-Based Advanced Oxidation Processes in Water and Wastewater Treatment. *In Advanced Oxidation Processes (AOPs) in Water and Wastewater Treatment* pp 384-414 IGI Global

[11] Liu F, Zhang Z, Wang Z, Li X, Dai X, Wang L and Wang S 2019 Experimental study on treatment of tertiary oil recovery wastewater by electrocoagulation *Chemical Engineering and Processing-Process Intensification* **144**, 107640

[12] Núñez J, Yeber M, Cisternas N Thibaut R Medina P & Carrasco C 2019 Application of electrocoagulation for the efficient pollutants removal to reuse the treated wastewater in the dyeing process of the textile industry *Journal of hazardous materials* **371**, 705-711

[13] Syam Babu D Anantha Singh T S Nidheesh P V & Suresh Kumar M 2019 Industrial wastewater treatment by electrocoagulation process *Separation Science and Technology* 1-33

[14] Koby M, Can O T and Bayramoglu M 2003 Treatment of textile wastewaters by electrocoagulation using iron and aluminum electrodes *Journal of hazardous materials* **100**(1-3) pp 163-178

[15] Mouedhen G, Feki M, Wery M D P and Ayedi H F 2008 Behavior of aluminum electrodes in electrocoagulation process *Journal of hazardous materials* **150**(1) pp 124-135