Batik Home Industry Wastewater Treatment Using UVC/Ozon Oxidation Method: Case Study in Cibelok Village, Pemalang, Indonesia

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Abstract. Batik is one of Indonesia's cultural heritages that spread across various regions with their unique characteristics. One of the regions that have batik industries is Pemalang Regency. However, batik industries also contribute to liquid waste. Wastewater containing pollutants such as waxes, resins, dyes, and binders such as silicates produce high concentrations of Biochemical Oxygen Demand (BOD) and vibrant colors. There are still many batik enterprises that discard wastewater directly to the environment without being processed first. This study aims to degrade Remazol Black B and Biochemical Oxygen Demand (BOD) dyes in batik liquid waste to contact time variations 0, 15, 30, 45, 60 minutes with UVC-Ozone oxidation methods. The Ozone-UVC method is an alternative method for decolorization and degradation of BOD. The dye degradation test was carried out using Spectroquant UV / VIS Spectrophotometer, and the BOD degradation test was carried out using Dissolved Oxygen - DO Meter AZ-8403. The result shows that the BOD degradation at batik wastewater was from 190.17 – 96.83 mg/L. Visually, the increase in treatment time makes the sample look clearer (decolorization), evidenced by the sample image and decreased absorbance results.

1. Introduction

Batik is a valuable technique, symbolism, and cultural heritage of Indonesia. In 2009, UNESCO (The United Nations Educational, Scientific and Cultural Organization) officially designated Indonesian batik as "Intangible Cultural Heritage of Humanity." The batik industry is spread in various regions in Indonesia with their respective characteristics. One area that has a home-based batik industry is in Pemalang Regency. Cibelok Village is a home-based batik industry center in Pemalang Regency. In the process of making batik, there is a coloring process that requires coloring. The batik industry uses natural dyes, such as turmeric, mango leaves, Indigofera leaves, and also synthetic dyes (artificial), such as indigosol, naphthol, and remazol. However, synthetic dyes are more often used by the batik
industry because they are faster in terms of making, practical, and also economical [1]. One of the
dyes that are often used is remazol, including in the batik home industry of Cibelok Village. Remazol
is classified as azo dyes, which are dyes that have double N = N bonds, and if they stay in the
environment for too long, they will become a source of disease because they are carcinogens and
mutagens [2].

Therefore, the batik industry is also one of the contributors to liquid waste. There are still many
batik industries that discard wastewater directly into the environment without being treated first. This
waste disposal without prior processing causes pollution of the aquatic environment. The coloring
agent is the primary pollutant contained in batik liquid waste. Wastewater containing pollutants such
as waxes, resins, dyes, and binders such as silicates produce high concentrations of Biochemical
Oxygen Demand (BOD) and vibrant colors [3-4]. Wastewater treatment technology can be carried out
biologically and physicochemically. Biological methods can be carried out by the use of microorganisms to decompose organic compounds contained in batik liquid waste. However, this
method is less effective because dyes have resistance to biological degradation [5]. Physicochemical
methods such as activated carbon adsorption have good adsorption ability to remove color, odor, oil,
and organic pollutants but cause new waste that is floc /coagulant, which cannot be used anymore and
high cost [6-7].

For this reason, a more efficient and affordable batik industry wastewater treatment method is needed.
The Ozone-UVC method is an alternative method for decolorization and BOD degradation. This study
used a combination of ozone and UVC rays. Chemical oxidation can be used to degrade organic
pollutants that are difficult to decompose, including surfactants found in wastewater. One of the
oxidants that can be used is ozone (O3) [8]. Ozone has to remove the color from wastewater. This is
evidenced by various studies that have existed before [9]. Processes that use this combination of
oxidants with ultraviolet (UV) irradiation to form hydroxyl radicals (HO ·) resulting from the
decomposition of hydrogen peroxide can oxidize organic compounds contained in wastewater more
efficiently [10].

2. Method

2.1. Materials

The sample used in this research was liquid batik waste (remazol black b dye). Samples were taken
directly from the batik home industry, Cilebok, Pemalang Regency. The tools used in this research are
UV-C lamps, ozone reactors, magnetic stirrers, measuring cylinders, and beaker glasses.

2.2. Procedure

![Figure 1. Experimental Set-Up.](image-url)
Control variations in this study were UV irradiation using wavelength 365 nm and ozonation rate of 400 mg / h. The research procedure was carried out by homogenizing 1.2 liters of batik liquid waste using magnetic stirrer for 5 minutes at 70° C, then degraded under UV-C with ozonation for 0, 15, 30, 45, and 60 minutes.

2.3. Characterization
The optical properties of batik waste were analyzed using Ultraviolet-Visible Photospectroscopy (Shimadzu 1240 SA, Japan), the value of Biochemical Oxygen Demand was tested using an Instrument Dissolved Oxygen Meter (AZ-8403 Series), while the acidity of the sample was tested using AD100 Standard Pocket pH Tester.

3. Results and Discussion
3.1. UV-Vis (Ultraviolet-Visible) Analysis
Degradation of batik waste taken directly from the home industry in the village of Cilebok, Pemalang Regency, Central Java Province, has been successfully carried out. Before treatment, batik waste appears to have a deep black-red color, as shown in figure 1 (a). This dark color confirms the presence of remasol, organic pollutants, and various types of heavy metals in the waste. While concentrations indicate that the waste is polluted with high concentrations of pollutants.

Figure 1 (b-e) shows the results of the sample after UV-Ozone irradiation for 15 to 60 minutes. Visually, increasing treatment time makes the sample look clearer (decolorization). This qualitative result is strengthened by the results of quantitative testing using a UV-Vis spectrophotometer. At a peak wavelength of 312 nm sample 0; 15; 30; 45; and 60 minutes showed an absorbance value of 1.87; 1.05; 1.00; 0.82; and 0.81. Similarly, at other wavelengths, the absorbance value decreases with increasing treatment time. This shows that UV / Ozone can increase transmittance and effectively purify solid waste. Then, the absorbance peaks at 312 nm and 469 nm, which were originally owned by the waste, were significantly reduced at 15 and 30 minutes treatment times and disappeared at 45 and 60 minutes. This shows that UV irradiation and ozonation have succeeded in reducing the concentration of pollutants.
Ozone combined with UV irradiation has been used as a possible alternative for the degradation of organic contaminants for a long time [11]. Ozone is a volatile molecule and has a very short half-life. Ozone will decompose in the form of oxygen (O2), and one oxygen ion (O-), which functions like a bullet fired to kill bacteria, germs, fungi and other micro-organisms [12]. Ozone has two mechanisms to degrade a pollutant, by direct oxidation by ozone molecules and indirect oxidation by • OH radicals that have been formed through ozone decomposition of waste solutions [13]. UV is irradiated during the ozonation process to be able to degrade waste more efficiently by producing hydroxyl radicals produced from hydrogen peroxide decomposition. The reactions that take place in the process are as follows [14]:

\[
\begin{align*}
\text{O}_3 + \text{UV} + \text{H}_2\text{O} & \leftrightarrow \text{H}_2\text{O}_2 + \text{O}_2 \\
\text{H}_2\text{O}_2 + \text{UV} & \leftrightarrow 2 \text{OH}
\end{align*}
\]

3.2. BOD (Biochemical Oxygen Demand) Analysis

![Figure 3](image1.png)

**Figure 3.** Absorbance spectrum based on increasing treatment time.

![Figure 4](image2.png)

**Figure 4.** Degradation of BOD in batik wastewater.
Based on the graph that was formed, it was seen that the decrease in BOD concentration occurred gradually at each time variation. The decrease in BOD occurred from the initial BOD value of 190.17 mg/L in the 0th minute or the BOD value before the wastewater was treated until the 60th minute after the wastewater was treated. The best decrease in BOD occurred in the 30th minute before then the BOD concentration value rose again, this was due to the presence of bacteria that began to be resistant to ozone, so the amount of oxygen needed to degrade waste organic matter increased again [15]. The best value of the reduction in concentration is at the 30th minute 96.83 mg/L. Table 1 showed that the highest concentration of reduction efficiency occurs at the 30th minute by 49.08%. An increase in the value of efficiency occurs at a value that is not large and significant in every minute variation until it occurs at the 30th point and then decreases at the 45th minute.

| Parameter | Before Treatment (mg/L) | After Treatment (mg/L) | 15 minutes | 30 minutes | 45 minutes | 60 minutes |
|-----------|-------------------------|------------------------|------------|------------|------------|------------|
| BOD       | 190.17                  |                        | 110.83     | 96.83      | 109.67     | 136.5      |
|           |                         |                        | (41.72%)   | (49.08%)   | (42.33%)   | (28.22%)   |

4. Conclusion

Black remazol dyes in batik industry liquid waste can be degraded and decolorization of Biochemical Oxygen Demand (BOD) degradation by UV and ozone radiation methods. The decrease in BOD in batik wastewater was 28.22-49.08%. The optimum BOD reduction condition occurred in the 30th minute with a concentration value of 96.83 mg/L and efficiency value of 49.08%. The absorbance peaks at 312 nm and 469 nm, which were initially owned by the waste, were significantly reduced at 15 and 30 minutes treatment times and disappeared at 45 and 60 minutes. This shows that UV irradiation and ozonation have succeeded in reducing the concentration of pollutants.

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