Absorption of indigosol dye waste from batik home industry at ex redlight district, Dolly, Surabaya using activated carbon

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Abstract. Research on adsorption of indigosol batik dye waste that derived from batik home industry from ex redlight district, Dolly, Surabaya using activated carbon has been done. The variation of contact time and adsorbent dosage was optimized. This research was conducted by a batch method. The contact time was varied from 10-70 minutes. The adsorbents dosage was varied from 2-14 mg/25 mL. The dilution factor was varied from 160-240 for initial concentration. This research was aimed to obtain the optimum conditions of indigosol adsorption onto activated carbon. Spectrophotometer UV-Vis shows that the equilibrium of indigosol adsorption by activated carbon was achieved at 50 minutes contact time. In addition, the highest indigosol removal by the addition of 10 mg activated carbon in 25 mL indigosol solution with the dilution factor of 200 for initial concentration. The result, 72.73% was optimum indigosol removal. From the analysis results, it can be concluded that the optimum conditions for indigosol adsorption using activated carbon were achieved at 50 minutes contact time with an adsorbent dosage of 10 mg/25 mL and the dilution factor was 200 for initial concentration.

1. Introduction

Surabaya is the capital of East Java province where local government, politics, commerce, industry, education, and culture were located. Surabaya is also a city that has the 6\textsuperscript{th} largest redlight district in Southeast Asia of which include Dolly, Bangunsari, Kermil, Klakah Rejo, and Moroseneng \cite{1}. The development process of the prostitution activity is supported by market mechanisms that make prostitution more profitable \cite{2}. Finally, on June 19, 2014, Dolly redlight district was closed by Dr. Ir. Tri Rismaharini, Mayor of Surabaya. To cope with the employment problem for the citizens affected by the closing, some NGO provides capital assistance that worth Rp 3 million to create new business and developing Dolly area as tourist attractions\cite{1}. Many people in the area set up and make business in the field of textiles craft. Rumah Batik is one of a new home industry located at the West Street VIII B No. 31 Putat Jaya, Dolly. The common coloring agents used in Rumah Batik were Remasol, Indigosol, and Naphthol. The dye compounds were dangerous if directly discharge to the environment. However, the communities surrounding Rumah Batik Dolly were not aware of the risk as well as treatment to handle wastewater that produced.

The textile dye is a compound which can provide color on the surface of the fabric. The majority of textile dyes have complex organic structures. Indigosol is one of the most commonly used dyes in textile\cite{3,4}. Indigosol waste that exists in the environment requires special attention because of its...
toxicity to the environment. Indigosol can cause skin disease and damage the eye cornea [5-7]. For years, the methods to reduce indigosol waste was studied i.e. precipitation, adsorption, and photocatalysis [8-9]. Adsorption is one of the most effective methods for wastewater treatment that used by industry to reduce the inorganic and organic pollutants [10]. Many of the textile industry was used activated carbon to absorb commercial dye wastewater. Activated carbon was adsorbent which is economical and has high efficiency [11]. Adsorption by batch adsorption was carried out by the addition of adsorbent to a solution that contains substances to be absorbed [12]. The absorption efficiency was determined by UV-Vis Spectrophotometry technique. The difference of the solution absorbance before and after adsorption was compiled to obtain optimum adsorption condition[13].

2. Experimental

Materials
The material used in this research i.e. Indigosol Dye that was obtained from a local store and used without further purification, academic for dye solvent, activated carbon (Merck KGaA) that was used as absorbent and indigosol waste that obtained from Rumah Batik, Dolly, Surabaya. Dye removal was monitored by UV-Vis Spectrophotometer (Genesy 10S)

2.1 Standard Calibration Curve
A stock solution of 1000 ppm was prepared by dissolution of 0.25 grams of indigosol yellow powder in 250 mL of aquademin. A stock solution of 100 mL was diluted into 1000 mL to obtain a solution of 100 ppm. Furthermore, the maximum wavelength was determined by wavelength scanning of 100 ppm solution using UV-Vis spectrophotometer. After that, out of 100 ppm solution was further diluted to 10 ppm 20 ppm, 30 ppm, 40 ppm, 50 ppm, and 60 ppm in 10 mL measuring flask. The absorbance of each solution was plotted as a function of its concentration to make a calibration curve.

2.2 Preparation of Indigosol Waste
Indigosol waste from Rumah Batik of 5 ml was diluted to 1000 ml. Further dilution by a dilution factor of 200 was carried out so that the sample absorbance was in the range of calibration curve. Any particulate that presents in the sample was removed by mean of centrifugation at 250 rpm for 30 minutes followed by decantation. The filtrate obtained was analyzed using spectrophotometer UV-Vis at wavelength ranges of 350-800 nm.

2.3 Contact Time Optimization for Indigosol Natural Waste
Activated carbon of 10 mg was added into 25 mL of Indigosol waste solution in a 250 mL beaker. The mixture was stirred at varied contact time i.e. 10, 20, 30, 40, 50, 60, and 70 minutes. From each contact time variation, the filtrate was tested for absorbance using a UV-Vis spectrophotometer at the maximum wavelength.

2.4 Adsorbent Dosage on Indigosol Natural Waste
Indigosol waste of 25 mL was put into a 250 mL beaker. Activated carbon of 2, 4, 6, 8, 10, 12, and 14 mg was added to the indigosol solution. The mixture was stirrer at optimum contact time. Every time the variation of the dose of the adsorbent is done 3 times the test to get triple data. The remaining filtrates were then tested for their absorbances using a UV-Vis spectrophotometer at the maximum wavelength.

2.5 Initial Concentration on Indigosol Natural Waste
Indigosol waste of 25 mL was put into a 250 mL beaker. The variation of initial concentration were 160, 180, 200, 220, and 240 of the dilution factor. Every initial concentration was analyzed using a
spectrophotometer UV-Vis to get the initial absorbances. Activated carbon in optimum adsorbent dosage was added to the indigosol solution. The mixture was stirred at optimum contact time. Every time the variation of the initial concentration is done 3 times the test to get triple data. The remaining filtrates were then tested for their absorbances using a UV-Vis spectrophotometer at the maximum wavelength.

3. Results and Discussion

3.1. The Calibration Curves of Yellow Indigosol Dyes

The maximum wavelength of yellow indigosol dye solution can be seen in Figure 1

![Figure 1. The maximum wavelength Indigosol Yellow solution](image)

Figure 1 shows that the maximum wavelength of the indigosol yellow batik dye solution was at 465 nm. The wavelength was in accordance with the yellow complement color wavelength that lies between 435-480 nm [14]. The absorbances of indigosol yellow dye solution with concentration from 10 - 60 ppm were measured using UV-Vis spectrophotometer at maximum wavelength, 465 nm. The absorbances obtained were presented in Table 1.

| Solution concentration (ppm) | Absorbance (A) |
|------------------------------|----------------|
| 10                           | 0.137          |
| 20                           | 0.25           |
| 30                           | 0.365          |
| 40                           | 0.464          |
| 50                           | 0.576          |
| 60                           | 0.673          |

The plot of absorbance as Indigosol Yellow concentration function was presented in Figure 2 below:
Figure 2. Calibration curve of Indigosol Yellow solution

The regression equation that obtained from Figure 2 was used to determine the concentration of indigosol waste sample as shown in Equation 1.

\[ y = 0.0107x + 0.0351 \]  

Information:
\[ y = \text{absorbance} \]
\[ x = \text{Indigosol Yellow concentration} \]

3.2 The Maximum Wavelength of Indigosol Waste Solution

Initial Indigosol waste solution was diluted 200 times and centrifuged to separate any particulates in the solution. The maximum wavelengths of indigosol waste solution were shown in Figure 3.

![Figure 3. Maximum wavelength of Indigosol waste solution](image)

Based on the graph, the maximum wavelength of Indigosol waste above was at 465 nm with an absorbance of 0.616. The absorbance data obtained, then calculated to obtain the initial concentration
of indigosol waste sample solution through Equation 1. From the linear regression equation of the calibration curve, it was obtained that the initial concentration of the Indigosol waste solution was 54.29 ppm.

3.3 Contact Time Optimization of Indigosol Waste Solution

The contact time optimization that obtained from triple measurement showed that the standard deviation was ≤ 2%. Thus, the measurement precision statistically satisfied [15]. The % Removal was calculated following Equation 2 below:

\[
\% \text{Removal} = \frac{C_{\text{init}} - C_{\text{final}}}{C_{\text{init}}} \times 100\% 
\]

Information:

\(C_{\text{init}} = \) Initial concentration of Indigosol Yellow

\(C_{\text{final}} = \) Concentration of Indigosol Yellow after adsorption

The averages of % Removal of Indigosol Yellow at varied contact time were presented in Table 2.

| Contact time (minutes) | % Removal average (%) |
|------------------------|-----------------------|
| 10                     | 47.34 ± 1.70          |
| 20                     | 57.50 ± 0.30          |
| 30                     | 65.53 ± 0.50          |
| 40                     | 70.81 ± 0.10          |
| 50                     | 72.53 ± 0.10          |
| 60                     | 72.59 ± 0.20          |
| 70                     | 72.93 ± 0.26          |

The correlation between contact time and the average of % Removal was plotted in Figure 4 below:

![Figure 4. Correlation between contact time and average % removal of Indigosol waste](image)

From Figure 4, it was obtained that the optimum contact time for adsorption of indigosol waste using activated carbon was 50 minutes. Thus, the optimum contact time will be used for the next optimization.

3.4 The Optimization of Adsorbent Dosage on Indigosol Waste Adsorption

The averages % Removal at varied adsorbent dosage were tabulated in Table 3. The average of % removal was plotted as the dosage of adsorbent function. The graph of the % Indigosol removal at varied adsorbent dosage can be seen in Figure 5 below:
From Figure 5, it can be seen that the optimum adsorbent dosage for indigosol waste adsorption using activated carbon was 10 mg/25 mL of Indigosol solution.

Table 3. The average of % Removal at a varied adsorbent dosage

| Adsorbent dosage mg/25 mL | % Removal average (%) |
|---------------------------|-----------------------|
| 2                         | 55.43 ± 0.30          |
| 4                         | 56.69 ± 0.10          |
| 6                         | 62.60 ± 1.05          |
| 8                         | 69.60 ± 0.80          |
| 10                        | 72.65 ± 0.34          |
| 12                        | 72.24 ± 0.70          |

Figure 5. The activated carbon dosage for Indigosol Yellow waste adsorption

3.5 The Optimization of Initial Concentration on Indigosol Waste Adsorption

The averages % Removal at varied initial concentration were tabulated in Table 4.

Table 4. The average of % Removal at an initial concentration

| Dilution Factor | % Removal average (%) |
|-----------------|-----------------------|
| 160             | 65.34 ± 0.17          |
| 180             | 65.92 ± 1.22          |
| 200             | 72.73 ± 0.31          |
| 220             | 72.99 ± 1.76          |
| 240             | 72.94 ± 0.99          |

The average of % removal was plotted as the dilution factor function. The graph of the % Indigosol removal at varied initial concentration can be seen in Figure 6 below:

From Figure 6, it can be seen that the optimum initial concentration for indigosol waste adsorption using activated carbon was 200 of Indigosol solution.
Figure 6. The initial concentration for Indigosol Yellow waste adsorption

4. Conclusion
Based on the optimization results, it can be concluded that the optimum adsorption contact time for Indigosol Yellow waste solution onto activated carbon was 50 minutes with optimum removal of 72.53%. In addition, the optimum adsorbent dosage of activated carbon was 10 mg/25 mL of solution with optimum removal of 72.65%. And the optimum initial concentration of Indigosol Yellow natural waste solution is dilution factor of 200 with optimum removal of 72.73%.

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