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The effect of mixing speed and contact time on the process of dye adsorption using corncobs adsorbent

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Abstract. The home screen printing industry generally discharges wastewater directly into drainage without being processed first. By utilizing corncobs waste will reduce the amount of waste in the environment. The purpose of this study is to find out the optimum removal efficiency using corncobs in the removal of dyes. The manufacture of adsorbents using corncobs was dried and carbonized using a kiln to become charcoal powder. After the carbonization process, activated it using H₂SO₄. The dye adsorption process was carried out with variations in speed of 50, 75, 100, 125, and 150 rpm, variations in contact time of 0, 30, 45, 60, 90, and 120 minutes. From the results of this study it was found that the optimum conditions with a dye removal efficiency of 99.98% were obtained when the mixing speed was 100 rpm, contact time was 60 minutes, and the adsorbent dose was 10 g / L. From these results it can be said that the corncobs adsorbent is effective in removing the screen printing wastewater dye.

1. Introduction
The problem of environmental pollution in big cities, especially Jakarta has shown serious symptoms, especially the problem of water pollution. On the other hand the rate of development of a centralized municipal wastewater treatment system was still very low there are still many industries, both small and large industries that do not yet have a wastewater treatment unit, so that most wastewater still discharged into public waters without processing. Sources of dyes in the textile industry contain heavy metals such as copper (Cu), zinc (Zn), arsenic (As), cadmium (Cd) and lead (Pb). These heavy metals come from the process of making dyes for the textile industry [1]. One method for removing organic dyes in wastewater is the adsorption process [2]. All carbon-containing materials, whether derived from plants, animals, or minerals such as corncobs, coconut shells, cow bones, or coal, are raw materials that can be used as activated carbon [3]. The content of carbon compounds, namely cellulose (41%) and hemicellulose (36%) which is quite high indicates that corncobs have the potential to be a charcoal/active carbon making material [4]. This study used corncobs waste as an alternative adsorbent aimed to analyze the removal of dyes contained in screen printing wastewater at the household scale at the most optimum mixing speed and contact time and calculate the use of corncob waste as a field scale adsorbent.
2. Methodology

2.1. Activation of corncobs
Washing with clean water aims to remove impurities that stick to the corncobs. After the corncobs were washed clean, the next process was drying for 7-8 days to reduce the moisture content attached to the corncobs. After being dried in the sun for 7-8 days, then the corncobs were cut into small pieces and put in a furnace at 500°C for 50 minutes to form charcoal. Corncobs were mashed with uniform size and sieved with 100 mesh sieves. Charcoal that has been mashed, put in the desiccator. Activation of adsorbent was by soaking corncobs in H₂SO₄ with a concentration of 5% solution for 24 hours. Then the activated carbon was washed with distilled water and dried in an oven at 110°C for 2 hours.

2.2. Determination of mixing speed
Beaker glass size 600 mL filled with 250 mL screen printing wastewater. Then corncobs adsorbent was added with an adsorbent weight of 10 g. The mixture was stirred using Jartest with a speed variation of 50, 75, 100, 125, and 150 rpm with a time variation of 0, 30, 45, 60, 90, and 120 minutes. Then the solution was filtered with Whatman filter paper number 42 to separate residues from filtrate. The filtrate obtained was measured using a spectrophotometer with a wavelength of 450 nm. The mixing speed that produced the greatest allowance was expressed as the optimum mixing speed.

2.3. Removal efficiency and adsorption capacity analysis
The contact between solid and liquid phases was using the adsorption isotherm. Conversation between the two adsorptions phases can be determined using the Langmuir and Freundlich methods which are agreed in equality (1) and (2) [5]:

\[
\frac{C_e}{q_e} = \frac{C_e}{q_m} + \frac{1}{q_mK_l}
\]

\[
\ln q_e = \ln K_f + \frac{1}{n} \times (\ln C_e)
\]

Where \(q_e\) is the amount of dye absorbed (mg/g), \(C_e\) is dye concentration and equilibrium (mg/L), \(q_m\) is maximum adsorption capacity of adsorbent (mg/g), \(K_l\) is Langmuir isotherm constant, \(K_f\) is Freundlich isotherm constant (L/mg), and \(n\) is heterogeneity factor which shows the capacity and intensity of adsorption. Reactions that depend only on one substance or are proportional to one of the reactants are called first-order reactions. First order linear equation shown in equation (3) and second order linear equation shown in equation (4) as follows [6]:

\[
\ln (q_e - q_t) = \ln q_e - kl \times t
\]

\[
\frac{t}{q_t} = \frac{1}{K_2q_e^2} + \frac{t}{q_e}
\]

Where \(q_e\) is the number of metal ions absorbed at equilibrium (mg/g), \(q_t\) is the number of metal ions absorbed at time \(t\) (mg/g), \(t\) is time (minutes), \(K_l\) is the rate constant of constants (minutes⁻¹), \(K_2\) is the rate constant of constants (g.mg⁻¹.minute⁻¹).

3. Results and discussion

3.1. Color analysis of household screen printing wastewater
Screen printing waste water in this research was obtained from Krendang Timur Village, West Jakarta, which will be analyzed using corncobs adsorbents. Screen printing wastewater samples used by color were red, yellow, blue, black, green, and white. The results of the levels of screen printing wastewater characterization is shown in Table 1.
Table 1. Color levels of screen printing waste water.

| No | Sample       | Color Level (Pt-Co) |
|----|--------------|---------------------|
| 1  | Green color  | 173.32              |
| 2  | Blue color   | 164.18              |
| 3  | White color  | 135.06              |
| 4  | Yellow color | 130.21              |
| 5  | Black color  | 112.66              |
| 6  | Red color    | 18.82               |

Based on Table 1 shows that screen printing wastewater obtained from Krendang Timur Village, West Jakarta which has the highest color content was green, while the lowest color content was red.

3.2. Determination of optimum mixing speed
In determining the optimum speed, a 600 mL beaker glass was filled with 250 mL of screen-printing wastewater and then an adsorbent was added with a dose of 10 grams of adsorbent. The mixture was stirred using jartest with 5 speed variations, namely 50, 75, 100, 125, and 150 rpm with contact time of 0, 30, 45, 60, and 90 minutes to reduce the level of green color in screen printing wastewater. The effect of mixing speed and contact time on color removal efficiency showed in Figure 1.

![Figure 1. Effect of mixing speed and contact time on color removal efficiency.](image)

From Figure 1 shows that at each mixing speed had a different highest allowance percentage. However, at a mixing speed of 100 rpm with a contact time of 60 minutes it was considered to have the most effective allowance percentage value of 99.98%. This happened because the mixing speed of 100 rpm results in a uniform distribution process between the adsorbent and the adsorbate so that the adsorbent had an effective ability to reduce the color content in the screen-printing wastewater sample.

3.3. Isotherm adsorption
The coefficient of determination in the adsorption equation can be determined by the isotherm model. If the adsorption process shows a significant relationship between adsorbents and adsorbates, the coefficient of determination is close to one. The results of the Langmuir and Freundlich isotherm calculation of the optimum mixing speed of 100 rpm showed in Figure 2.a and Figure 2.b.
Figure 2. (a) Langmuir Isotherm to the optimal mixing speed of 100 rpm (b) Freundlich Isotherm to the optimal mixing speed of 100 rpm.

Table 2. Value of R² and constants of Langmuir and Freundlich Isotherms.

| Optimum Mixing Speed 100 rpm | Isotherm | R²    | Constant | Value  |
|-----------------------------|----------|-------|----------|--------|
|                             | Langmuir | 0.9997| a        | 1190.918|
|                             |          |       | b        | 0.086  |
|                             | Freundlich| 0.9999| K_f     | 63.694 |
|                             |          |       | n        | 0.083  |

Table 2 shows that the Langmuir and Freundlich isotherm R² values were close to 1. Adsorption of dyes was considered to follow the Freundlich isotherm model because it has a regression value close to one or almost follows a linear line of 0.9999 so that this type was more appropriate to be used for the mechanism of dye adsorption by corncob adsorbents. In the Freundlich isotherm, the maximum capacity (K_f) was obtained that is 63.694 mg/g and the n value was 0.083. If the value of 1/n is between 0 and 1, the dye is easily adsorbed. The physical adsorption process was the absorption that only occurred on the surface of the adsorbent in the Freundlich adsorption isotherm model.

3.4. Adsorption kinetics

To know the effect of initial concentration on screen printing wastewater on the mechanism of adsorption kinetics that occurs can be done by calculating the adsorption kinetics [6]. It shown that there is an adsorption kinetics graph using order 1 (Figure 3.a) and order 2 (Figure 3.b).
Figure 3. (a) Adsorption kinetics order 1 in mixing speed of 100 rpm, (b) Adsorption kinetics order 2 in mixing speed of 100 rpm.

In Figure 3 and Figure 4 show that the adsorption mechanism that occurred between the dyes and corncob adsorbents in the stirring speed with the optimum contact time for 60 minutes could be described by the kinetics of adsorption in order 2. It can be concluded that the greater the speed used with a long contact time and a large constant value, the less the content of the dyes contained in the sample. Another factor in the selection of the kinetics model is the k kinetics constant, k adsorption on the dyes produced using order 2 was greater than the order kinetics model 1. The transfer of adsorbate from the outer surface of the adsorbent into the inner surface of the adsorbent in the form of the adsorbent pores can affect the speed of adsorption. Adsorption kinetics value show in Table 3.

Table 3. Adsorption kinetics value.

| Adsorption Parameters | Order 1 | Order 2 |
|-----------------------|---------|---------|
| Mixing Speed 100 rpm   | k_1     | q_e     | R^2  |
|                       | -0.063  | 5.33E-04| 0.5  |
|                       | k_2     | q_e     | R^2  |
|                       | 0.0871  | 1       |

3.5 Application of use of corncobs on field scale

In this research, corncob raw material used on a laboratory scale of 12 kg which through a furnace process for 50 minutes produces 8 kg and after the mesh process with a vibration speed of 100 rpm for 2 hours produces 6 kg in screen printing wastewater as much as 20 liters. This research can be carried out on a field scale if a screen-printing industry can produce screen printing wastewater as much as 80 liters per day, then:

Calculation:

Field scale corncob raw material = \( \frac{12 \text{ kg}}{20 \text{ L}} \times 80 \text{ L} \)

= 48 kg

Field-scale corncob adsorbent dose = \( \frac{6 \text{ kg}}{20 \text{ L}} \times 80 \text{ L} \)

= 24 kg

Therefore, in the application of this research on a field scale, the screen-printing industry required 48 kg of corncobs as raw material and a dose of 24 kg of adsorbent produced. The application of the use of corncob waste as an adsorbent can help to reduce the income of corncob waste itself because the estimated corn production of 13 million tons of shelled corn and waste that will be produced around 10.6 million tons/year [7].
4. Conclusion
The color analysis of household scale screen printing wastewater located in Krendang Timur, West Jakarta shows that green has the highest color content. By using 5 variations in the analysis of the optimum mixing speed, the most optimum results were obtained at a speed of 100 rpm with a contact time of 60 minutes with an allowance of 99.98%. This happened because the mixing speed of 100 rpm results in an even distribution process between the adsorbent and the adsorbate so that the adsorbent has an effective ability to reduce the color content in the screen printing wastewater sample. The process of adsorption performance on corncob adsorbent in removing the dyes can be seen at a mixing speed of 100 rpm (optimum) following the Freundlich adsorption isotherm model obtained an $R^2$ value of 0.9999. In this study, corncob raw material used on a laboratory scale of 12 kg through a furnace process for 50 minutes produces 8 kg of corn charcoal and after the mesh process with a vibration speed of 100 rpm for 2 hours produced 6 kg for screen printing wastewater as much as 20 liters. In the application of the use of corn cobs as an adsorbent can also be used on a field scale by requiring 48 kg of corn cobs and an adsorbent dose of 24 kg. The use of corncob waste which was used as an adsorbent can help reduce the amount of waste produced because the annual corn production can reach 13 million tons of corn which produces 10.6 million tons of corn cob waste/year.

References
[1] Komarawidjaja W 2017 Paparan limbah cair industri mengandung logam berat pada lahan sawah di Desa Jelegong, Kecamatan Rancaekek, Kabupaten Bandung Jurnal Teknologi Lingkungan 18(2) 173-181
[2] S Atminingtyas, W Oktiawan and I Wisnu Wardana 2016 Effect of Naoh activator concentration and high column on active charcoal from banana skins on the effectiveness of heavy metal copper (Cu) and Zinc (Zn) electroplating liquid waste Journal of Environmental Engineering 5
[3] ARDIANI, F. (2018). Pengaruh Berat Karbon Aktif Kulit Jagung Terhadap Penurunan COD (Chemical Oxygen Demand) Limbah Cair Industri Batik (Doctoral dissertation, Universitas Muhammadiyah Semarang)
[4] Ningsih U S and Wandi S 2012 Utilization of Corn Cobs Waste as Active Charcoal for Siak River Water Treatment (Final Project Report, Riau University)
[5] Sutirman Z A, Sanagi M M, Abd Karim K J, Ibrahim W A W and June B H 2018 Equilibrium, kinetic and mechanism studies of Cu (II) and Cd (II) ions adsorption by modified chitosan beads International journal of biological macromolecules 116 255-263
[6] Sanjay A S and Agustine R P 2015 Studi Kinetika Adsorpsi Pb Menggunakan Arang Aktif dari Kulit Pisang Konversi 4(1)17-24
[7] Lumempouw L, Suryanto E and Paendong J 2012 Aktivitas anti UV-B ekstrak fenolik dari tongkol jagung (Zea mays L.) Jurnal MIPA 1(1) 1-4