The effect of mixing speed and contact time on dye removal using Cassava Peel adsorbents

S D Aulia, A Wijayanti* and R Hadisoebroto
Department of Environmental Engineering, Faculty of Landscape Architecture and Environmental Technology, Universitas Trisakti, Jakarta, Indonesia

*ashwijayanti@trisakti.ac.id

Abstract. The screen printing home industry generates wastewater causing dangerous environmental pollution since it has heavy metal contents. Cassava peel is one material that can be activated and used as an adsorbent to treat the wastewater. This study aims to analyze the effect of mixing speed on dye adsorption using cassava peel waste in a batch reactor and mixed by the jar test device. In the process of making adsorbents, cassava peel was dried and carbonized in a furnace into a powder, and then it was activated using H$_2$SO$_4$ solution. Wastewater was contacted with the 10 gr of adsorbent then mixed in variation speed of 50, 100, 150, 200, 250 rpm and variation contact time of 30, 60, 90, 120, 150 minutes. The maximum removal of 96.78% was observed in the mixing speed of 100 rpm over the 60 minute contact time. It could be concluded that organic waste such as cassava peel is a great adsorbent and resolves color pollution in the environment.

1. Introduction

Environmental pollution caused by the screen printing industry in Indonesia that uses dyes in the production process because most of the screen printing industrial waste water is directly discharged into the airways or city drainage [1]. The screen printing industry is a part of the textile industry that produces water. Industrial wastewater contains mixed materials and synthetic dyes that are quite difficult to integrate into the environment. The dyeing process in the textile industry generates waste that still contains dyes and dyeing supporting substances. This is because the color is not absorbed on the fabric waste treatment [2].

Color is one of the materials used in the process of industrial activities. Color waste are generated from screen printing, paper, plastic, cosmetics, and food industries activities. The biggest use of dyes is found in the screen printing industry. Dye stuffs from the coloring process in the form of dyes are dissolved in the water [3]. Adsorbents are substances or materials that are able to absorb fluids [4]. One type of adsorbent that can be used in the adsorption process is cassava peel. Cassava peel is large in amount, each kilogram of cassava can produce 15-20% cassava peel, fresh cassava peels from processing waste contain HCN 109 mg/kg [5]. Cassava peels that have become waste can be utilized as activated carbon [6].
2. Methodology

2.1. Tools and materials
The equipment used in this study were ovens, furnaces, analytical scales, 100 mesh filters, pH meters, spectrophotometers, magnetic stirrers, beaker cups, Erlenmeyer, funnels, cups, and mortars. The materials used this research were cassava peel, screen printing industrial wastewater, H2SO4 solution, Whatman filter paper No. 42, aluminum foil, distilled water.

2.2. Cassava peel preparation
Cassava peel that will be used in this research was white and brown cassava peel. Cassava peel was washed using flowing and distilled water. Washing with water aims to remove impurities that stick to the peel of cassava [7]. After the cassava peel was cleaned, the next process was to cut the cassava peel into small pieces and dry it in the sun for 7 days to reduce the moisture content attached to the cassava peel [8]. The dried cassava peels then furnace at 400°C for 2 hours to form charcoal [9]. After that, cassava peel was mashed into a uniform size and sieved with a mesh of 100 [10]. The 100 mesh size was chosen because it provides a high adsorption capacity. Theoretically, the absorption efficiency will increase with the smaller particle size [11].

2.3. Activation of cassava peel
Carbonized cassava peels were activated using H2SO4 solution with a concentration of 20% for 24 hours. The amount of activated adsorbate and adsorbent is 2 ml: 1 gram. Then the activated carbon was washed with distilled water and dried in an oven at 110°C for 2 hours.

2.4. Determination of mixing speed
The determination of mixing speed was done by using variations of 50, 100, 150, 200, 250 rpm. Beaker glass was filled with 250 mL of screen printing wastewater then cassava peel adsorbent was added with weight of 10 g. Stirred using jar test with a time variation of 30, 60, 90, 120, 150 minutes. Then the results of mixing was settled and filtered with Whattman filter paper no. 42 to separate residues from filtrate. The best results from the removal can be seen using spectrophotometers.

2.5. Efficiency and adsorption capability
Analysis the adsorption capacity or the number of color parameter that can be absorbed by the adsorbent was calculated using the following equation:

\[ q = \frac{[(C_0 - C) \times V]}{W} \]  

q was the number of color parameter absorbed by the adsorbent (mg/g), C0 was initial wastewater containing color parameter concentration (mg/L), C was ultimate wastewater containing color parameter concentration after adsorption (mg/L), V was the initial volume of wastewater containing color parameter solution (L), and W was adsorbent weights (gr). Removal efficiency could also be determined using the following equation (2):

\[ RE = \frac{[(C_0 - C) / C_0]}{x} \times 100\% \]

3. Results and discussion

3.1. Color analysis of household screen printing
Wastewater contains dyes are compounds that are used in the form of a solution or dispersion on another material so that it is colored [12]. Household screen printing wastewater obtained from Krendang Timur Village, Tambora, West Jakarta was treated using cassava peel adsorbents. Screen printing wastewater samples used by color are red, yellow, blue, black, green, and white.
Screen printing wastewater used in this study is red, yellow, blue, black, green, and white. The following results of screen printing wastewater characterization are shown in Table 1.

| No | The Sample     | Level  |
|----|----------------|--------|
| 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  |

From Table 1, it can be seen that the results of the color analysis on household screen printing waste the highest yield was malachite green, that was commonly found during screen printing. The basic dyes are salts of organic basic colors that contain amino and imino groups and were also combined with acid colors, such as hydrochloric acid. Malachite green has the most brilliant color compared to other synthetic dyes. Malachite green are dyes cationic which have a positive charge and used for negative anionic fabrics such as wool, silk, and nylon [13]. This chemical dye is mainly used for silk, leather, and paper dyes. Malachite green is a hazardous material that will contaminate waters if the Malachite green dye is removed [14].

3.2. Effects of stirring speed and time

In this study using variations in the speed of 50, 100, 150, 200, 250 rpm and contact time variations of 30, 60, 90, 120, 150 minutes to reduce the color levels in screen printing wastewater. In the reduction of color in screen printing wastewater is influenced by the stirring speed. Data on the percentage of color removal using cassava peel adsorbents show in Figure 1.

![Figure 1](image_url)

**Figure 1.** Correlation between stirring speed of cassava peel adsorbent and contact time to color removal.

Figure 1 shows that the optimum stirring speed for absorbing colors was 100 rpm with 60 minutes with removal of 96.78%. At optimum speed in optimum contact time, the adsorbate and the adsorbent were spread evenly so that the adsorption process increases. However, at 30 minutes with a stirring speed of 100 rpm it has been able to reduce color with a removal of 91.67% even though it was not as maximum as the contact time of 60 minutes. At stirring speed of 150 rpm with contact time of 60 minutes yielded a removal of 72.55%. At stirring speed of 200 rpm with contact time of 60 minutes produces a removal of 51.56% and at stirring speed of 250 rpm with a time of 60 minutes produces a removal of 30.24%. The reduced efficiency of absorption of color levels due to speed of stirring that was too fast so that the adsorbate and adsorbent were released. Based on the results of research
conducted, cassava peel waste could be a material for dealing with dye waste in screen printing waste. Cassava peel waste could be as an alternative since it is easily obtained, shows good performance as adsorbent of color in dye wastewater from screen printing and could reduce cassava peel waste generation as well.

3.3. Isotherm adsorption

The adsorption isotherm described about concentration that depends on equilibrium distribution of metal ions between the solution and the solid phase at a fixed temperature. In determining the concentration of the solution using the Freundlich isotherm model and the Langmuir Isotherm. Following are the results of the Langmuir and Freundlich isotherm calculation of the optimal mixing speed of 100 rpm shown in Figure 2 and Figure 3.

![Figure 2. Langmuir isotherm the optimal mixing speed of 100 rpm.](image)

![Figure 3. Freundlich isotherm to the optimal mixing speed of 100 rpm.](image)

From Figure 2 and Figure 3 shows that the R2 value of Langmuir and Freundlich isotherm scores 1. Adsorption of dyes is considered to follow the Freundlich isotherm model because it has a regression value of one so that this type is more suitable for use in the mechanism of dye adsorption by cassava peel adsorbents. In the Freundlich isotherm, the maximum capacity (Kf) is obtained ie 36,900 mg / g and the value of n is 0.081. If the value of 1 / n is between 0 and 1 then the adsorption isotherm process is according to the Freundlich method. The physical adsorption process is the absorption that only occurs on the surface of the adsorbent in the Freundlich adsorption isotherm model.

3.4. Adsorption kinetics

The adsorption kinetics are used to determine the rate of adsorbate and adsorbent absorption ability which is affected by the contact time to reach the equilibrium point. Absorption ability can be seen from the rate of adsorption in this case the test of the adsorption rate is done through the determination of the reaction order [15]. A first-order reaction is a reaction speed affects one a substance that reacts or is proportional to one the rank of reactant. Second-order reactions are reactions that are the speed is directly proportional to the product the concentration of the two reactants or proportional directly to the square of concentration one the reaction. The following are the results of the calculation of the adsorption kinetics shown in Figure 4 and Figure 5.
Figure 4. Order 1 kinetics stirring speed 100 rpm.

Figure 5. Order 2 kinetics stirring speed 100 rpm.

Figure 4 and Figure 5 show that the kinetics result obtained R2 in order 1 of 0.5 while the kinetics result obtained R2 in order 2 was 0.99. The stirring speed with the optimal contact time 60 minutes received order two. The choice of the order of each adsorption kinetics is based on the highest linear regression value, where the higher the linear regression value, then the linearity of the curves based on the linear regression equation of each sequence will be more numerous easily achieved.

3.5. Application of cassava peel waste using field scale

The use of raw materials for cassava peel as much as 10 kg through the furnace process becomes 6 kg and after the carbonization process the cassava peel becomes powder and it gets as much as 3 kg. In this study, getting the optimum stirring speed of 100 rpm with an adsorbent weight of 10 grams with 250 mL of wastewater obtained an optimum contact time of 60 minutes on a laboratory scale. The results obtained will be calculated on a large scale for the treatment of screen printing wastewater as much as 80 L.

Calculation of Adsorbent Weight

Requirement required Known:
Adsorbent Weight = 3 kg
Wastewater = 20 L
Wastewater to be treated = 80 L

Asked: The weight of the adsorbent needed to treat 80 L of wastewater?

Answer:

\[
\text{Weight of research adsorbent Screen printing wastewater} = \frac{x}{3 \text{ kg} \times \frac{20 \text{ L}}{80 \text{ L}}} = \frac{x}{12 \text{ kg}}
\]

So, the weight of the adsorbent used to treat 80 L screen printing wastewater is 12 kg. Using of cassava peel as an adsorbent material in the treatment of screen water waste is due to the amount of cassava peel produced as much as 3.3 million tons per year. Cassava peels that have become waste can be utilized as cassava peels can be used as an adsorbent in decreasing the color content in screen printing wastewater.

\[
\frac{10 \text{ kg}}{20 \text{ L}} = \frac{x}{80 \text{ L}}
\]

Cassava peel Raw Material Weight = 40 kg
The use of cassava peel raw material as an adsorbent material used in the treatment of screen printing wastewater for decreasing the color content using cassava peel raw material as much as 40 kg. Cassava peel derived from cassava (Manihot esculenta Cranz) is a waste produced from food produced. Cassava peel waste produced from production can produce cassava peel waste by 8-15% [16]. Cassava peel waste can be used as a material that is able to reduce the coloration of screen printing waste. Cassava peels contain polysaccharides [17] and tannins which can be used as natural activated carbon.

4. Conclusion
Based on research conducted that cassava peel can adsorb color with a removal percentage of 96.78% with a stirring speed of 100 rpm with a contact time of 60 minutes. This proves that by utilizing cassava peel waste into adsorbent can set aside the color well and economically.

References
[1] Fitriani D, D Oktiarni and Lusiana 2015 Utilization of banana peel as methylene blue dyes adsorbent Gradient Journal 11 2 1091-1095
[2] Rohmah N and Sugiaro A T 2008 Effect of pH and Concentration of Dyes on the Reduction of Remazol Navy Blue Scarlet Dyes with AOP Technology (LIPI)
[3] Irawati H, Aprilita N H and Sugiharto E 2018 Adsorpsi Zat Warna Kristal Violet Menggunakan Limbah Kulit Singkong (Manihot esculenta) BIMIPA 25(1) 17-31
[4] Sudibandriyo M and Lydia 2011 Surface area characteristics of activated carbon from bagasse with chemical activation Indonesian Chemical Engineering Journal 10 3 149-156
[5] Sandi Y O, Rahayu S and Suryapratama W 2013 Upaya peningkatan kualitas kulit singkong melalui fermentasi menggunakan Leuconostoc mesenteroides pengaruhnya terhadap kecerahannya bahan kering dan bahan organik secara in vitro Jurnal Ilmiah Peternakan 1(1) 99-108
[6] Santoso R H, Susilo B and Nugroho W A 2014 Manufacture and characterization of activated carbon from cassava peel (manihot esculenta crantz) using KOH activating agent Journal of Tropical Agricultural Engineering and Biosystems 2(3) 279-286
[7] Hasrianti H 2015 Adsorpsi Ion Cd²⁺ pada Limbah Cair Menggunakan Kulit singkong Dinamika 4(2).
[8] Permatasari A R, Khasanah L U and Widowati E 2014 Karakterisasi Karbon Aktif Kulit Singkong (Manihot Utilissima) Dengan Variasi Jenis Aktivator Jurnal Teknologi Hasil Pertanian 7(2) 70-75
[9] R Karamma and S Madinah 2011 Utilization of Cassava Peel as Adsorbent in Reducing Heavy Metal Chromium (Cr) in Wastewater
[10] A Suprapti, B Bakri, and N Rahmanita 2015 Pemanfaatan Kulit Singkong untuk Mengadsorpsi Ion Logam Timbal (Pb) (Research Report, Universitas Hasanuddin)
[11] Rambe A M 2009 Pemanfaatan Biji Kelor (Moringa oleifera) sebagai Koagulan Alternatif dalam Proses Penjernihan Limbah Cair Industri Tekstil (Master's thesis)
[12] Muna N 2014 Adsoprsi Zat Warna Malachite Green (Mg) oleh. Komposit Kitosan-Bentonit (Thesis, UN Sunan Kalijaga)
[13] Fujianstuti M D 2019 Degradasi Zat Warna Malachite Green Pada Limbah Laboratorium PT X Dengan Adsorbent Berbasis Kulit Singkong (Doctoral Dissertation, Universitas Sahid)
[14] Pratama D A 2017 Efektivitas Ampas Teh Sebagai Adsorben Alternatif Logam Fe Dan Cu Pada Air Sungai Mahakam Jurnal Integrasi Proses 6(3)
[15] Rahmawati A 2010 Pemanfaatan limbah kulit ubi kayu (manihot utilissima pohl.) dan kulit nanas (ananas comosus l.) pada produksi bioetanol menggunakan aspergillus niger (Thesis, Sebelas Maret University)

[16] Mohd-Asharuddin S, Othman N, Mohd-Zin N S and Tajarudin H A 2018 Removal of total suspended solid by natural coagulant derived from cassava peel waste International Seminar on Mathematics and Physics in Sciences and Technology 2017 995

[17] Yuniarti R and Syahputra R A 2017 Studi pendahuluan limbah kulit singkong sebagai eksipien sediaan farmasi Prosiding Seminar Nasional Penelitian UNIMED