Utilization of Banana Inflorescence As Adsorbent of Textile Dyes Waste Using Adsorption-Fluidization Method

Dheasy Herawati, Setyo Dwi Santoso, Ilma Amalina
Faculty of Health Sciences
Universitas Maarif Hasyim Latif
Ngelom Megare, Sidoarjo, Indonesia
dheasy_herawati@dosen.umaha.ac.id, setyo.dwi@dosen.umaha.ac.id,
ilma_amalina@dosen.umaha.ac.id

Abstract

Application research of banana inflorescence (Musa spp) for adsorption of textile dyes waste (Congo Red, Remazol Black, Remazol Yellow and Methylene Blue) with adsorption-fluidization method was carried out. The objective of this research was determine the adsorption capacity of banana inflorescence to the textile dyes waste under optimum conditions. This experiment was done to get the optimal condition of adsorption of textile dyes waste by banana inflorescence before determine the adsorption capacity. Adsorption process was performed by variety of pH (4-10), temperature (30°C-90°C), and contact time (15, 30, 45, 60, 75, 90 and 105 minute). The adsorption of textile dyes using UV-VIS Spectrofotometer. The optimum adsorption capacity of textile dyes waste using banana inflorescence for Congo Red 1.94%, Remazol Yellow 4.93%, Remazol Black 1.11% and Methylene Blue 0.51%

Keywords
Banana Inflorescence, Adsorbent, Adsorption-Fluidization, Textile Dyes Waste

1. Introduction

The classification of textile industry into three categories based on the materials used, ie cotton, wool, and synthetic fibers. The coloring process in the textile industry uses a large amount of dye and produces textile industry dye waste at the end of the process. Waste from printing and dyeing is rich in dyes containing reactive and chemical dyes, such as chromium, aerosols, COD and BOD, which are materials that are difficult to degrade. There are more than 8000 chemical products related to the coloring process in Color Index, including several variations of dyestuff structure, such as acid, anionic, reactive acids, alkaline cationic, nonionic dispersions, aromatic and heterocyclic compounds (azo, diazo, antraquinon) and metal complexes heavy-dye (Raymundo et al., 2010; Zuorro et al., 2013). 80% of the dye comprises azo aromatic compounds (Zuorro et al., 2013). Substances in textile industry waste have complex, stable, and high-salt (Hauser and Clausing, 1988; Buthelezi, Olaniran and Pillay, 2012) structures that cause textile dyestuffs to degrade from textile waste (Rachakornkij, Ruangchuay and Teachakulwiroj, 2004; Raymundo et al., 2010).

The textile industry uses a lot of chemicals and dyes that can cause pollution. 17-20% of industrial pollution in water is caused by textile dyeing (Raymundo et al., 2010). Production of dyes per year exceeds 7x 105 ton s. 12% of the synthetic textile dyes used together with the waste stream annually (Laus et al., 2010; Zuorro et al., 2013). The final process of the textile industry causes 50% of the dye compound to be released in the textile waste; about 28,000 tons of dyestuffs are carried away by textile industry waste released in the environment per year (Gonawala and Mehta, 2014).

Existing textile wastes usually contain dyes such as Remazol Yellow, Congo Red, Remazol Black B (RBB), Brilliant Blue R (RBBR) Remazol, and BrilliantRed F3B Remazol (RBRF3B), Coralen blue, Rhodamine B, Methylene Blue and Malachite Green (Rachakornkij, Ruangchuay and Teachakulwiroj, 2004; Raymundo et al., 2010; Ouasif et al., 2013; Gonawala and Mehta, 2014).

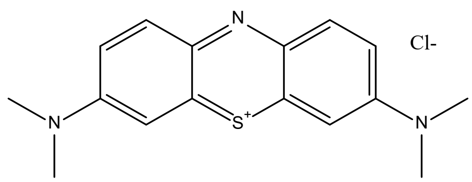

Figure 1. Structure of methylene blue

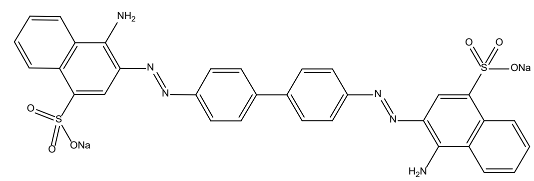

Figure 2. Structure of congo red

Textile waste dumped into the environment without first treatment will pollute water sources in the environment that will also affect the life of aquatic biota in the ecological system (Hauser and Clausing, 1988) and difficult to degrade and toxic.
One method for removing organic dyes is adsorption. It has been demonstrated that adsorption (activated carbon adsorbent) is one of the most effective and potential methods for removing color, odor, oil and toxic organic pollutants from waste treatment processes due to their excellent adsorption capacity (Rachakornkij, Ruangchuay and Teachakulwiroj, 2004; Raymundo et al., 2010; Ouasif et al., 2013; Gonawala and Mehta, 2014). The capacity of the activated carbon depends on the physical character of the adsorbent, the condition of the adsorbate, and the condition of the solution. Although it has many advantages, such as efficiency and versality, carbon adsorption is a costly process (the amount of carbon or activated sludge is much needed) and is an obstacle for developing countries, which causes this method to be less favorable (Gottipati and Mishra, 2010). Banana leather waste and banana stem are widely utilized as adsorbents, ie heavy metal adsorbents Pb, Fe metals (Hidayah, Deviyani and Wicakso, 2012), Ni2+ and Co2+ (Abbasi, 2013); and as antioxidants and antimicrobials (Mokbel and Hashinaga, 2005); as antioxidants and cell control (Khan, HAJIRA TAHIR and HAMEED, 2005; Elaveniya and Jayamuthunagai, 2014).

2. Material and Methodology

2.1. Materials

2.1.1. Sample

The sample used is textile industry liquid waste from batik industry.

2.1.2. Materials

The materials used are textile waste, banana heart (adsorbent), dyestuff (Congo red, Remazol Black, Remazol Yellow, and Methylene Blue), aquades, 0.1 N HCl solution, and 0.1 N NaOH solution.

2.1.3. Instruments

The tool used is fluidization column (1 L measuring cup), air pump, thermometer, hot plate, stirrer, indicator pH, knife, gauze, plastic container, glassware commonly used in Chemical Laboratory, oven and UV-VIS Spectrophotometer Shimadzu.

2.2. Methods

The method of this research used quantitative by utilizing banana inflorescence as textile waste adsorbent using adsorption-fluidization method with 3 treatments, namely pH variation, temperature, and time of adsorption-fluidization process will be made 3 times replication. The determination of the dyestuff was measured using the UV-VIS Spectrophotometer instrument.

2.2.1. Sample Preparation

Samples taken from industry of Batik at Jetis Sidoarjo measured pH using indicator pH. The sample will be added 0.1 N HCl solution to reach pH 4.0; 5.0; and 6.0, and NaOH solution was added to reach pH 7.0; 8.0; 9.0; 10, which is controlled using pH indicator. Textile waste samples were also measured in levels of each dye (Congo Red, Remazol Black, Remazol Yellow, and Methylene Blue) contained in the waste.

2.2.2. Adsorbent

The banana inflorescence is purchased from Traditional Market and dried in the open air. Once dry, the heart of the banana is cut into pieces and ground into powder. Grounded banana inflorescence were soaked in 0.1 N HCl for 24 hours, filtered, and washed aquades. The next banana heartbeat in the oven at a temperature of 800C for 12 hours (Ouasif et al., 2013).

2.2.3. Adsorption-Fluidization Experiment

200 ml of sample with variations of pH, as well as variations of temperature were incorporated into fluidization columns. Then 0.5 g of grinded banana inflorescence adsorben is added to the fluidization column. Air is channeled using air pumps from below the column, which will spur the adsorption-fluidization process. The fluidization with variations of the time varies. After the fluidization-adsorption process, the dye levels remaining in the fluidization column were measured using UV-Vis Spectrophotometer. The adsorbent capacity was also calculated based on the level of textile waste left in the sample (Laus et al., 2010; Lasmana, Mukhtar and Tamboesai, 2016).

2.2.4. Determination of Sample

The sample that has been through the adsorption-fluidization process measured the levels using a UV-VIS Spectrophotometer with wavelengths of 490, 597, 256, 665 nm respectively for Congo Red, Remazol Black, Remazol Yellow, and Methylene Blue (Khan, HAJIRA TAHIR and HAMEED, 2005; Carletto et al., 2008; da Silva, de Barros Neto and da Silva, 2009; de Alvarenga et al., 2015). The content of dye in sample is determined before and after the adsorption-fluidization process using a UV-VIS Spectrophotometer. The dye content is calculated by regression equation, $y = ax + b$. obtained from dye standard curve.
The adsorption capacity can be calculated using the equation (Laus, 2010):

$$p = [(Ci-Ca) / Ci] \times 100\%$$

$$p = V\,(Ci-Ca) / m$$

Note : adsorption capacity (AC) (% or mg/g), Ci and Ca are the dye concentrations before and after the adsorption-fluidization process (mg/L), m is the adsorbent mass (g), and V is volume of sample (L).

3. Results and Discussion

Standard solution of each dye with concentrations of 10, 20, 30, 40, 50, 60, 70, 80 and 90 ppm for Congo Red, Remazol Black, Remazol Yellow and Methylene Blue with wavelength 490, 597, 256, 665 nm. The result of standard solution measurement can be seen on table 1.

Table 1: Standard solution.

Cons. (ppm)	Congo Red	Remazol Black	Remazol Yellow	Methylene Blue
10	0,1350	0,0545	0,0250	0,2700
20	0,5660	0,1100	0,0725	0,7460
30	0,3960	0,1450	0,1345	1,0505
40	0,3230	0,2330	0,1835	1,5210
50	0,6610	0,2270	0,2300	1,5905
60	0,8790	0,3455	0,2850	2,0730
70	0,9320	0,3150	0,3415	2,1175

Cons. (ppm)	Congo Red	Remazol Black	Remazol Yellow	Methylene Blue
80	1,1750	0,4735	0,3830	2,6370
90	1,1490	0,3750	0,2560	2,6560

From the measurement result of standard solution of each dye obtained regression equation as shown on figure 3.

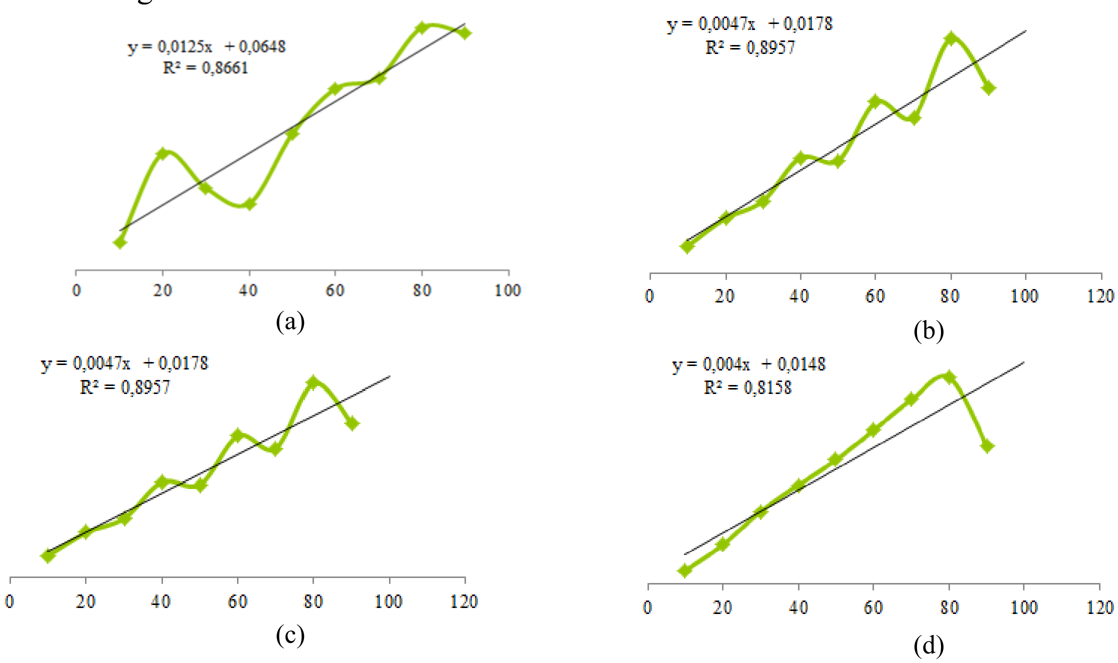

Figure 3. Curve of standart solution for Congo Red (a), Remazol Black (b), Remazol Yellow (c) and Methylene Blue (d)

The fluidization-adsorption process is to determine the optimum pH, temperature and time for the determination of the waste dyestuff and the adsorption capacity as shown on table 2.

Table 2: Adsorption Capacity (AC)

Optimum Condition	Congo Red	Remazol Yellow	Remazol Black	Methylene Blue
pH	5	9	5	9
AC (%)	1.78	4.29	0.56	0.36
Temp (°C)	60	50	40	40
AC (%)	1.51	4.65	0.56	0.22
Time **(minutes)**	45	75	75	45
AC (%)	1.63	1.83	0.56	0.43

The optimum pH, to effect protonation of the adsorbent used. Each of the adsorbents will have different charges so they can interact with each other. In acidic conditions, the dyestuff will be deprotonated and then when the adsorbent is added to the dye solution, the surface of the adsorbent will undergo protonation first and then proceed with the electrostatic interaction causing the displacement of the dye in the solution to the surface of the protonated adsorbent (Maghfiroh, Ulfin and Juwono, 2016). The vinyl radical group of the dyestuff will react with the hydroxyl group of the adsorbent to form a stable covalent bond. With the formation of these bonds the heart of banana is able to adsorb the dyestuff optimally (Kusumaningsih, Masykur and Supriyanto, 2006) as shown on figure 4.

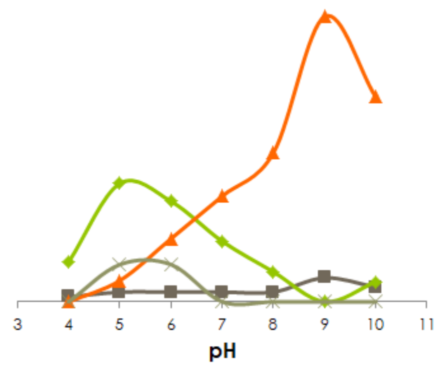

Figure 4. Adsorption capacity in optimum pH

The optimum temperature, can accelerate the process of dye adsorption because with the rise of temperature it can accelerate the reaction resulting in the increase of kinetic energy of particulate matter to enable the number of effective collisions that produce the change (Agustina, 2012) as shown on figure 5.

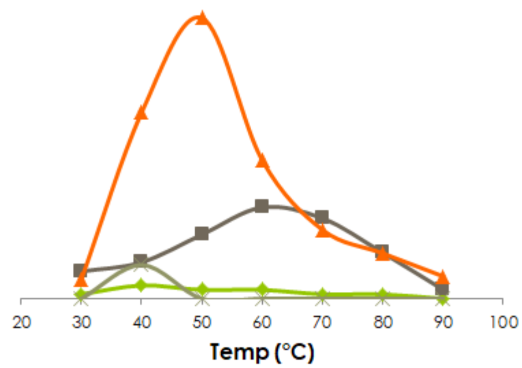

Figure 5. Adsorption capacity in optimum temperature

The optimum time, contact time increases, the amount of adsorbate adsorbed on the surface of the adsorbent increases will reach the equilibrium point. this results in the surface of the adsorbent being fully covered by the absorbed dye and the adsorbent having saturation point so that the adsorbent can not absorb the dye again (Lasmana, Mukhtar and Tamboesai, 2016) as shown on figure 6.

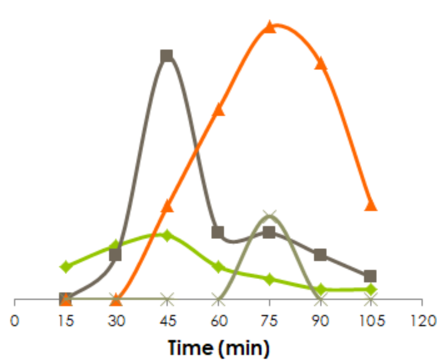

Figure 6. Adsorption capacityiin optimum time

The next step is determination of adsorption capacity at optimum condition as shown on table 3.

Table 3. The optimum adsorption capacity

Waste Dye	Before (ppm)	After (ppm)	AC (%)
Congo Red	0,0671	0,0658	1,94
Remazol Black	0,0180	0,0178	1,11
Remazol Yellow	0,0304	0,0289	4,93
Methylene Blue	0,1379	0,1372	0,51

Adsorption-fluidization capacity of banana inflorescence to textile waste dye increases when done under optimum conditions. The pH, temperature and time factors are very influential in the adsorption process. The pH at which the adsorption process takes place has a large effect because the hydrogen ion itself is strongly adsorbed, in part because pH affects the ionisation and affects the adsorption of some compounds. The temperature factor affects the speed and amount of adsorption that occurs. The speed of adsorption increases with increasing temperature. Contact time allows the diffusion process and adhesion of the adsorbate molecules to be better.

4. Conclusion

The optimum adsorption capacity of textile dyes waste using banana inflorescence for Congo Red 1.94%, Remazol Yellow 4.93%, Remazol Black 1.11% and Methylene Blue 0.51%.

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Biographies

Dheasy Herawati

Is an assistant professor at Maarif Hashim Latif University in the fields of chemistry, bioassays, toxiology. also as dean of the faculty of health science who is active in several studies. currently pursuing a doctoral program at the university of airlangga surabaya.

Setyo Dwi Santoso

A lecturer in the medical laboratory technology study program, Faculty of Health Sciences, Maarif Hashim Latif University. has a research concentration in the field of chemistry. in active academic activities as coordinator of laboratory practicum and designing research processes.

Ilma Amalina

a lecturer in the Medical Laboratory Technology Study Program, Faculty of Health Sciences, Maarif Hashim Latif University. has a research concentration in the field of chemistry. recorded as currently pursuing a PhD program at the University of Manchester UK with funding from the Ministry of Finance Education Fund Management Institute. a PhD Chemistry student from Indonesia, attended the Academic Support Program at the University Language Center (ULC).