The effect of particle size and dosage on the performance of Papaya seeds (*Carica papaya*) as biocoagulant on wastewater treatment of batik industry

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Abstract. In this study, the performance of papaya seeds (*Carica papaya*) as biocoagulant was evaluated using Batik wastewater which referred to the water sample. The effectiveness of particle size and dosage of papaya seeds were evaluated based on turbidity removal (%), total dissolved solids (TDS), and electrical conductivity (EC). The Tyndall effect of clear solution was also evaluated in this study. The results showed that the turbidity removal of water sample achieved as much as 92.2%, and had followed by the decreasing of TDS and EC. The optimum results from the decrease in turbidity, TDS, and EC were obtained at the particle size of 250 mesh and the biocoagulant dosage of 1000 mg. The measurement of the Tyndall effect has concluded that the water sample has to remain the colloidal particle even though the treatment water as clear as the quality standard of freshwater.

1. Introduction
The Sustainable Development Goals are 17 goals with 169 world targets with a deadline set by the United Nations as the world development agenda for the benefit of humans and planet Earth. A total of 169 targets, all of which cover health, energy, sanitation, social and environmental aspects. Environmental issues are still one of the obstacles in the achievement of these targets [1]. One of the causes of serious environmental problems today is related to the textile industry, for example, wastewater from the batik industry. Approximately 80% of water is used in the batik process including coloring which has turned into polluted water [2]. Some methods that can be used to deal with textile wastewater are coagulation-flocculation, precipitation, electrodialysis, electroflotation, and adsorption [3]. Coagulation-flocculation method is a method of treating wastewater that aims to reduce pollutants and colloidal particles in liquid waste. The mechanism of floc formation in the coagulation-flocculation process consists of three stages, namely the destabilization of colloidal particles, the stage of microphilic formation, and the stage of macrophilic formation [4]. The substances used in water treatment can be either synthetic or natural coagulants. However, the continued use of synthetic coagulants has trigger Alzheimer's disease and neurotoxicity [5-6]. Therefore, one way to reduce the adverse effects of synthetic coagulants is to use natural coagulants (biocoagulants). One of the
natural ingredients that make a natural material can be used as a coagulant is a biocoagulant based on the protein [7].

Papaya fruit contains a large number of small black seeds. Papaya fruit and seeds have a large protein content. Papaya seeds contained 25.1% protein, 8.2% ash, and 45.6% crude fiber [8]. Papaya seeds can be used as a biocoagulant due to the presence of positively charged proteins that bind to negatively charged particles (silt, clay, bacteria, and toxins, etc.), then it can produce flocks that will precipitate and produce clear water (adsorption & charge neutralization). Papaya seed powder can bond with solid particles in water and then settle to the bottom [9]. The use of biocoagulant has various advantages including being environmentally friendly, easily obtainable raw materials, affordable prices, simple synthesis processes, and biodegradable. Therefore in this study, the performance of papaya seed (Carica papaya) as biocoagulant based on the protein was evaluated in terms of turbidity removal, TDS, EC, and Tyndall effect from the treated water sample.

2. Material and methods

2.1. Materials and instruments

Papaya seeds (Carica papaya) were obtained from fruit traders around Universitas Islam Indonesia. The seed was washed and then dried at 110 °C for 10 h before characterized by FT-IR spectroscopy (PerkinElmer Spectrum Version 10.5.1, USA). The dried seeds were then crushed and sieved to get fine powder with a size of 150; 200 and 250 mesh before it was stored in a plastic container. The evaluation of biocoagulant was carried out using wastewater from the batik industry based on turbidity (Waterproof Portable Turbidimeter TN100, Eutech, Netherland), total dissolved solids (TDS), and electrical conductivity (EC) (Multi Checkers Hanna HI 9813-5, Romania). The wastewater sample was obtained from the Sekar Idaman Batik Industry, Yogyakarta, Indonesia (GPS points, 7°40’56.1”S 110°22’04.1”E).

2.2. Evaluation of biocoagulant

The treatment of batik wastewater was carried out by the coagulation-flocculation process. As much as 250 mL of water sample has been added to four glass beakers, and then 150 mesh papaya seed powder was added with the dosage of 250, 500, 750, and 1000 mg. Furthermore, the coagulation and flocculation were carried out with rapid stirring at 100 rpm for 5 mins, followed by a lower speed at 40 rpm for 24 mins, then left for 60 mins in Mohr tube before filtered by Whatman 42 filter paper (GE Healthcare Life Sciences, USA). After that, the final characterization of the water sample was carried out based on turbidity, electrical conductivity, and Tyndall effect. The turbidity removal was calculated according to Equation 1. The Tyndall effect was evaluated by measuring the remaining light passing through the solution using a light meter (Lutron LX-103, USA) after the sample cell at a distance of 16.5 cm as shown in Figure 1. A similar evaluation was carried out for the coagulant size of 200 and 250 mesh.

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\text{Turbidity removal (\%) = } \left( \frac{T_i - T_f}{T_i} \right) \times 100
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Where \(T_i\) is the initial turbidity (NTU) of the water sample and \(T_f\) is the turbidity (NTU) after the process.
3. Result and discussion

3.1. Characterization of biocoagulant

The functional groups in the biocoagulant were measured to identify -OH, -COOH, and NH groups that infer possible intramolecular interaction between polymers biocoagulant and particles dissolved in a solution [10]. Figure 2 shows the FTIR peaks of functional groups in papaya seed (Carica papaya) as biocoagulant. The result showed that the molecule had a broad peak at 3280.41 cm\(^{-1}\) due to the O-H band, 1709.31 cm\(^{-1}\) due to C=O, 1640.11 cm\(^{-1}\) due to N-H, and C-O at 1035.45 cm\(^{-1}\). The group of -OH, -CO and -NH in the spectral peak affirm the presence of hydroxyl, carboxyl acid, and amina groups that causes papaya seed to have more effect on the coagulation abilities [11].

3.2. Effect of particle size and biocoagulant dosages on the turbidity removal

Figure 3 shows the effect of particle size and biocoagulant dosage on the removal of turbidity from the water sample. In general, the turbidity removal of water samples increased with the increase of particle size and biocoagulant dosage. In this regard, the biocoagulant with 150, 200, and 250 mesh of particle size obtained as much as 89.3\%, 86.2\%, and 92.2\% of turbidity removal in 1000 mg/250 mL biocoagulant dosage. Based on these results, it can be concluded that the particle size of 250 mesh and the biocoagulant dosage of 1000 mg was the optimum process on the turbidity removal from the water sample. Particle size and coagulant dose are two parameters that play an important role in determining the efficiency of coagulation-flocculation. Particle size and coagulant dose are two parameters that play an important role in determining the efficiency of coagulation-flocculation [12]. The particle size affects the performance of the coagulant. The smaller the size of the coagulant particles, the larger the
surface area of the coagulant. This can make the aggregation process between the coagulant and the particles in the solution was easier to be occurred, so that the potential for the aggregation process between solid particles and coagulants will be greater. It causes floc to be more easily formed and then separated from the wastewater easily. In addition, the higher the number of coagulant doses the greater the aggregation occurred between the particles. then it causes the particle destabilization. When the dose reaches the optimum concentration causes a greater number of particles in the solution to gather and settle so that flocs can form, and turbidity can decrease.

Figure 3. Effect of particle size and dosage on decreasing the turbidity of wastewater.

3.3. Effect of particle size and biocoagulant dosages on the TDS and EC

Figure 4 shows the effect of particle size and biocoagulant dosage on the TDS and EC measurements. Total dissolved solids (TDS) and electrical conductivity (EC) have indicated how much the presence of mineral elements, charged macromolecules, and other ionic compounds may be dissolved or dissociated into the solutions [13]. In general, the TDS and EC of water samples decreased by the decrease of particle size. In addition, the lowest TDS and EC were obtained when the particle size of 250 mesh was used for all biocoagulant dosage applied for. However, in this regard, the TDS would not be always decreased by the increase of biocoagulant dosage at the particle size of 250 mesh (see Figure 3a). In the optimum dose of biocoagulant, the colloidal particle has been neutralized and precipitated. When the biocoagulant dosage was added excessively in the solution, the water becomes turbid again because the biocoagulant cannot interact with the colloidal particles of different charge [14].

Figure 4. Effect of biocoagulant particle sizes and dosage on the TDS (a) and EC (b).

3.4. Effect of particle size and biocoagulant dosage on Tyndall effect

The Tyndall effect was evaluated based on light scattering by colloidal particles. The light beam passed through the solution and then the remaining light intensity was measured to indicate how much
the colloidal particle remaining in the solution even though the solution as clear as the quality standard of freshwater. If the solution contains a high colloidal particle, the low measuring of light intensity after the sample cell was detected by the light meter in (see Figure 1). In general, the increasing biocoagulant dosage used in the treatment has resulted in the high intensity of light measurement as shown in Table 1. This means that the treatment solution has contained a low concentration of colloidal particles [15]. Also, the increase of particle size has decreased the colloidal particle concentration in the solution, so that the treatment has decreased the turbidity of the solution. The biocoagulant dosage of 1000 mg and a particle size of 250 mesh hash obtained a clear water treatment as well as freshwater.

Table 1. Tyndall effect (light measurement) on the wastewater quality after treatment

| Biocoagulant dosage (mg) | Initial | 250 | 500 | 750 | 1000 | Tap water |
|-------------------------|--------|-----|-----|-----|------|-----------|
| Light measurement (Lux) | 78.3   | 231.3 | 318.7 | 313.3 | 406.0 | 743.0 |
| Particle size 150 mesh |        |      |      |      |      |           |
| Light measurement (Lux) | 78.3   | 224.3 | 300.0 | 353.3 | 401.3 | 743.0 |
| Particle size 200 mesh |        |      |      |      |      |           |
| Light measurement (Lux) | 78.3   | 306.7 | 449.7 | 396.7 | 538.0 | 743.0 |
| Particle size 250 mesh |        |      |      |      |      |           |

4. Conclusions
The result showed that the biocoagulant of papaya seed (*Carica papaya*) had a good performance in the coagulation-flocculation process in the treatment of Batik wastewater. This can be seen from the decreasing of turbidity removal (%), TDS, and EC from the sample solution. Based on the results showed that the particle size and biocoagulant dosage has greatly affected the performance of the biocoagulant. It was found that the smaller the particle size and the higher by coagulant dosage, the increasing of turbidity removal, and the decreasing TDS, and EC. The results showed that the particle size of 250 mesh and 1000 mg of biocoagulant dosage was the highest turbidity removal for as much as 92.2%, respectively. In this regard, the Tyndall effect of the treatment solution has concluded that the addition of a high dose (1000 mg) and particle size (250 mesh) of biocoagulant decreased the remaining colloidal particle in the wastewater to produce clear water as well as freshwater.

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