

Application of *Tamarindus indica* seed extract as bio-coagulant to removal suspended solids and colors

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ABSTRACT

The batik traditional industries in East Java, Indonesia generally not have a proper wastewater treatment plant yet, so liquid waste directly discharge into the river. Batik wastewater generally have a dark color, which derived from the coloring of naphthol with number of suspended solids greater than 100 mg/L and color concentration more than 250 Pt.Co. Tamarind seed extract is known to contain natural polyelectrolytes active group, which had function as bio-coagulant. The research objective was to analyze the application of tamarind seed extract as bio-coagulant in wastewater treatment of the Batik traditional industries, by reducing suspended solids levels and color of wastewater. The research design used pretest and posttest control group design with variations of bio-coagulant doses of 10ml/L, 30ml/L, and 50ml/L, and analyzed using the Two Way Anova Test. The results showed that the level of suspended solids in wastewater before treatment averaged 291mg/L, and the average color content was 593 Pt-Co, so it did not meet the quality standards of the Governor of East Java No 72/2013. For the highest reduction in suspended solids levels at a dose of 10ml/L reduced up to 95.1% and the highest decrease in color levels at a dose of 50ml/L, reduced up to 87.8%. Traditional batik wastewater treatment, which used a coagulation-flocculation process with bio-coagulant extract of tamarind seeds could reduce levels of suspended solids and colors, in order to meet the specified quality standards.

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1. INTRODUCTION

Batik industry is one of the thousands of Indonesian cultures that have experienced a significant increase over time. In the process of batik production, they produce a large amount of liquid waste, as much as 80% of the total amount of water used in batik [1], [2]. The batik and textile industries produce wastewater from the coloring process, in addition to the high content of dyes; also contain ingredients that are synthetically difficult to be broken down.

Batik liquid waste produce dyes in the process of batik which is a big problem for the environment, because it can make the water conditions become turbid with the presence of dyes. Dyes contribute to organic content and wastewater toxicity. Batik liquid waste from the coloring process is dangerous for aquatic life in rivers and lakes, because it makes the waters become turbid, reduced light penetration and the presence of complex metal dyes that are poisonous to aquatic biota [3], [4].

Batik Jetis Sidoarjo is the home industry of batik crafts in Sidoarjo-East Java, Indonesia, which produce homemade batik [5]. The problems that occur in Kampung Batik Jetis Sidoarjo is the unavailability of the processing to wastewater before thrown into the river and the absence of a wastewater treatment plant from the production process before being discharged into the river. Waste directly discharged into the river contains high pollutants such as organic matter which can pollute the river [2], [5]. The characteristics of wastewater from the coloring process using naphthol dye obtained suspended solid (SS) levels of 675mg/L with a pH of 4.3- 5.7, which exceeds the established quality standard [6].

In a study conducted by Nurroisah *et al.* [7], the processing of batik liquid waste with the characteristics of COD and suspended solids can be treated with aeration system tray and filtration methods that can reduce suspended solids by 87.31%. The use of other methods carried out by [2], using several methods namely adsorption, coagulation and using anaerobic reactor baffle can reduce SS according to quality standards i.e. 1.0544mg/l from 160mg/L. The aeration system waste treatment method of tray and filtration system is ineffective because it requires a rather long process, while the adsorption, coagulation, and anaerobic baffle reactor methods can reduce SS according to quality standards but require a fairly long processing process and require several materials for the liquid waste treatment process.

One method that can be used for liquid waste treatment in reducing organic material content is to use the coagulation and flocculation methods. Coagulation-flocculation is a physics-chemical method used in industrial wastewater treatment to remove colloidal particles, dissolved compounds and very fine suspended solids that exist in wastewater by destabilizing and floc formation [8]. Some researchers have shown that the use of natural coagulants that are environmentally friendly is a promising approach as an alternative in water and wastewater treatment, one of which is tamarind seeds (*Tamarindus indica*) [8].

Java tamarind seeds can be used as bio-coagulant in the coagulation process because they have protein content as much as 0.171-0.201g/mL [9], [10]. The protein contained in the Java Tamarind seeds is expected to play a role as a natural polyelectrolyte where the use is similar to synthetic coagulants. The efficiency of coagulation can be improved by extracting active components from Java tamarind seeds as natural coagulants by using saline solution. [11]. Tamarind seed coagulant extracted with water is only able to reduce turbidity 78% at a dose of 32ml/L, while the coagulant of seeds extracted with 1M NaCl solution could reduce turbidity by 95% with a dose of 4ml/L [12]. Extraction using NaCl (salt) solution is a salting-in mechanism where ionic strength increases with addition and solubility of natural coagulants [11]. The purpose of this study is to analyze the ability of Java tamarind seed extract (*Tamarindus indica*) as a bio-coagulant in reducing levels of suspended solid (SS) and color in liquid waste of batik home industry.

2. RESEARCH METHOD

2.1. Types and design

The research carried out was a pure experimental study (true experiment) with the design of a re-experiment research (pretest-posttest control group design). Subjects were randomly divided into treatment groups (X) and control groups that were not treated (-) [13], with a total sample of 24 samples. Variables in this research include bio-coagulant dose of java tamarind seed extract, stirring speed and stirring time. The effect of application of tamarind seed extract dose on the reduction of Fe content was analyzed using One Way Anova Test.

2.2. Tools and materials

The tools used in this study Jar Test equipment Model JT 203/6 with six 1L vats, suspended solid meter AMTAST TB200, pH (pH meter-PG1800 GEHAKA). A qualitative analysis to reveal the specific surface function groups on *Tamarindus indica* extract was performed by fourier transform infrared (FTIR) transmission spectra using KBr Technique. The analysis was carried out on MAGNA-IR 560, in the wave number of 400-4000 cm^{-1} .

2.3. Batik home industry wastewater

The wastewater used as objects in this research came from the sump pit in the batik home industry, which was collected over five days. During the preservation process, wastewater was being stored at 4°C.

2.4. Java tamarind seed

Java tamarind plant used in this research was obtained from local collectors in East Java, Indonesia. The seed were dried in the sun for approximately 12 hours [14]. The dried beans were mashed using a blender or pestle mortar until it became powder and sieved to a size of 80 mesh [15]. Powder that has been mashed then dissolved in n-hexane solution to remove fat content in a ratio of 1:5 (w/v), soaked for six hours, stirred using a magnetic stirrer with a rotation of 150rpm for 10 minutes, and leave it for 18 hours then

strained and dried the powder at room temperature [14], [16]. The fat free Java tamarind powder (3 grams) then added with 100ml of 1.5M NaCl solution to extract the protein on Java tamarind according to the procedure done by [17]-[22]. The resulting filtrate was used as bio-coagulant extract of Java tamarind seeds [22], [23].

2.5. Coagulation-flocculation test

Coagulation test-flocculation is done by the jar test method. Flash mixing was performed with a G factor 390 sec^{-1} for 1 minute, followed by slow mixing for 15 minutes with G factor 50 sec^{-1} , and settling at room temperature for 30-60 minutes. Removal of suspended solids and color were selected as the dependent variable.

3. RESULTS AND DISCUSSION

In this section, it is explained the results of research and at the same time is given the comprehensive discussion. Results can be presented in figures, graphs, tables and others that make the reader understand easily [2], [5]. The discussion can be made in several sub-chapters.

3.1. Wastewater of batik home industry

In this research, the concentration of suspended solid (SS) of batik home industry wastewater was 1580mg/L, average initial pH 4-6, settling time of sedimentation over 60 minutes, the color level was 610 Pt.Co.

3.2. Characteristic of Java tamarind seed extract

The identification of the coagulation functional groups was measured by the fourier transform infra-red (FTIR) method. The FTIR method is used to obtain information on the presence of functional groups of molecules that have specific vibrational regions [11], so that quantitative/inorganic compounds can be identified quantitatively. Spectral cluster examination of the active Java tamarind seed extract is shown in Figure 1. FTIR test results in Figure 1 shows that specific peak absorption of tamarind seed powder extract occurs in the wavelength 3338.93cm^{-1} , 2065.86cm^{-1} , and 1635.73cm^{-1} . The following is for the reading of FTIR test results of tamarind seed powder extract shows in Table 1.

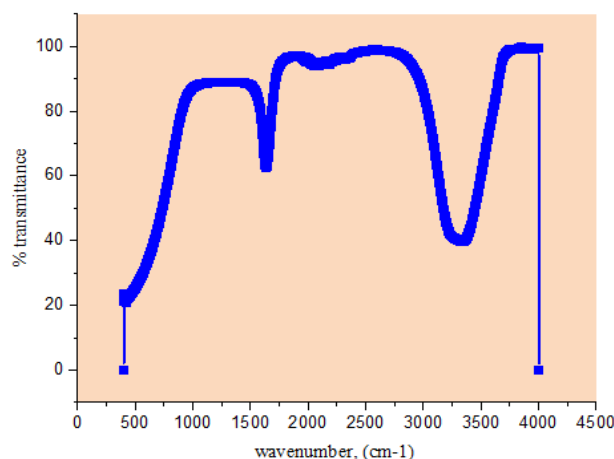


Figure 1. FTIR test result of Java tamarind seed powder extract

Table 1. FTIR Java tamarind seed extract

Frequency area (cm^{-1})	Functional groups	Peak absorprtion (cm^{-1})	Transmitten
3330-3500	N-H (Amida)x	3338.93	40
2000-3600	O-H (Alcohol, Phenol (H bond)	2065.86	90
1610-1680	C=C (Alkena)	1635.73	63

Specific peak at around 3338.93cm^{-1} indicated the presence of (N—H) group, the peak at 1644cm^{-1} indicated the presence of C=C (alkene) group. The effect of bonding O—H group was shown at the peak 2065.86cm^{-1} . These results confirmed the specific peak indicates that Java tamarind seed extract has aliphatic primary amides and primary, aliphatic alcohol function cluster. Amide cluster indicates the flocculant is positively charged, and hydroxyl cluster is charged negatively [9], [22], [24], [25]. SS levels after the addition of Java tamarind seed extract bio-coagulant. The results of SS levels after being treated with the addition of bio-coagulant extract of tamarind seeds with different dosage variations can be seen in Figure 2. The figure shows that SS levels in batik wastewater have decreased after the addition of bio-coagulant extracts. The highest decrease occurred at a dose of 10ml/L , which is 76mg/L or 95.1% removal FTIR Test Result of Java tamarind seed powder extract.

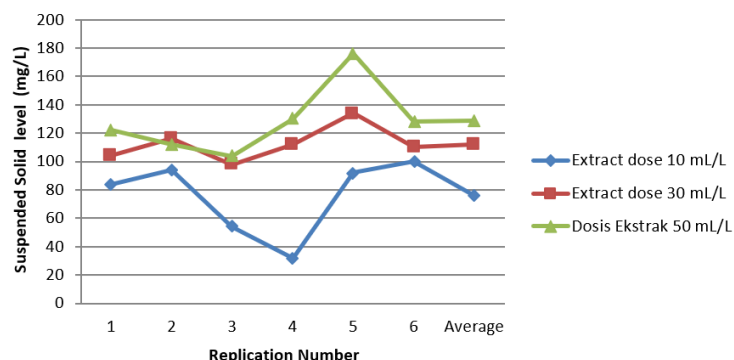


Figure 2. SS levels in batik wastewater

At a bio-coagulant dose of 30ml/L , the SS wastewater level becomes 112mg/L or 92.9% removal. In affixing bio-coagulant extract by 50ml/L , the SS level in wastewater becomes 129mg/L or with 91.8% removal. The results of statistical analysis with Two Way Anova Test on treatment data obtained Sig. (p) 0.001 . It means that the use of tamarind seed extract as bio-coagulant can significantly reduce SS levels. Color levels after the addition of bio-coagulant Java tamarind seed extract. The results of the examination of the color levels after being treated with the addition of bio-coagulant extract of Java tamarind seeds with different dosage variations it can be seen in Figure 3.

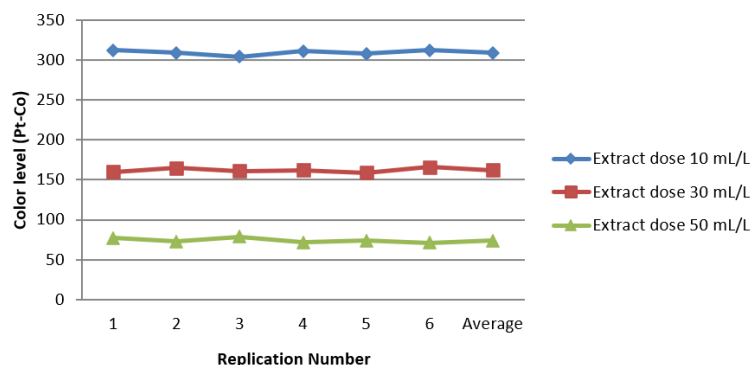


Figure 3. Color levels after the addition of bio-coagulant Java tamarind seed extract

Figure 3 shows that bio-coagulant extract at a dose of 10ml/L can reduce the color concentration of waste by 49.3% or 309Pt-Co . Bio-coagulant at a dose of 30ml/L , decreases by 73.4% or 162Pt-Co , while at a dose of 50ml/L can reduce color levels up to 74Pt-Co , or 87.8% removal and has fulfilled the Governor of Java East-Indonesia regulation, maximum of 200Pt-Co [26]. Based on the results of Two Way Anova Test analysis, it shows the value of Sig. (p) treatment of 0.0001 . It means that the use of tamarind seed extract as bio-coagulant can significantly reduce the color concentration of wastewater.

Mechanism of coagulation-flocculation with Java tamarind seed extract. Wastewater of batik home industry is acid colloid ($\text{pH} < 7$) and stable. In acidic conditions, alum does not function optimally, because no charge of neutralization in the suspension occurs. Extract bio-coagulant of tamarind seed can function as a flocculant because it contains water-soluble protein with low molecules [15], [27]. Bio-coagulant extract from the seeds of tamarind has active groups of polyelectrolytes that are positively and negatively charged, namely the amide and hydroxyl groups. The most likely mechanism that occurs in the tamarind flocculation process is the adsorption and the neutralization of stress or adsorption and unstable particle bonds. It is very difficult to determine which mechanism happened first, because it happened simultaneously [26]. Active groups with negative charges released into the solution will react with positive ions or positive metal ions in colloids and form heavier flocks. On the other hand, the positive charge will react with hydroxyl ions in suspension, to neutralize the pH [22], [28], [29]. The coagulation-flocculation process is also influenced by the G factor (gradient of stirring speed), both fast and slow stirring. In the research the G value of the factor has been controlled to produce optimal SS and color removal. Research conducted by [30], [31] states that the optimum G of fast and slow stirring for the flocculation coagulation process is 390 seconds-1 and 50 seconds-1. Determination of the value of the G factor is an important factor, because a G that is too large will inhibit the formation of flocks or flocks will break again [32].

4. CONCLUSION

The results of bio-coagulant examination from the extract of tamarind seeds showed that the protein content had a functional group of N-H (Amide), O-H (Alcohol), and C=C (Alkene) polyelectrolytes. The largest active group of polyelectrolytes in bio-coagulants is the hydroxyl group. The presence of amides and hydroxyl will disrupt the colloidal stability of batik waste water, and form a large floc so that it can be sedimented. The highest reduction in SS occurred at a dose 10ml/L, which was 95.1% removal, while for the highest removal in color occurred at a dose of 50ml/L, which was 87.8%. Traditional batik wastewater treatment, which used a coagulation-flocculation process with bio-coagulant extract of tamarind seeds could reduce levels of suspended solids and colors, in order to meet the specified quality standards. Tamarind seeds extract can be used in large scale batik crafts industries.

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