Performance of trembesi seed (Samanea saman) on tempeh wastewater treatment (a case study in Semanan Tempeh Industry), West Jakarta

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IOP Conference Series:
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To cite this article: L A Syerin *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1263** 012060

Performance of trembesi seed *(Samanea saman)* on tempeh wastewater treatment (a case study in Semanan Tempeh Industry), West Jakarta

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Abstract. Tempeh wastewater contains organic matter, TSS, and high turbidity, which negatively impact if discharged directly into water bodies. The use of biocoagulant from trembesi seeds to treat wastewater is considered more environmentally friendly, easy to find, and affordable. The purpose of this research is to determine how effective trembesi seeds are as a coagulant in removing turbidity, Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) from tempeh wastewater in a batch-stirred reactor. Jar test with dose variations of 10-700 mg/L, finding the optimum stirring duration for coagulation at 200 rpm with time intervals of 1-3 minutes and for flocculation at 80 rpm with time intervals of 15, 30, and 45 minutes. The findings show that using a coagulant concentration of 500 mg/L resulted in a 63% reduction in turbidity. The optimum coagulation duration is 2 minutes and flocculation is 30 minutes. BOD initially at 1,245 mg/L decreased by 78% to 273 mg/L. COD initially at 6,400 mg/L decreased by 40% to 3,840 mg/L. TSS initially at 609 mg/L decreased by 66% to 205 mg/L. The percentage of allowance for BOD, COD, TSS, and turbidity using a reactor is 68%, 35%, 58%, and 70%. From these results it can be said that trembesi seed coagulant is effective in removing BOD, COD, TSS, and turbidity in tempeh wastewater.

1. Introduction

The Semanan area is one of the centers of industrial activities producing tofu and tempeh in West Jakarta. The behavior of disposing tempeh wastewater directly into the drainage channels has the potential for water pollution [1]. Tempeh wastewater is produced from the processes of boiling, soaking, and washing soybeans. Tempeh wastewater is biodegradable, has an acidic pH, high content of BOD, COD, and TSS. High number of BOD and COD in mg/L can endanger the lives of aquatic biota. Increased TSS will inhibit sunlight in the water and disrupting phytoplankton growth [2].

The problem of tempeh wastewater which is a high content of organic matter, TSS, and turbidity can be overcame by wastewater treatment through the coagulation-flocculation and sedimentation process. Currently, a lot of research are developed to find a substitute for chemical coagulants because these coagulants are less environmentally friendly and harmful for human health. The use of biocoagulants are considered more environmentally friendly and can be found easily because they can be taken or extracted from plants and animals and the price is affordable. Plant extracts that are often used as coagulants are seeds, one of which is from trembesi seeds. Trembesi seeds can be used as a coagulant because they contain protein, tannin, and calcium. Protein is an effective biocoagulant because it has

IOP Conf. Series: Earth and Environmental Science 1263 (2023) 012060 doi:10.1088/1755-1315/1263/1/012060

cationic polyelectrolytes. Cationic polyelectrolytes can attract and neutralize the negative charge of colloidal particles in wastewater, forming larger flocs that settle more easily [3]. Utilization of trembesi seed extract at a concentration of 200 mg/L can reduce TSS concentration by 83% [4]. The aim of this study is to determine the effectiveness of trembesi seeds as a fot the removal of TSS, BOD, and COD in tempeh wastewater using a batch-stirred reactor.

2. Methods

2.1. The production of trembesi seed coagulant
Coagulant from trembesi seeds initiates by preparing trembesi seeds, usually yellowish brown. The trembesi seeds are dried for one hour in an oven at 105°C. After drying, the trembesi seeds are further processed by grinding them using a blender and subsequently sifting them through an 80 mesh sieve to obtain finely powdered trembesi seeds[4]. This finely powdered trembesi seed material is then dissolved by combining 1 gram of it with 500 ml of 1 M NaCl solution. Stir the trembesi seed coagulant solution with a magnetic stirrer for 15 minutes, then filter to separate the filtrate and the residue. The residue will be discarded and the filtrate used as a coagulant during the coagulation process[5].

2.2. Determination of sampling location
Determination of effluent sampling locations begins with visiting two different tempeh production sites. The first location is a public kitchen making tempeh and the second location is a tempeh production house. The things that are taken into consideration in choosing the sampling location are the volume of tempeh wastewater produced and the sampling time. The production house was chosen as the sampling location because the wastewater produced is more, this is related to the capacity of the batch reactor that will be used. Samples of tempeh wastewater can be taken in the morning so that it is more efficient when analyzed in the laboratory.

2.3. Determination the optimum coagulant dosage and stirring durations
Various coagulant doses were used including 0, 10, 20, 30, 50, 70, 100, 500, 600, and 700 mg/L. The coagulation phase was conducted at a speed of 200 rpm with stirring times of 1, 2, and 3 minutes. Subsequently, the flocculation was performed at 80 rpm with durations of 15, 30, and 45 minutes, followed by sedimentation for 60 minutes[6].

2.4. Experiment of the removal of turbidity, TSS, BOD, and COD utilizing a batch-stirred reactor
The analysis begins by measuring the initial content of tempeh wastewater to compare it against national wastewater quality standards before progressing to the experimental phase. During the determination of the optimum coagulant dosage, the trembesi seed coagulant solution was added to the wastewaterat a dose ranging from 0-700 mg/L. The turbidity parameter was analyzed to ascertain the ideal coagulant dosage. Subsequently, jar test was conducted, involving stirring for 1, 2, and 3 minutes at 200 rpm, followed by 80 rpm for 15, 30, and 45 minutes. To identify the optimum coagulation and flocculation durations, analyses of turbidity, TSS, BOD, and COD parameters was performed. BOD analysis using the winkler titration method refers to Indonesian National Standard (SNI) 6989.72:2009[7]. COD analysis using the closed reflux method with titration as outlined in SNI 6989.73:2019[8]. TSS analysis using the gravimetric method, referring to SNI 06-6989.3-2004[9]. Turbidity measurement using a turbidimeter refers to SNI 06-6989.25-2005[10].

3. Results and Discussions

The results of the characterization of wastewater from tempeh production are as shown in Table 1.

Table 1. Initial characterization of tempeh wastewater.

Parameters	Analysis			
	Boiling	Soaking	Washing	Mixed process
TSS (mg/L)	172	609	135	500
BOD (mg/L)	2,293	1,245	1,845	1,613
COD (mg/L)	5,440	6,400	640	7,040
Turbidity (NTU)	630 - 680	810 – 2,200	110 - 150	1,060 – 1,115
pH	6	4	5	5

In Table 1, displays results that highlight the notably high levels of BOD and COD in tempeh wastewater, indicative of its rich organic composition. In this study, the selected sample originated from the soaking process of tempeh production. This choice aligns with the BOD/COD ratio of soaking process wastewater, which renders it non-biodegradable and characterized by a substantial TSS content. Consequently, the wastewater treatments approach involves coagulation, flocculation, and sedimentation. The application of trembesi seed coagulant can remove BOD by 42% and COD by 66% in tempeh wastewater[2]. Another consideration pertains to optimizing the efficiency of sampling time. Extracted coagulants prove more effective due to increased protein solubility, often achieved using a salt solution, commonly NaCl[11]. The extract from trembesi seeds with 1 M NaCl solvent can remove turbidity with the percentage of 70.4%[5]. The determination of the ideal coagulant dosage involved varying doses of 0, 10, 20, 30, 50, 70, 100, 500, 600, and 700 mg/l. The parameter observed was turbidity. The ability to remove turbidity can be seen in Figure 2.

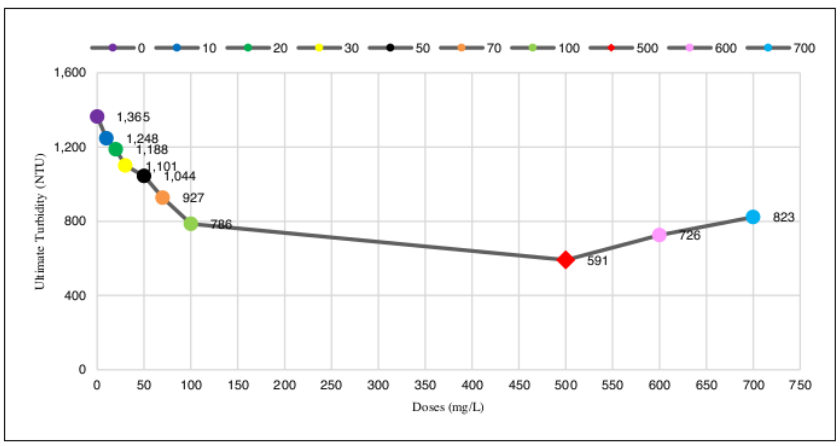

Figure 1. The correlation between coagulant dosages and the removal of turbidity.

In Figure 1, the results showed that trembesi seed coagulant can remove turbidity in tempeh wastewater. The most significant reduction in turbidity occurred at trembesi seed coagulant dosage of 500 mg/L with a turbidity value of 591 NTU. However, when the dose was increased to 600 mg/L, there was a decline in the percentage of turbidity removal. This decrease can be attributed to the coagulant dosage exceeding the optimal concentration., preventing further binding of colloidal particles in tempeh wastewater. Consequently, the previously formed flocs broke apart, leading to a reduction in the percentage of turbidity removal[12]. Jartest aims to determine the optimum stirring time. In this experiment, alum was used as a comparison in treating tempeh wastewater.

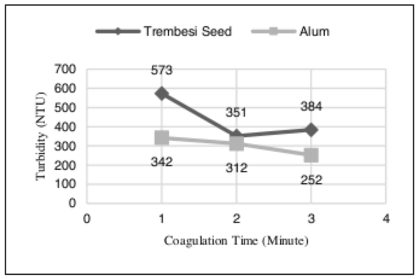

Figure 2. The relation of coagulation time on the removal of turbidity.

In Figure 2**, t**he optimum turbidity removal with coagulation at a speed of 200 rpm for 2 minutes, followed by flocculation at 80 rpm for 30 minutes. During this period, the turbidity decreased to 351 NTU, representing a 78% reduction. This stirring duration allowed for the optimal formation of flocs, resulting in large and more easily settled flocs. Prolonged stirring beyond this point led to the flocs reaching their maximum size and subsequently breaking into smaller particles that are challenging to settle. Consequently, the effectiveness of the coagulation and flocculation process in turbidity removal declined[13].

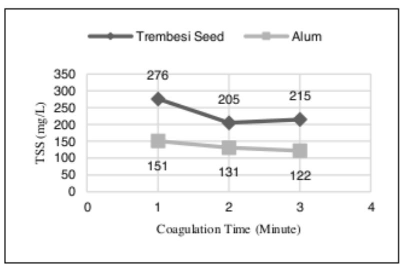

Figure 3. The relation of coagulation time on the removal of TSS.

In Figure 3**,** the optimum TSS concentration removal at a coagulation at a speed of 200 rpm for 2 minutes, followed by flocculation at 80 rpm for 30 minutes. During this process, the TSS concentration decreased to 205 mg/L, representing a 66% reduction. There is a correlation between TSS concentration and turbidity. Higher levels of suspended matter in water result in increased turbidity.

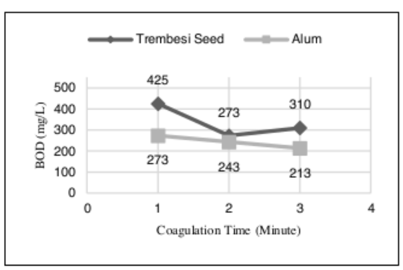

Figure 4. The relation of coagulation time on the removal of BOD.

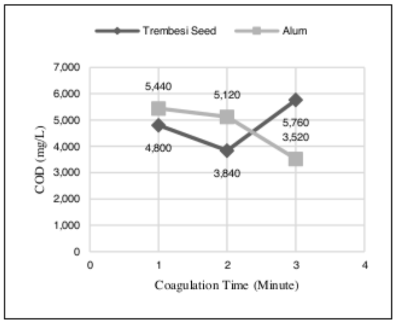

Figure 5. The relation of coagulation time on the removal of COD

In Figure 4 and 5, The optimum removal of BOD and COD concentration occurred when coagulation at a speed of 200 rpm for 2 minutes, followed by flocculation **at** 80 rpm for 30 minutes. Under these conditions, the BOD concentration reduced to 273 mg/L, representing a 78% reduction. The COD concentration reduced to 3,840 mg/L, representing a 40% reduction. The reduction in BOD and COD concentrations can be attributed to the tannin content present in the trembesi seed coagulant, which has the ability to bind and precipitate organic substances in the tempeh wastewater[2].

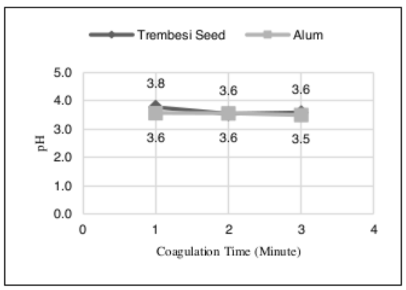

Figure 6. The relation of coagulation time on the removal of pH.

In Figure 6, stirring time can influence on pH changes indirectly, for example through interaction with particles or decomposition of organic matter in wastewater (Figure 6). However, this influence is not significant enough to result in large pH changes [14].

The parameter values of BOD, COD, TSS, turbidity, and pH in tempeh wastewater after treatment using a batch-stirred reactor are as shown in Table 2.

Table 2. The outcomes of tempeh wastewater analysis after processing with stirred batch reactor.

Parameters	Influent Reactor	Effluent Reactor	% Removal	Quality Standard
TSS (mg/L)	609	254	58%	100
BOD (mg/L)	1,245	395	68%	150
COD (mg/L)	6,400	4,160	35%	300
Turbidity (NTU)	1,605	479	70%	-
pH	4.1	3.8		6 - 9

In Table 2, the analysis results of parameters BOD, COD, TSS, turbidity, and pH indicate that they do not meet the quality standards set by the Minister of Environment Regulation Number 5 of 2014. As a result, additional treatment is needed for the liquid effluent from the reactor before it can be safely discharged into the environment.

4. Conclusion

A dose of 500 mg/L of trembesi seed coagulant proved effective in reducing the concentrations of BOD, COD, TSS, and turbidity using a batch-stirred reactor. Specifically, BOD decreased by 68%, COD by 35%, TSS by 58%, and turbidity by 70%. However, it's important note that the BOD, COD, and TSS parameters still did not meet the quality standards of the Minister of Environment Regulation Number 5 of 2014 concerning wastewater quality standards. Consequently, additional treatment is necessary to ensure that the tempeh wastewater can be safely discharge into the environment.

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