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Poly Aluminum Chloride (PAC) as Coagulant in Liquid Waste Treatment of Tofu

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Abstract

The tofu craftsmen have not processed the liquid waste produced and disposed of the liquid waste directly into the waters as a result, the water quality has decreased. Tofu liquid waste has BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), and TSS (Total Suspended Solid) exceeding the permitted quality standards. Treatment of tofu liquid waste needs to be done before being disposed of, one of which is by using coagulant. The purpose of this research is to know the value of BOD, COD, TSS, and pH of tofu liquid waste before and after the addition of PAC. The study was conducted by varying the concentration of PAC (10 mg/L, 30 mg/L, and 75 mg/L). The test results show that the tofu liquid waste has a BOD value of 3,890 mg/L, COD 9558.7 mg/L, TSS 2,905 mg/L, and a pH of 3.7. The use of PAC as a coagulant reduced the values of BOD, COD, TSS, and pH. PAC concentration of 75 mg/L can reduce BOD, COD, TSS, and pH values to 3,015 mg/L, 6,900 mg/L, 840 mg/L, and 3.59, respectively.

Keywords: *coagulant; PAC; waste tofu*

Introduction

Tofu is a type of food made from soybeans. Tofu is highly familiar to Indonesian. Tofu is widely consumed as a side dish or as a snack. Unfortunately, traditional tofu production continues in Indonesia, resulting in solid and liquid waste. Traditional tofu makers usually dump liquid waste directly into the water without processing it first (Bija *et al.*, 2020). This behavior causes a decrease in water quality because tofu liquid waste has BOD, COD, and TSS values that exceed the water quality standard (Dewa and Idrus, 2017; Dewi and Buchori, 2106).

Tofu liquid waste contains organic compounds. The decomposition of organic compounds in the liquid waste will produce oxygen gas, nitrogen, ammonia, hydrogen sulfide, methane, and carbon dioxide (Ruhmawati *et al.*, 2017; Yudhistira, Andriani and Utami, 2018). Therefore, the discharge of untreated liquid waste into bodies of water can result in unpleasant odors and the extinction of aquatic biota (Sato, Utomo, and Abineri, 2015; Bija *et al.*, 2020).

Treatment of tofu liquid waste is required. Many tofu waste treatments have been carried out, including phytoremediation with the *Thypa Latifiola* (Disyamto *et al.*, 2014), electrocoagulation (Ananda *et al.*, 2018), as well as using coagulants and flocculants (Sabilina, Setiawan and Afiuddin, 2018). Coagulants have been utilized in sewage treatment for a long time and are widely used. This is owing to the ease with which it may be used in waste treatment. The additional coagulant is commonly a positive-charged multivalent molecule. This is necessary to neutralize the waste charge, which is mostly negatively charged (Mustafiah *et al.*, 2018; Setyawati *et al.*, 2018).

Iron (II) sulfate, iron (III) chloride, aluminum sulfate, and poly aluminum chloride (PAC) are the most commonly used coagulants in waste treatment (Triarmadja, 2019). Because PAC has better capabilities and is less expensive, it has become a concern to replace previous coagulants (Daud *et al.*, 2016). The chemical formula for PAC is $Al_nCl_{(3n-m)}(OH)_m$. Meanwhile, the chemical formula for PAC, which is commonly used in waste treatment, is $Al_{12}Cl_{12}(OH)_{24}$ (Tanjung, 2016).

According to (Rahimah, Heldawati, and Syauqiah, 2018), PAC can reduce BOD and COD by 11.57% and 78.57 %, respectively, in the laundry. PAC outperformed $FeCl_3$ and $Al_2(SO_4)_3$ in lowering BOD, COD, TSS, TDS, and color of rubber soaking waste (Riskawanti *et al.*, 2016).

Based on the issues stated, the researchers intend to treat tofu liquid waste using *poly aluminum chloride* (PAC). The purpose of this research is to compare the BOD, COD, TSS, and pH levels of tofu liquid waste before and after adding PAC. The benefit of the research is that we now know the effectiveness of PAC in reducing the values of BOD, COD, TSS, and pH levels in tofu liquid waste.

Research Methodology

Materials

The tools used in this research are standard glassware (Iwaki-Pyrex), *magnetic stirrer* (Thermo Scientific), analytical balance (Ohaus), pH meter (Ohaus), BOD test equipment, COD test equipment, and TSS test equipment. Meanwhile, the materials used include tofu liquid waste, PAC, distilled water, filter paper, reagents for BOD testing, and COD testing reagents.

Working Procedures

Preparing of 10.000 ppm PAC Solution

PAC solution was prepared by dissolving 1 gram of PAC in 20 mL of distilled water in a 100 mL volumetric flask. Shake the flask until the PAC is completely dissolved, then add distilled water to the mark.

Adding of PAC Coagulant into Tofu Waste

Samples of tofu liquid waste were measured first for BOD, COD, TSS, and pH levels. The following is the procedure for treating tofu liquid waste with PAC coagulant. A glass beaker was filled with 1,500 mL of tofu liquid waste. The PAC solution was then added to the tofu liquid waste in various quantities (10 ppm, 30 ppm, and 75 ppm). The following formula determines the volume of PAC solution to be added:

$$V1 = \frac{C2 \times V2}{C1} \qquad (1)$$

V1 = volume of the PAC solution.
C1 = concentration of the main PAC solution.
C2 = PAC concentration
V2 = volume of the tofu liquid waste sample.

The mixture was stirred rapidly at 1000 rpm for 5 minutes and slowly at 300 rpm for 30 minutes. The mixture was then allowed to stand for 30 minutes and filtered. After that, the mixture was allowed to remain for 30 minutes before being filtered. The results of the filtering were then examined for BOD, COD, TSS, and pH. The Regional Health Laboratory in Magelang city executed BOD, COD, TSS, and pH tests.

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Results and Discussion

The Initial Quality Test of Tofu Liquid Waste

This study's test samples were taken at a tofu liquid waste disposal facility. The BOD, COD, and TSS test criteria were used to determine the quality of the tofu liquid waste before adding the PAC coagulant. Table 1 summarizes the results of the wastewater quality test.

Table 1. The quality test results of the tofu liquid waste

No	Parameter	unit	Outcomes	Limit Terms *
1	BOD	mg/L	3.890	150
2	COD	mg/L	9.558,7	300
3	TSS	mg/L	2.905	200
4	pH	-	3,7	6-9

*(the Regulation of Environment Ministry of the Republic of Indonesia No. 5 of 2014 about Wastewater Quality Standards, 2014)

Table 1 shows that tofu liquid waste samples have high BOD, COD, and TSS and low pH. The BOD, COD, and TSS values of tofu liquid waste are high because of their high organic compound content. Tofu liquid waste contains 40-60% protein, 25–50% carbohydrates, 10% fat, and other suspended solids (Pradana, Suharno, and Apriansyah, 2018; Novela and Dewata, 2019), which will then be decomposed by microorganisms under aerobic conditions.

The high BOD and COD values indicate an increased need for oxygen by microorganisms in decomposing organic compounds. If tofu liquid waste is discharged into the environment continuously while the amount of oxygen needed to decompose organic compounds is not met, then environmental pollution will occur. It will certainly affect the quality of the environment (Anggarwati, 2018).

In this study, a coagulation-flocculation process treated the tofu liquid waste. Coagulation is carried out to destabilize colloidal particles to form flocs and to absorb dissolved organic matter in the floc (Haydar and Aziz, 2009). In the wastewater treatment process, the coagulation stages include a) floc core formation, b) colloid particle destabilization, and c) particle size increase (Altenor and Gaspard, 2014). The coagulation process is accelerated with a coagulant substance, wherein in this study, *poly aluminum chloride* (PAC) was used. Rapid stirring of 1000 rpm for 5 minutes was carried out to evenly disperse the coagulant into the tofu liquid waste sample.

Slow stirring of 300 rpm for 30 minutes then followed rapid stirring of the sample. Slow stirring aims to increase the attractive forces among particles. The particles will collide with each other to form large flocs, and then the flocs will aggregate and settle. After rapid stirring, the tofu liquid waste sample was allowed to stand for 30 minutes to optimize the sedimentation process. The results of the quality test of tofu liquid waste after treatment are presented in Table 2.

Table 2. The results of the quality test of tofu liquid waste after treatment

Concentration PAC (mg/L)	Parameters			
	BOD (mg/L)	COD (mg/L)	TSS (mg/L)	pH
0	3,890	9,558.7	2.905	3.70
10	3,480	7,136.2	983	3.63
30	3,040	7,666.9	960	3.59
75	3,015	6,900	840	3.59

Table 2 shows that the values of BOD, COD, TSS, and pH of tofu wastewater decreased with increasing PAC concentrations. The use of PAC coagulant only slightly reduced the BOD value of the sample. The use of PAC at a concentration of 10 mg/L was only able to reduce BOD by 410 mg/L with a reduction efficiency of 10.5%. Meanwhile, the use of PAC with a concentration of 75 mg/L was able to reduce 875 mg/L with an efficiency of 22.5%.

PAC showed good performance in reducing COD values. The use of 10 mg/L and 75 mg/L PAC can reduce COD by 2,422.5 mg/L with an efficiency of 25.3% and 2,658.7 mg/L with an efficiency of 27.8%, respectively. Table 4.2 also shows that PAC can reduce the TSS of tofu liquid waste well. The PAC concentration of 10 mg/L decreased TSS by 1,922 mg/L with a reduction efficiency of 66.2%, while the PAC concentration of 75

mg/L decreased TSS by 2,065 mg/L with a reduction efficiency of 71.1%.

The results obtained in this study are from some previous researches (Anggarwati, 2018; Murwanto, 2018). (Murwanto, 2018) stated that the adding of PAC 75 mg/L with a contact time of 25 minutes could reduce the BOD value to 3,600 mg/L from the initial BOD value of 8,600 mg/L, and reduce the COD value to 6,600 mg/L from the initial COD value of 8,900 mg/L. It also could decrease the TSS value to 2,000 mg/L from the initial TSS value of 7,100 mg/L.

Liquid waste treatment using PAC showed a slow decrease in pH level. This is possible because the hydrolysis reaction of PAC in water only releases one H^+ as follows:

$$[Al(OH)] + H_2O \rightarrow 2Al(OH) + H^+$$

(Nur, Putra and Ningsih, 2020)

Table 2 shows that the PAC used has not been able to process tofu liquid waste to meet the permitted quality standards based on the Regulation of the Minister of the Environment of the Republic of Indonesia Number 5 of 2014, namely BOD 150 mg/l, COD 300 mg/l, TSS 200 mg/L, and pH 6-9. However, the research conducted has shown that PAC can reduce the BOD, COD, and TSS values of tofu liquid waste.

PAC as a coagulant works through its interaction with organic macromolecules in tofu liquid waste. The mechanism for treating tofu liquid waste using PAC involves *charge neutralization, sweep coagulation, polymer bridging,* and *patch flocculation* (Suopajärvi, 2015).

Conclusions

Tofu liquid waste has BOD, COD, and TSS values of 3,890 mg/L, 9,558,7 mg/L, and 2,905 mg/L. PAC, as a coagulant, can be used to treat tofu liquid waste by reducing the values of BOD, COD, and TSS.

Suggestion

Further research is needed by varying the fast and slow stirring times. Further research is also needed by comparing various coagulants in the treatment of tofu liquid waste.

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