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Effectiveness of Reducing Turbidity Levels of Tofu Industry Wastewater with Alum Coagulant

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Abstract:- Tofu industry liquid waste is one of the pollutants that can pollute the environment, especially can cause turbidity in rivers, lakes, and other waters. One of the countermeasures is to treat the liquid waste by giving alum coagulant. The purpose of this study was to measure the turbidity level of tofu industry wastewater before and after the application of alum coagulant and calculate the effectiveness or optimal dose/concentration of alum coagulant. This research is a type of quantitative research with a quasi-experimental research design. The research was conducted at the Public Health Laboratory of Universitas Muhammadiyah Surakarta in January 2024. The data analysis technique used was quantitative to determine the effectiveness of alum coagulant, the test used was anova test. The results of this study indicate that the level of turbidity in the liquid waste of the tofu industry after the coagulation process using alum is at a concentration of 2 ml which produces a decrease in turbidity levels of 22.93%, a concentration of 4 ml produces a decrease in turbidity levels of 26.24%, a concentration of 6 ml produces a decrease in turbidity levels of 29.08%, and a concentration of 8 ml produces a decrease in turbidity levels of 36.41%, so that the optimum dose / concentration of alum coagulant is 8 ml because it has the best effectiveness value in reducing turbidity levels in the liquid waste of the tofu industry.

Keywords:- *Effectiveness; Turbidity; Tofu Industry Liquid Waste; Alum Coagulant.*

I. INTRODUCTION

As we know that tofu waste is a by-product of the soybean milk industry and tofu production, and is attractively used as a cheap feed ingredient and is available at soybean cultivation sites [1]. According to the Central Bureau of Statistics, Indonesia in 2019 obtained up to 972,000 tons of soybeans with 998,000 hectares of planted land. This production increased compared to the previous year when the previous wastewater was only 947,000 tons. To produce 1 ton of tofu and tempeh, 3000-5000 liters of waste is produced. Tofu production is a water-intensive process, with various processes including: (a) soaking, grinding, and cooking of soybeans; (b) filtration; (c) protein coagulation; (d) pressing and molding; and (e) packaging. Wastewater from tofu production is generated from the soaking, washing, and coagulation pressing processes, as well as from households [2].

Wastewater is said to be turbid if the wastewater has many particles of suspended material, giving it a muddy and cloudy color or appearance [3]. The impact of turbidity in industry cannot be ignored, as it contributes to tank clogging and pipe corrosion, which in turn causes damage [4]. Not only that, turbidity in sewage creates severe resistance to unit operations carried out at industrial wastewater treatment plants. Hence the treatment of wastewater before discharge should not be neglected [5].

In the coagulation-flocculation process, the accumulation of substances is needed to help the process of settling suspended particles, namely coagulants, when the coagulant is reacted with wastewater, the colloidal particles in the wastewater will form aggregation or merging of small particles to form larger particles, due to the charge ratio between colloidal particles and coagulants [6].

According to research the application of coagulation-flocculation is considered one of the most important processes due to its process simplicity, effective turbidity removal, and low energy consumption. Turbidity in raw water results from the presence of small particulate and colloidal contaminants such as clay, silt, various microorganisms, food waste, industrial waste, and domestic waste [7], [8]. One of the relatively cheap and easily available coagulants, which is often used in water treatment, is alum, with the formula $(Al_2(SO_4)_3 \times H_2O$ where x = 14.16 [9]. One method used for coagulant dose optimization is the Jar Test. It has been commonly used to determine the required coagulant dosage concentration. The coagulant is stirred rapidly to disperse in water to neutralize the charge on the colloidal particles. Then, the focus is increased by slow stirring, which helps the formation of larger foci that can easily settle in the sedimentation tank leaving a clear supernatant [10].

The treatment of wastewater from the tofu industry is a critical environmental concern due to its high levels of pollutants such as Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), dissolved oxygen (DO), and turbidity [11]. Various studies have been conducted to assess the effectiveness of different methods in reducing these pollutants in tofu industry wastewater. One study evaluated the performance of combining coagulation-flocculation and ultrafiltration processes in reducing the levels of pollutants in tofu industry wastewater. Another study focused on the impact of pH on coagulant effectiveness

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in treating such wastewater. These studies highlight the importance of optimizing treatment processes to achieve efficient pollutant removal [12]. One of study investigated the use of a hybrid aluminum sulfate/kaolin coagulant in treating refinery industrial wastewater, demonstrating a significant reduction in turbidity levels [13]. Another study compared the effectiveness of organic (Moringa seed powder) and inorganic (aluminum sulfate) coagulants in treating tofu industrial wastewater, showing the superiority of the organic coagulant [14]. Furthermore, research emphasized the optimization of coagulant doses and pH levels to achieve high treatment efficiency in paper-recycling wastewater [15], [16]. The effectiveness of coagulation-flocculation and membrane processes in treating tofu wastewater, underscoring the importance of advanced treatment methods [17].

Research to mix alum coagulants has been researched about mixing 30 ppm and 40 ppm alum coagulants can reduce water turbidity by 92.34%. Therefore, it requires a method that is appropriate and effective in reducing the turbidity of tofu liquid waste [9]. The results of this study are expected to be able to serve as an effective alternative coagulant in overcoming the problem of tofu industry wastewater contamination. In conclusion, the effectiveness of reducing turbidity levels in tofu industry wastewater with organic coagulant is a multifaceted process that involves optimizing coagulant dosage, pH levels, and treatment processes. By integrating various techniques such as coagulation-flocculation, ultrafiltration, and the use of alternative coagulants, significant improvements in wastewater treatment efficiency can be achieved.

II. METHOD

This type of research aims to develop scientific knowledge by testing hypotheses, exploring cause-and-effect relationships, and validating theories through experiments and surveys that require statistical data [18]. This research employs a quantitative research approach with a quasi-experimental design [19].This research was conducted at the Public Health Laboratory of Universitas Muhammadiyah Surakarta, which is located at Jl. Garuda Mas No.08, Gatak, Pabelan Village, Kartasura District, Sukoharjo Regency, Central Java Province. While the research time was conducted in January 2024. The equipment used in this research is 1 container of tofu liquid waste (jerry can), 4 beaker glass 1000 ml, 1 unit jar test, 1 stirrer and 1 unit turbidity meter. While the materials used are liquid waste from the tofu industry, alum, and pure water (distilled water). The data collection technique used in this study is observation technique, which is a systematic process in collecting research data by observing the actual behavior patterns of people, objects and events that occur carefully and recording / recording all things around the object of research related to the information to be obtained from the object of observation.

Analysis of Variance (ANOVA) is a statistical method used to compare means between two or more groups to determine if there are statistically significant differences between them. In the context of research studies, ANOVA is frequently employed to assess the impact of different variables on a particular outcome. The researchers utilized a one-way ANOVA to identify significant differences among sample groups [20]. Furthermore, ANOVA is often followed by post hoc tests to further analyze and compare specific group differences. Conducted post hoc tests after ANOVA to determine the comparison levels of each information system basis [21]. Additionally, ANOVA was followed by the LSD test to explore differences in organoleptic evaluation and bacterial colony counts [22]. Moreover, ANOVA can be extended to multivariate settings, known as Multivariate Analysis of Variance (MANOVA). MANOVA allows for the analysis of multiple dependent variables simultaneously, providing a comprehensive understanding of the relationships between variables [23].

The data collection carried out is primary data, namely by conducting direct testing of the object of research at the research site. The data that will be generated include: Data on the turbidity level of the tofu industry liquid waste sample before giving alum coagulant; Data on the turbidity content of tofu industry liquid waste samples after the provision of alum coagulants that have been dissolved with different concentration variations, namely: 2 ml, 4 ml, 6 ml, and 8 ml; Data on the optimum dose/concentration of alum coagulant. The results of the decrease in turbidity levels in the best tofu liquid waste show the optimum concentration of alum coagulant.

The data analysis technique used in this research is descriptive comparative method, where the turbidity content of the tofu industrial liquid waste sample before the provision of alum coagulant is compared with the turbidity content after the alum coagulant pemebrian to get the effectiveness value of reducing turbidity levels expressed in percent (%). The effectiveness of reducing turbidity levels can be calculated using the following formula:

Effectiveness =
(Turbidity Before - Turbidity After) / (Turbidity Before) X 100%

III. RESULT AND DISCUSSION

- *Turbidity Levels in Tofu Industry Liquid Waste Before and After Giving Alum Coagulant*

The testing process begins with the dilution of tofu industry liquid waste samples using distilled water into a container with a ratio of 2: 2 liters, then stirred until well mixed. Before further processing, the waste sample is first measured for turbidity using distilled water, then filled with tofu liquid waste samples until the limit mark. Furthermore, the cuvette is inserted into the turbidity meter and the measurement results will be displayed on a digital layer. The initial measurement results can be seen in table 1.

Furthermore, tofu liquid waste samples that have been mixed with distilled water are calculated into 4 beaker glasses of 1000 ml each. then 1 gram of alum is taken and dissolved with distilled water as much as 100 ml. the alum

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solution is put into each beaker glass that has been filled with thau liquid waste samples with different concentrations, namely 2ml, 4 ml, 6 ml, and 8 ml. the coagulation process is carried out using a jar test. Each sample solution was stirred quickly at 100 rpm for 10 minutes, then continued with slow stirring at 20 rpm for 5 minutes. This slow stirring is intended to accelerate the flocculation process. After the coagulation-flocculation process is carried out, the sample solution is allowed to stand for 30 minutes until the flocs settle and the water becomes clear. Next, the turbidity level of the sample solution in each beaker glass was measured. The turbidity measurement results can be displayed in the following table.

Table 1 Measurement Results of Turbidity Levels in Tofu Industry Liquid Waste Before and After Application of Alum Coagulant

No	Concentration Alum Coagulant	Turbidity Level		Decrease in Turbidity Level
		Before	After	
1	2 ml	423 NTU	326 NTU	97 NTU
2	4 ml		312 NTU	111 NTU
3	6 ml		300 NTU	123 NTU
4	8 ml		269 NTU	154 NTU

Source: Test Results, 2024

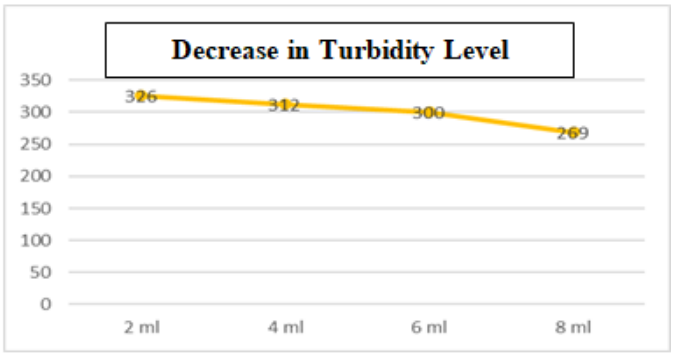

Fig 1. Measurement Results of Turbidity Levels in Tofu Industry Liquid Waste after the application of Alum Coagulant
Source: Test Results, 2024

Based on the table and graph above, it can be seen that the measurement results of turbidity levels in the tofu industry wastewater before the coagulation process using alum are 423 NTU. After the coagulation process using alum, the turbidity levels in the tofu wastewater decreased, namely 326 NTU at a coagulation concentration of 2 ml alum (decreased by 97 NTU), 312 NTU at a coagulation concentration of 4 ml alum (decreased by 111 NTU), 300 NTU at a coagulant concentration of 6 ml alum (decreased by 123 NTU), and 269 NTU at a coagulant concentration of 8 ml alum (decreased by 154 NTU).

The decrease in turbidity levels in the liquid waste of the tofu industry is caused by alum coagulant binding particles suspended in wastewater so that the particles settle down and the turbidity decreases. This is as stated by [24] which explains that alum is a dispersed colloid that has a positive charge and will bind fine particles that have a negative charge in wastewater. Alum will neutralize the positive charge in it with fine impurity particles in the waste so that it will form flocs of various sizes and will settle during the sedimentation process.

Stirring speed will be applied also very influential in the coagulation process. Fast stirring serves to dissolve the coagulant so that neutralization of particles in water occurs. While slow stirring serves to produce movement slowly and in laminar conditions in wastewater. This laminar condition will produce contact between colloidal particles to form large particles called flocs. This contact between particles produces forces between molecules to form a merger or agglomeration [24].

- *Effectiveness of Reducing Turbidity Levels in Tofu Industry Liquid Waste using Alum Coagulant*

After the measurement results of turbidity levels in the tofu industry wastewater before and after the provision of alum coagulant are obtained, calculations are then carried out to determine the effectiveness of reducing turbidity levels. The results of the calculation of the effectiveness of turbidity levels can be displayed in the following table.

Tabel 2. Calculation Results of the Effectiveness of Decreasing Turbidity Levels in Tofu Industry Liquid Waste using Alum Coagulant

No	Concentration Alum Coagulant	Decrease in Turbidity Level
1	2 ml	22,93 %
2	4 ml	26,24 %
3	6 ml	29,08 %
4	8 ml	36,41 %

Source: Test Results, 2024

Based on the table above, it can be seen that the decrease in turbidity levels in the liquid waste of the tofu industry has different effectiveness values depending on the dose/concentration of 2 ml alum coagulant of 22.93%, while the highest effectiveness value is seen at a concentration of 8 ml alum coagulant which is 36.41%. Thus it can be concluded that alum coagulant is quite effective in reducing turbidity levels in tofu industry wastewater. In addition, based on table 2 above, it can also be seen that the optimum dose/concentration of alum coagulant is 8 ml because it has the best effectiveness value in reducing turbidity levels in tofu industry wastewater.

IV. CONCLUSION

At an alum coagulant concentration of 2 ml, there was a decrease in turbidity level by approximately 22.93%. Increasing the alum concentration to 4 ml resulted in a slightly higher decrease in turbidity level, about 26.24%. Further increasing the alum concentration to 6 ml led to a more significant decrease in turbidity level, reaching approximately 29.08%. The highest concentration of alum

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tested, 8 ml, yielded the most substantial decrease in turbidity level, with a reduction of about 36.41%. Based on the results, it can be concluded that alum coagulant is effective in reducing turbidity levels in tofu industry liquid waste. Moreover, there is a clear trend indicating that higher concentrations of alum lead to greater reductions in turbidity. However, it's important to consider the balance between effectiveness and cost, as using higher concentrations of alum may incur higher expenses. Further research could explore optimizing the alum concentration to achieve the desired level of turbidity reduction while minimizing costs and potential environmental impacts. The results showed that an alum concentration of 8 ml resulted in a 36.41% decrease in wastewater turbidity, the highest reduction compared to other concentrations. Therefore, 8 ml can be concluded as the optimal dose/concentration of alum coagulant for reducing turbidity in tofu industry wastewater.

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