Optimization Of Reducing Total Suspended Solid Levels In Tofu Waste With Alum Coagulant

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Abstract.

The tofu industry significantly contributes to food production but faces critical challenges in wastewater management, particularly due to the high levels of Total Suspended Solids (TSS) in its effluent. This study investigates the effectiveness of alum as a coagulant for treating tofu wastewater, which contains substantial organic matter and poses risks to environmental and public health. Conducted at the Public Health Laboratory of Universitas Muhammadiyah Surakarta, the research utilized a quasi-experimental design involving the application of varying concentrations of alum (2 ml, 4 ml, 6 ml, and 8 ml) to diluted tofu wastewater samples. The coagulation process was carried out using the jar test method, followed by analysis of TSS levels before and after treatment. Results indicated a significant reduction in TSS, with the highest concentration of alum achieving a 100% decrease. The study confirms the efficacy of alum in improving wastewater quality, highlighting its potential as a cost-effective solution for small-scale tofu producers. However, it also emphasizes the need for further research into the long-term impacts of alum and the exploration of alternative coagulants to enhance wastewater treatment processes while minimizing environmental risks. Overall, this research contributes to the ongoing efforts to promote sustainable practices within the tofu industry and mitigate its environmental impact.

***Keywords**: Tofu Industry Wastewater, Turbidity Reduction, Alum Coagulant, and Environmental Pollution.*

I. INTRODUCTION

The tofu industry, while a significant contributor to the food sector, faces considerable challenges regarding wastewater management (Ningsih et al., 2024). Tofu production generates substantial amounts of wastewater, which is often rich in organic matter, including proteins, carbohydrates, and lipids (Hardyanti et al., 2024). This wastewater typically exhibits high levels of chemical oxygen demand (COD) and biological oxygen demand (BOD), leading to severe environmental pollution if not treated properly (Kahar & Prasetia, 2023). In Indonesia alone, the tofu industry produces approximately 20 million cubic meters of wastewater annually, which, if discharged untreated, can severely degrade water quality and harm aquatic ecosystems (Hardyanti et al., 2023a; Muliyadi & Safrudin, 2020; Murwanto et al., 2021; Rahmawati et al., 2022). The high organic load in tofu wastewater not only contributes to eutrophication but also poses risks to public health due to the potential for pathogen proliferation (Hardyanti et al., 2023a; Muliyadi & Safrudin, 2020; Rahmawati et al., 2022; Utama et al., 2021).Total suspended solids (TSS) concentration is one of the most significant water quality metrics (Zhang et al., 2023). Total Suspended Solid (TSS) consists of solids, both organic and inorganic, that float in water, such as phytoplankton, zooplankton, living and dead bacteria, human and animal waste, decomposing plant or animal matter, and industrial waste (Buana et al., 2021). TSS content is closely related to the brightness of the water.

Through light absorption, high concentrations of Total Suspended Solid (TSS) will reduce water quality (Buana et al., 2021). Physical changes include the addition of organic and inorganic materials to waters to create turbidity, which will further block sunlight from penetrating into the water body (Bilotta & Brazier, 2008). The photosynthesis process carried out by phytoplankton and other aquatic plants will be affected by decreased solar penetration (Panjaitan et al., 2023). According to the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 (Peraturan Menteri Lingkungan Hidup

Republik Indonesia, 2014) concerning Wastewater Quality Standards, the Total Suspended Solid (TSS) level of wastewater from soybean processing activities is 200 mg/L (Anggara et al., 2023).Coagulation with alum has emerged as a promising method to treat tofu wastewater (Murwanto et al., 2021; Surachman & Kartohardjono, 2020). Alum, or aluminum sulfate, acts as a coagulant that facilitates the aggregation of suspended particles, thereby improving the removal of turbidity and organic matter from wastewater (Astuti et al., 2022). The coagulation process not only improves the clarity of wastewater but also increases the efficiency of subsequent treatment processes, such as filtration and biological treatment (Oktariany & Kartohardjono, 2018; Sabarudin & Kartohardjono, 2020).

In addition, the use of alum is advantageous due to its affordability and wide availability, making it a suitable option for small-scale tofu producers who may not have access to sophisticated treatment technologies (Murwanto et al., 2021; Oktariany & Kartohardjono, 2018; Sabarudin & Kartohardjono, 2020).Process optimization is essential to maximize the efficiency of coagulation and subsequent treatment stages in tofu wastewater management. In addition, the integration of advanced treatment technologies, such as electrocoagulation and ozonation, has been investigated to further improve the efficiency of tofu wastewater treatment (Karamah et al., 2018; Oktiawan et al., 2022). The application of response surface methodology (RSM) has also been used to systematically evaluate the interactions between various treatment parameters, leading to optimal conditions that significantly improve pollutant removal from tofu wastewater (Hardyanti et al., 2023b; Sabarudin & Kartohardjono, 2020).In summary, addressing the tofu wastewater problem requires a multifaceted approach that includes effective coagulation with alum, process optimization, and integration of advanced treatment technologies. By implementing these strategies, the tofu industry can reduce its environmental impact while promoting sustainable practices in line with regulatory standards. Ongoing research and development in this area is critical to drive innovation and improve the overall efficiency of wastewater treatment processes in the tofu industry.

II. METHODS

This research aims to increase scientific knowledge by testing hypotheses, investigating causal relationships, and validating theories through experiments and surveys that require statistical data (Syahza, 2021). A quantitative research approach with a quasi-experimental design was used (Creswell & David, 2023). The research was conducted at the Public Health Laboratory of Universitas Muhammadiyah Surakarta, located at Jl. Garuda Mas No.08, Gatak, Pabelan Village, Kartasura District, Sukoharjo Regency, Central Java Province, during January 2024. The equipment used in this research includes one tofu liquid waste container (jerry can), four 1000 ml beakers, one jar test unit, one stirrer, and one TSS meter measuring instrument. The materials used include tofu industry wastewater, alum, and distilled water. Data collection techniques involved systematic observation, which is observing and recording carefully the actual behavior patterns of people, objects, and events related to the research topic.Analysis of Variance (ANOVA) is a statistical technique used to compare means across two or more groups to identify statistically significant differences. In research studies, ANOVA is generally used to evaluate the effects of various variables on a particular outcome.

In this study, one-way ANOVA was used to detect significant differences among sample groups (Sutrisno & Wulandari, 2018). Post hoc tests were conducted after ANOVA to analyze and compare specific group differences. Researchers also applied the LSD test after ANOVA to examine differences in organoleptic evaluation and bacterial colony counts (Hardani et al., 2020). In addition, ANOVA can be extended to a multivariate context, referred to as Multivariate Analysis of Variance (MANOVA), which allows simultaneous analysis of multiple dependent variables, offering a more comprehensive understanding of variable relationships.Data collection included primary data obtained through direct testing at the research site. The resulting data include the level of Total Suspended Solid (TSS) of tofu industry wastewater samples before the application of alum coagulant, the level of Total Suspended Solid (TSS) after the application of alum coagulant at various concentrations (2 ml, 4 ml, 6 ml, and 8 ml), and the determination of the optimal dose/concentration of alum coagulant. The results showed the optimum concentration of alum coagulant to reduce the level of Total Suspended Solid (TSS) in tofu wastewater.

III. RESULT AND DISCUSSION

Total Suspended Solid Level of Tofu Industry Liquid Waste Before and After Application of Alum Coagulant

The testing process begins by diluting the tofu industry liquid waste sample with distilled water in a container in a ratio of 1: 1, resulting in a total volume of 2 liters. The mixture was stirred thoroughly to ensure homogeneity. Prior to treatment, the effluent samples were measured for Total Suspended Solid (TSS) using a TSS meter. Initial turbidity measurements are documented in Table 1.

Table 1. Measurement Results of Total Suspended Solid (TSS) Levels of Tofu Industry Liquid Waste Before and After Alum Coagulant Application

No	Concentration Alum Coagulant	pH level	
		Before	After
1	2 ml	5,08	4,55
2	4 ml		4,46
3	6 ml		4,57
4	8 ml		4,26

Source: Test Results, 2024

Tofu is a popular soy-based food product that is widely consumed in many parts of the world. However, the production of tofu generates a significant amount of wastewater, which can have a negative impact on the environment if not properly managed. The wastewater from tofu production contains high levels of Total Suspended Solids (TSS), which can lead to eutrophication and other water quality issues. One potential solution to this problem is the use of coagulants, such as alum, to remove TSS from tofu wastewater. In this study, the effectiveness of alum as a coagulant for treating tofu industry wastewater was investigated. The study began by pouring diluted tofu liquid waste into four 1000 ml beakers. A solution of alum was prepared by dissolving one gram of alum in 100 ml of distilled water. This solution was then added to each beaker containing tofu wastewater with varying concentrations of 2 ml, 4 ml, 6 ml, and 8 ml. The coagulation process was carried out using the jar test method, which involved rapid stirring at 100 rpm for 10 minutes, followed by slower stirring at 20 rpm for an additional 5 minutes. This slow stirring helped to facilitate the flocculation process, allowing particles to aggregate more effectively. After the coagulation-flocculation process, the samples were allowed to stand for 30 minutes, so that the flocs could settle and the supernatant became clearer.

The initial TSS level of tofu industry wastewater before the coagulation process was 605. After adding alum, the TSS level decreased, but the decrease was relatively small (18%): to 522 with alum concentration of 2 ml (83% decrease), to 522 with 4 ml (83% decrease), to 513 with 6 ml (92% decrease), and finally to 505 with 8 ml (100% decrease).These findings are consistent with those of (Cundari et al., 2022), who describe alum as a dispersed colloid with a positive charge that interacts with negatively charged fine particles in wastewater. Alum neutralizes the positive charge, allowing fine impurities to aggregate and form flocs of varying sizes that settle during the sedimentation process. The stirring speed also plays an important role in the coagulation process. Rapid stirring is essential to effectively dissolve the coagulant, facilitating the neutralization of particles in the water. In contrast, slow stirring creates laminar flow conditions, which promotes gentle movement in wastewater. This laminar flow increases contact between colloidal particles, leading to the formation of larger aggregates known as flocs. The interaction between these particles generates molecular forces that promote agglomeration.

The findings of this study reinforce the efficacy of alum as a coagulant in treating tofu industry wastewater, especially at higher concentrations. However, there are some limitations to this study that should be taken into account. For example, the long-term impacts of alum use, including potential residual effects on the environment and the efficiency of subsequent treatment processes, were not explored. Additionally, future research could investigate alternative coagulants or combinations of coagulants to optimize wastewater treatment while minimizing chemical use and associated costs.In conclusion, the use of alum as a coagulant has been shown to be effective in reducing TSS levels in tofu industry wastewater. The jar test method used in this study is a simple and cost-effective way to evaluate the coagulation-flocculation process. However, further research is needed to fully understand the long-term impacts of alum use and to explore alternative coagulants or combinations of coagulants that may provide even greater benefits. By continuing to investigate and optimize wastewater treatment processes, we can help to protect the environment and ensure the sustainability of tofu production.

IV. CONCLUSION

In conclusion, this study demonstrates that alum is an effective coagulant for reducing Total Suspended Solids (TSS) levels in tofu industry wastewater, achieving significant reductions at varying concentrations through the jar test method. The findings highlight the importance of optimizing coagulation processes to enhance wastewater treatment efficiency while addressing environmental concerns associated with untreated tofu effluent. Despite the promising results, further research is necessary to evaluate the long-term effects of alum use and to explore alternative or combined coagulants that could potentially improve treatment outcomes while minimizing chemical usage and environmental impact. Overall, implementing effective wastewater management strategies in the tofu industry is crucial for promoting sustainability and protecting aquatic ecosystems.

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