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Effect of Tamarind Seeds on the Reduction of BOD and TSS of Tofu Factory Liquid Waste

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Abstrak

Liquid waste from the tofu industry is one of the significant sources of pollution in Indonesia, with high BOD and TSS content. High BOD and TSS can damage environmental quality and aquatic ecosystems if not managed properly. This study aims to evaluate the effectiveness of tamarind seed core in reducing BOD and TSS. The results showed that increasing the dose of tamarind seed and the coagulation-flocculation process time effectively reduced BOD and TSS. A dose of 8 g/L with 45 minutes resulted in a reduction of BOD by 64.8% and TSS by 60.3%. Increasing the coagulant dose accelerates the flocculation and adsorption process, thereby reducing contaminants. The use of tamarind seed as a natural coagulant shows an environmentally friendly potential for industrial wastewater treatment. Tamarind seeds are effective as a biocoagulant in reducing BOD and TSS of tofu factory wastewater, with higher doses and process time giving the best results.

Keywords: Liquid waste, BOD, TSS, Tamarind seeds, Biocoagulant

INTRODUCTION

Liquid waste from the tofu industry is a significant source of pollution in many countries, including Indonesia. This waste contains high levels of organic matter and dissolved solids, which can damage environmental quality if not managed properly. (Hardyanti *et al.*, 2023).. One of the important parameters in assessing effluent quality is Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS). BOD measures the amount of oxygen required by microorganisms to degrade organic matter in the effluent, while TSS reflects the amount of solids suspended in the liquid. (Pesqueira, Pereira and Silva, 2020).. Both are key indicators of pollution that can affect water quality and aquatic ecosystems if not managed appropriately.

In an effort to reduce the environmental impact of tofu factory wastewater, various methods have been tested, including the use of natural materials as adsorbents or coagulants. One material that has attracted attention is tamarind seed (Tamarindus indica L.), which is known to have the potential to affect the quality of wastewater effluent. (Ana *et al.*, 2021). Tamarind seeds are rich in active compounds such as tannins, polysaccharides, and organic acids, which can play a role in the waste treatment process. (Malik *et al.*, 2022). However, although many studies have been conducted on the use of natural materials for effluent treatment, there is still a gap in the specific understanding of the effectiveness of tamarind seeds in reducing BOD and TSS of wastewater from tofu factories.

Tofu factory effluent contains high concentrations of BOD and TSS which can have a negative impact on the environment. High BOD indicates that the effluent contains organic matter that can cause a decrease in oxygen levels in the water, potentially causing the death of fish and other aquatic organisms. (Lv *et al.*, 2024) .. On the other hand, high TSS indicates the presence of solid particles in the effluent that can settle to the bottom of the water body, causing sedimentation that is detrimental to aquatic habitats. (Soaudy *et al.*, 2023) .. These effluents are often treated using conventional methods such as coagulation-flocculation or biological processes, but these methods are often expensive and inefficient on an industrial scale. (Nayeri and Mousavi, 2022)..

In this context, tamarind seeds offer a potentially cheaper and environmentally friendly alternative solution. Tamarind seeds, which are generally considered as agricultural waste, contain bioactive compounds that can be utilised in waste treatment processes. (Mansingh *et al.*, 2021).. Although several studies have explored the use of tamarind seeds in water treatment, the results are still varied and there is no consensus on their effectiveness in the context of tofu factory wastewater specifically. (Ueda Yamaguchi *et al.*, 2021).

The use of natural materials in wastewater treatment has been a rapidly growing area of research. Recent studies have shown that various natural materials such as banana peels, pomegranate peels, and tamarind seeds have the potential to reduce BOD and TSS in wastewater effluent. (Islam *et al.*, 2023). Tamarind seeds,

in particular, have attracted attention for their ability to adsorb contaminants and act as natural coagulants. (Raj and Lee, 2024).

Research by (Srinivasulu, Naidu and PK, 2019) revealed that tamarind seeds have a significant adsorption capacity for heavy metals and organic matter. Another study by (Thamaraiselvi *et al.*, 2024) showed that tamarind seed extract is effective in reducing BOD levels in industrial wastewater. However, these studies were generally conducted on a laboratory scale and have not been fully verified on an industrial scale in a tofu factory.

Tamarind seeds can serve as a natural coagulant to reduce TSS in wastewater. These results indicate that tamarind seeds have the ability to bind solid particles and precipitate them, which can reduce the concentration of TSS in wastewater. (Balbinoti *et al.*, 2023).. However, it is important to note that variations in extraction and processing methods of tamarind seeds may affect their effectiveness, and therefore, further studies need to be conducted to determine the optimal conditions for using tamarind seeds in the treatment of tofu factory wastewater. (Martins *et al.*, 2022) ..

While there are a number of studies that demonstrate the potential of tamarind seeds in wastewater treatment, there are several gaps that need to be filled. Firstly, many of the existing studies are still limited to laboratory scale and do not consider industrial variables that might affect the effectiveness of tamarind seeds in real applications. (Badawi, Salama and Mostafa, 2023).. Secondly, research on the effect of tamarind seeds on BOD and TSS of tofu factory effluent specifically is still very limited. Although some studies have shown that tamarind seeds can reduce these parameters, no studies have specifically explored the use of tamarind seeds in the context of tofu factories. (Ali, Tian and Wang, 2021). In addition, there is a need to understand the specific mechanism of how tamarind seeds function in reducing BOD and TSS, including studies on the coagulation and adsorption processes that occur in tamarind seeds. (Zhang *et al.*, 2024). Existing studies often do not explain in detail how the bioactive compounds in tamarind seeds contribute to this process. Lastly, the effectiveness of tamarind seeds can also be affected by external factors such as pH, temperature, and initial effluent concentration, which are often not explained in detail in existing studies. (Athira and Sumi, 2024).. The purpose of the study was to reduce BOD, TSS levels of tofu industry wastewater using tamarind seed core biocoagulant.

Research Methods

This study used a laboratory experimental design with a quantitative approach. The main objective was to evaluate the effectiveness of tamarind seeds in reducing the Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) in tofu factory wastewater.

The variables of this study are independent variables: Concentration of tamarind seeds used as coagulant agent. The doses used were 4 g/L, 6 g/L, and 8 g/L), coagulation-flocculation process time of 15 minutes, 30 minutes and 45 minutes and the dependent variable: BOD and TSS values in tofu factory wastewater. Control variables: effluent pH 6-7 (measured at the beginning of the treatment), temperature 25-30°C (measured at the beginning of the treatment).

Data collection, data were collected through laboratory experiments with the following steps: Beginning with Sample Preparation: Collecting liquid waste samples from tofu factories. Preparation of Tamarind Seeds: Tamarind seeds were dried and ground into fine powder. This powder was then weighed in various concentrations (4 g/L, 6 g/L, and 8 g/L). After that, the Coagulation-Flocculation experiment was continued: The effluent samples were mixed with tamarind seed powder in various concentrations, stirred rapidly (150 rpm) for 3 minutes and stirred slowly (30 rpm) for 3 minutes. After that, it was allowed to settle. Sampling: Taking samples for BOD and TSS measurements after the coagulation-flocculation process for 15 minutes, 30 minutes and 45 minutes.

For BOD measurement using titration method and for TSS measurement: Using the gravimetric method, where the sample is filtered using 0.45 micron porous filter paper, then the filter paper is dried and weighed to obtain the weight of TSS.

Data obtained from the measurement of BOD and TSS before and after treatment were collected and presented in a table.

Calculation of BOD and TSS Reduction: Calculate the percentage reduction of BOD and TSS with the formula:

$$decrease\ (\%) = \frac{Initial\ concentration\ - Final\ concentration}{Initial\ concentration} \times 100$$

Data analysis with Descriptive Analysis, namely Calculating the average value, and the percentage of BOD and TSS reduction for each concentration of tamarind seeds and interpreted. These results were then further analysed to draw conclusions about the effectiveness of tamarind seeds in reducing BOD and TSS of tofu factory liquid waste.

RESULTS AND DISCUSSION

Table 1

Effect of Dosing of Tamarind Seed Core and Time Addition on the Decrease of Biochemical Oxygen Demand (BOD)

Administration Dosage of Tamarind Seed Core	BOD Decrease %				
	0	15 minutes	30 minutess	45 minutes	Average %
0 grams	210	0	0	0	0
4 grams	210	17.6	23.3	29.5	23.5
6 grams	210	27.6	37.1	47.1	37.3
8 grams	210	39.5	52.4	64.8	52.2

Effect of Tamarind Seed Core Dosing and Time Addition on the Decrease of Biochemical Oxygen Demand (BOD).

Table 1 shows the effect of tamarind seed kernel dosing on the decrease of Biochemical Oxygen Demand (BOD) in

various observation times. From the results obtained, it can be seen that without dosing (0 gram), there was no decrease in BOD at all, with a fixed value of 0% at all observation times. In contrast, with the addition of tamarind seed kernel dosage, there was a significant increase in BOD reduction.

The 4 gram dose showed an average BOD reduction of 23.5%, with a consistent increase as time increased, from 17.6% at 15 minutes to 29.5% at 45 minutes. The 6 gram dose gave better results, with an average BOD reduction of 37.3%, showing a greater increase at each time interval. However, the 8 gram dose showed the most dominant results, with an average BOD reduction of 52.2%. This decrease also increased significantly from 39.5% at 15 minutes to 64.8% at 45 minutes. Thus, it can be concluded that the higher the dose of tamarind seed kernel given, the greater the decrease in BOD that occurs, especially at longer observation times.

Table 2

Effect of Tamarind Seed Core Dosing and Time Addition on the Decrease of Total Suspended Solids (TSS)

Dosing of Tamarind Seed Core	TSS Decrease %				
	0	15 minutes	30 minutes	45 minutes	Average %
0 grams	146	0	0	0	0
4 grams	146	12.3	16.4	20.5	16.4
6 grams	146	26	34.2	43.2	34.5
8 grams	146	36.3	47.9	60.3	48.2

Effect of Tamarind Seed Core Dosing and Time Addition on the Decrease of Total Suspended Solids (TSS).

Table 2 presents data on the effect of dosing tamarind seed kernel on the reduction of Total Suspended Solids (TSS) at different times. Just like in the previous table, without dosing (0 grams), there was no decrease in TSS, with a fixed value of 0% at all observation times.

The 4 gram dose showed an average TSS reduction of 16.4%, with a gradual increase from 12.3% at 15 minutes to 20.5% at 45 minutes. The 6g dose gave better results, with an average TSS reduction of 34.5%, showing a significant increase at each time interval. However, the 8g dose showed the most striking results, with the average TSS reduction reaching 48.2%. This decrease also increased significantly from 36.3% at 15 minutes to 60.3% at 45 minutes. Therefore, it can be concluded that dosing of tamarind seed kernel has a positive effect on TSS reduction, with higher doses resulting in greater reduction, especially at longer observation times.

The results showed that dosing of tamarind seed kernel had a significant effect on the BOD reduction of wastewater from tofu factory, as listed in Table 1. The decrease in BOD consistently increased with the dose of tamarind seed kernel and observation time, with the 8 gram dose showing the highest decrease. A decrease in BOD is an indication that more organic matter in the wastewater is successfully degraded or precipitated, thereby reducing the biological oxygen demand (Nasara et al., 2023).

According to a study by (Badawi, Salama and Mostafa, 2023)The use of natural materials such as tamarind seeds for wastewater treatment can facilitate the reduction of BOD due to the ability of natural coagulants to enhance the flocculation and adsorption processes. In this case, the greater reduction in BOD at the 8-gram dose compared to the lower dose may be due to the increased amount of functioning coagulant, which facilitates the removal of more organic matter from the effluent (Lokman *et al.*, 2021).

Increasing the dose of natural coagulant is directly proportional to the decrease in BOD, natural coagulants have a higher adsorption capacity, which leads to a greater decrease in BOD. (Desta and Bote, 2021). This is consistent with the findings in this study that higher doses of tamarind seed kernel provided the most significant reduction in BOD.

That the longer contact time between the coagulant and the wastewater allows sufficient time for the settling and decomposition of organic matter. Thus, a greater reduction in BOD at longer time intervals can be attributed to such processes (Nayeri and Mousavi, 2022). (Nayeri and Mousavi, 2022)..

Table 2 shows that dosing of tamarind seed kernel also had a positive impact on the reduction of Total Suspended Solids (TSS) in the effluent. Higher doses, especially 8 grams, showed a greater reduction in TSS and increased with observation time. This indicates that higher doses of tamarind seed kernel are effective in reducing solid particles suspended in the effluent.

That higher doses of coagulant can result in the reduction of more solid particles (Rosińska and Dąbrowska, 2021). (Rosińska and Dąbrowska, 2021). Natural coagulants aid in the settling of solid particles through the flocculation process, which results in greater TSS reduction. (El-taweel *et al.*, 2023) ..

The use of natural coagulants, such as tamarind seeds, can improve the precipitation and removal of solid particles from wastewater effluents. (Nath, Mishra and Pande, 2021).. That higher coagulant doses accelerate the flocculation process and increase the settling efficiency, which is consistent with the results of this study (Rosińska and Dąbrowska, 2021).

The increase in TSS reduction over time is also in line with research by (Nahiun *et al.*, 2021)This suggests that longer treatment times allow longer time for flocculation and settling of solid particles. Thus, the greater reduction in TSS at longer observation times can be attributed to this process.

Comparison of the results of this study with previous studies showed consistency in the findings that higher coagulant doses and longer treatment times contributed to the reduction of BOD and TSS. For example, the study by (Lv *et al.*, 2024) showed that the use of natural coagulants in higher doses contributed to a greater reduction in effluent pollution parameters. This is in line with the results found in this study, where higher doses of tamarind seed kernel provided more significant reductions in BOD and TSS.

However, it is important to note that there were variations in the types of natural coagulants used and different experimental conditions in those studies. For example, the study by (Nasara *et al.*, 2023) showed similar results in terms of BOD and TSS reduction using natural coagulants, but with differences in the types of materials and dosages used. This suggests that although the general results are consistent, the specific effectiveness of natural coagulants may vary depending on the type of material and experimental conditions.

The mechanism of action of tamarind seed core in reducing BOD and TSS can be attributed to the coagulant's ability to facilitate flocculation and adsorption processes. Tamarind seeds contain active compounds that can form bridges between solid particles and organic matter in wastewater, thus accelerating the settling process. These compounds function as coagulants that help bind solid particles and organic matter, ultimately leading to a reduction in BOD and TSS (Kuchaiyaphum et al., 2024). (Kuchaiyaphum *et al.*, 2024) ..

That an effective coagulation process involves the formation of larger flocs, which then settle out faster from the wastewater effluent (El-taweel *et al.*, 2023).. This is in line with the findings of this study, where higher doses of tamarind seed kernel contributed to greater reductions in BOD and TSS due to the increased ability of the coagulant to bind and precipitate particles.

The results of this study have important implications for wastewater management, especially in the context of using natural coagulants. Higher doses of tamarind seed core proved to be more effective in reducing BOD and TSS, indicating the potential of tamarind seed as an effective and environmentally friendly coagulant alternative.

The use of natural coagulants in wastewater treatment can reduce reliance on synthetic chemicals that are often expensive and potentially damaging to the environment. (Agarwal and Saini, 2022).. Tamarind seeds, as a relatively cheap and readily available natural ingredient, can be a sustainable solution for wastewater treatment, especially in resource-constrained areas. (Mansingh *et al.*, 2021)..

However, it is important to consider the cost and availability of coagulant materials on an industrial scale. Although natural coagulants such as tamarind seeds can be effective, the cost of processing and procurement of materials should be considered in large-scale implementation (Sofiavizhimalar *et al.*, 2022) .. Therefore, further research on the economical and sustainable aspects of using tamarind seeds in wastewater management is needed to ensure its practical application. (Koul, Yakoob and Shah, 2022)..

CONCLUSION

This study shows that the dosage of tamarind seed kernel is beneficial in reducing BOD and TSS in tofu factory wastewater. Higher doses and longer treatment times contributed to greater reductions in both parameters. These results are consistent with findings from other studies showing the effectiveness of natural coagulants in wastewater treatment.

SUGGESTION

However, for practical applications, it is important to evaluate the cost and availability of tamarind seeds and conduct further studies on the mechanism of action and efficiency under more diverse conditions. Further research can also explore combinations with other coagulants or additional treatment methods to improve the efficiency and sustainability of wastewater management.

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