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Evaluation of the Effectiveness of Biofilter Columns with Mixed Media for Tofu Liquid Waste Treatment

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Abstract. Indonesia's increasing number of tofu industries has led to a rise in waste volume from this sector, requiring exceptional management. Tofu wastewater, a byproduct of tofu production that is no longer utilized, contains a high concentration of organic matter and can adversely affect water supplies if discharged untreated. This study aims to investigate an efficient filtration technique using filtration media for processing tofu wastewater. The biofilter column used in this study was made from a Le Minerale gallon and comprised layers of zeolite, bio balls, bearings, and activated charcoal to filter and purify the water from organic substances. The results showed that while filtration effectively reduced Total Dissolved Solids (TDS) from 995 ppm to 129 ppm after the fourth filtration, it was ineffective in neutralizing the pH of the tofu wastewater, which remained at pH 4 before and after filtration. This indicates that the wastewater remains acidic and cannot be directly discharged into the environment. Additionally, conductivity and salt levels increased after multiple filtrations, possibly due to ion release from the filter materials or saturation effects. This study reveals that the column configuration and filtration materials used were ineffective in removing acidic components from tofu wastewater. Therefore, design adjustments and filtration media selection are needed to achieve better results in treating tofu wastewater.

Keywords: *biofilter column, tofu wastewater, pH, total dissolved solids (TDS).*

1. Introduction

Tofu is a very popular traditional food in Indonesia, because it contains a lot of protein and vitamins the human body needs [1,2]. Along with the growing demand, tofu production has become a significant household industry, especially in urban areas. Based on data from the Ministry of Agriculture (2019), tofu consumption in Indonesia shows an increasing trend with an average per capita consumption of 7.41 kg per year from 2002 to 2018. This increase is expected to continue, with tofu consumption predicted to reach 8.67 kg/capita in 2021 [3].

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However, along with the rise in tofu production, the problem of wastewater generated by this industry is a serious concern. Tofu wastewater contains high concentrations of organic compounds, such as carbohydrates, proteins, and fats [4]. If not treated properly, these can degrade water quality through decomposition processes that reduce dissolved oxygen levels and increase essential parameters such as pH, salinity, conductivity, and total dissolved solids (TDS) [5].

The characteristics of tofu wastewater vary depending on the raw materials and production process. The main parameters to consider in treating this effluent include pH, salinity, conductivity, and TDS. pH indicates the acidity or basicity of the water, which can affect biological and chemical processes in the wastewater. Salinity and conductivity are related to the amount of dissolved ions in water, affecting the electrical conductivity and indicating the pollution level. Meanwhile, TDS measures the amount of dissolved solids in water, such as salts and other minerals, which pollute the overall quality of water [6]. To overcome the negative impact of tofu liquid waste, various treatment methods have been proposed, including biofilter columns with mixed media.

Biofilter is a treatment system that utilizes microorganisms growing on solid media to decompose organic matter in wastewater. The main advantage of this biofilter system is its ability to effectively reduce the concentration of organic and inorganic pollutants in wastewater with relatively low operational costs and ease of application at the household or small industry scale [7,8].

This study aims to evaluate the effectiveness of biofilter columns with mixed media in treating tofu wastewater to meet water quality standards that are safe for discharge into the environment. This research focuses on testing the parameters of pH, salt, conductivity, and TDS, which are the leading indicators in determining the quality of wastewater produced. The results of this study are expected to provide practical guidance for the tofu industry, especially at the household scale, in implementing more effective and sustainable waste treatment technology.

2. Research Method

This study used tofu liquid waste taken directly from a tofu factory in the Kelapa Dua area, Depok City, as the sample. The tofu liquid waste was stored for 3 days before being used in the experiment. The filtration media used included bioballs, bioring, zeolite sand, and

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activated carbon. The tools used in this study included a filtration column, an effluent reservoir, beakers, pH paper, and a conductometer.

The research began with manually washing the filter media and baking zeolite sand. Next, the media were arranged into the filtration column in the following order: coconut shell charcoal 5 cm thick, zeolite sand 5 cm thick, wood charcoal 5 cm thick, and bioring 3 cm thick. Cotton is used as a separator between filtration media and placed at the bottom of the column or on the faucet to prevent media leakage. After the filtration column was set up, the tofu liquid waste sample was put into the column for filtration. After filtration, the samples were tested to measure the tofu wastewater's pH, conductivity, salt content, and TDS.

3. Result and Discussion

This study aims to examine in depth the changes in physical properties of tofu wastewater that occur after going through several stages of the filtration process. The main parameters observed in this study include pH value, salt content, electrical conductivity, and total dissolved solids (TDS). The filtration process was carried out in two stages, three times and four times, to evaluate how each filtration stage could affect changes in each parameter. Observations focused on the difference in parameter values before and after filtration, to provide a quantitative picture of the impact of the filtration process on the quality of the tofu effluent. The results of these observations are presented in detail in Table 1, which contains data on pH, salt content, electrical conductivity, and TDS at each filtration stage. Analysis of these observations is expected to contribute to developing more effective and efficient tofu wastewater treatment methods.

Table 1. Observation Data Results

Filtering	pH	salt	condt	TDS
Before filtering	4	0.93 ppt	1.75 ms	995 ppm
After 3 times filter	4	1.25 ppt	2.48 ms	122 ppm
After 4 times filter	4	1.30 ppt	1.57 ms	129 ppm

Measuring the pH of tofu wastewater is important because pH is a key element in the wastewater treatment process. In the biofiltration system, pH affects the performance of mixed media in absorbing and treating pollutants, including the adsorption process that occurs in the biofilter column [9]. pH also determines the surface properties of the adsorbent, such as surface charge, ionization of functional groups, and the degree of dissociation of functional groups on the active site of the adsorbent, which directly affects the effectiveness of the biofilter in reducing pollutant levels in tofu liquid waste [10]. Wastewater suitable for disposal into the

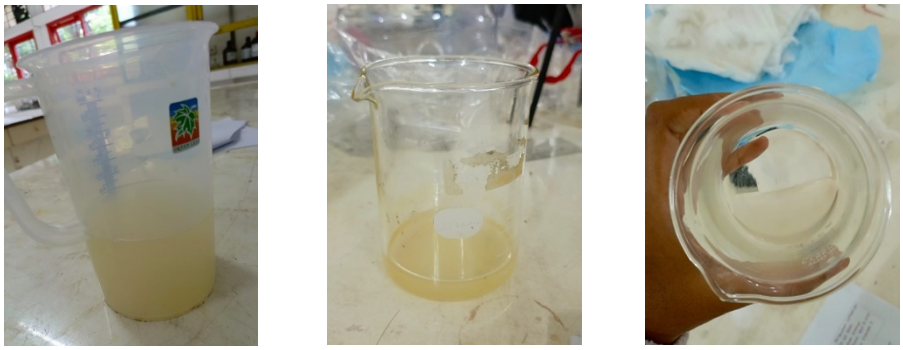
environment generally has a pH between 6 and 9. However, in this study, the results showed that the pH of the tofu wastewater remained stable at 4, both before and after the filtration process. This indicates that tofu wastewater is still acidic even after filtration several times. Wastewater from the tofu industry is generally acidic, which can cause unpleasant odors and reduce the pH of the environment, thus affecting water quality and damaging the ecosystem [11]. The study showed that the pH remained at 4, which means that the filtration media used has not been able to raise the pH significantly. This may be due to the limited capacity of the media or chemical interactions that maintain acidity. Therefore, further treatment is required to neutralize the pH of the effluent [12].

The results showed an increase in salt content in tofu wastewater after filtration. Before the process, the salt content was 0.93 ppt. After three filtrations, the salt content rose to 1.25 ppt; after four filtrations, it increased to 1.30 ppt. This indicates a buildup of salt in the filtration media that is released gradually. Dissolved salt can become trapped in the media if not washed or replaced regularly, causing the media to saturate and release salt back into the effluent. Increased salt levels are essential to note as they can affect the conductivity of the water and negatively impact groundwater quality and aquatic life.

Conductivity, which indicates the amount of dissolved ions in water, also underwent significant changes after the filtration process. Before filtration, the conductivity was recorded at 1.75 ms. After three filtrations, the conductivity increased to 2.48 ms, but then decreased to 1.57 ms after four filtrations. The increase in conductivity after the third filtration may be due to the release of ions from the filtration medium that started to reach saturation capacity [13]. However, the decrease in conductivity after the fourth filtration may be due to the reabsorption of specific ions by the filtration media or the precipitation of those ions. Conductivity can decrease if dissolved particles precipitate or get trapped back in the filtration media that still has absorbency [14].

These conductivity fluctuations indicate that the filtration process is not optimal and requires further monitoring to ensure that harmful dissolved ions are effectively minimized. In addition, total dissolved solids (TDS), which measure the number of dissolved particles in water, also changed after filtration. Before filtration, the TDS was recorded at 995 ppm, and after three filtrations, the TDS dropped drastically to 122 ppm. However, after four filtrations, the TDS increased slightly to 129 ppm. The initial decrease in TDS indicates the effectiveness of the filtration media in filtering out dissolved particles. However, the increase in TDS after

the fourth filtration indicates a possible release of fine particles from the filtration media. This could also indicate a saturation effect, where the media begins to lose its ability to absorb additional particles. This can occur because the media has reached saturation point or been damaged, so the previously retained particles start to be released back into the wastewater, affecting the filtration efficiency.



(a) (b) (c)

Figure 1. Effluent before filtration (a), the result of the 3rd time filtration (b), and the results of the 4th time filtration (c)

Based on Figure 1(a), the tofu wastewater has a very high turbidity before the filtration process, with a dense water color and indications of suspended particles and untreated organic matter. This indicates that the effluent contains significant concentrations of pollutants, both solid materials and dissolved compounds. In Figure 1(b), after filtering three times, the wastewater shows an apparent decrease in turbidity. This indicates that most of the suspended particles have been successfully removed through the filtration process. The filter media plays an effective role in capturing solid particles. However, there is still turbidity, which indicates the presence of fine particles or organic matter that has not been eliminated.

Meanwhile, in Figure 1(c), after filtering four times, the wastewater looks clearer than in the previous stage. This additional filtration process provides more optimal results, where the remaining suspended particles are successfully reduced, making the wastewater visually cleaner. However, despite the improvement in water clarity, it is likely that some dissolved contaminants, such as salts or organic compounds, remain in solution, which cannot be entirely removed by the filtration process alone. The effectiveness of this filtration shows that stepwise filtration can reduce the level of turbidity and suspended particles. Still, its effectiveness may decrease as the filter media becomes saturated. Therefore, further treatment using a mixed-media biofilter column is required to ensure that the quality of wastewater meets environmental

standards. This column can function as a physical filter and a biological medium capable of decomposing organic matter and dissolved compounds, resulting in safer discharge into the wastewater environment.

4. Conclusions

Based on the study's results, it can be concluded that the filtration process can reduce total dissolved solids (TDS) and salt levels in tofu wastewater. However, the effectiveness of this process decreases gradually due to the saturation of the filtration media that occurs over time. This decrease in filtration media capacity indicates that its use has a specific time limit before requiring replacement or regeneration. The pH value of the tofu effluent remains in the acidic range after the filtration process, indicating that this method has not effectively neutralized the effluent's acidity. This shows the need for additional treatment steps, such as adding neutralizing agents, to optimize wastewater quality to meet discharge standards. Observations also showed fluctuations in conductivity and TDS values, indicating that the filtration media is starting to lose its ability to absorb dissolved particles consistently. These fluctuations could be caused by saturation of the filtration media or variations in the wastewater entering the filtration system. Thus, to ensure tofu effluent meets safe environmental standards, additional treatment is required, such as a combination of filtration with other methods (e.g., coagulation-flocculation or biological treatment) and regular monitoring of water quality parameters. This approach is essential to improve the efficiency of tofu effluent treatment while reducing potential adverse environmental impacts.

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