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Used Plastic Spoon Application as Anaerobic Biofilter Media in Reducing Bod_5, Cod, And Tss Levels in Tofu Industry Liquid Waste

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ABSTRACT: Used plastic spoons and liquid tofu waste are two examples of negative impacts from the food sector. This study aims to utilize used plastic spoons as anaerobic biofilter media to reduce BOD_5, COD and TSS levels in liquid tofu industry waste. The research began with the creation of biofilter media from used plastic spoons and the design of an anaerobic biofilter reactor. The seeding process lasted 14 days, followed by a three-day acclimatization process, followed by the treatment process. Wastewater was continuously fed into the anaerobic biofilter reactor using varying residence times of 24, 48, 72, 96, and 120 hours. The results of the tofu liquid waste sampling before processing obtained BOD5 levels of 4485.0 mg/L, COD of 6975.0 mg/L, and TSS of 962 mg/L. The highest efficiency of BOD5 and COD reduction was found at a residence time of 120 hours, for BOD5 of 87.36% with a level of 568.0 mg/L, for COD of 60% with a level of 2750 mg/L; the highest efficiency of TSS reduction was found at a residence time of 24 hours of 86.79% with a level of 127 mg/L. Based on DIY Regional Regulation no. 7 of 2016 concerning wastewater quality standards, tofu liquid waste has a maximum level of 150 mg/L for BOD5, 300 mg/L for COD, and 200 mg/L for TSS. It can be concluded that the results of processing tofu industrial liquid waste with anaerobic biofilters using used plastic spoon media that meet the quality standards are only for the TSS parameter.

KEYWORDS: anaerobic biofilter, liquid waste, plastic spoons, tofu industry

I. INTRODUCTION

One of the needs humans have to sustain their lives is food. The growing human population increases the demand for food. To meet this need, the presence of the food industry is very necessary in providing products that are safe to consume (Niken Nurwati et al., 2016)

One of the food industries you can easily find is the tofu industry, which primarily uses soybeans as its main raw material. The affordable price of tofu and its delicious taste have increased consumer demand, so tofu producers have boosted the frequency and capacity of their production to meet that demand. However, the tofu-making process itself also produces liquid waste that has the potential to pollute aquatic ecosystems (Samsudin et al., 2018).

Most tofu industries in Indonesia do not have a waste treatment unit because of the limited capital that business owners have. Because of this, tofu industries directly dispose of the wastewater produced without paying attention to the resulting pollution (Haerun et al., 2018)

Based on previous research, wastewater treatment from tofu has been done by (Amri et al., 2020) using the electrocoagulation method for BOD5, COD, and TSS parameters. The results of this study showed that using the electrocoagulation method can reduce BOD5, COD, and TSS levels in tofu wastewater according to the Minister of Environment Regulation No. 5 of 2014 on Wastewater Quality Standards for Businesses. However, using the electrocoagulation method has a drawback, which is the relatively high electricity cost as a power source (Chen, 2004). Further processing is usually done physically or chemically, such as fine filtration (microscreen), activated carbon adsorption, reverse osmosis, and disinfection (Pepper et al, 2006).

Wastewater treatment can be done in various ways, one of which is using the anaerobic biofilter method. The treatment process with the anaerobic biofilter method has the advantage of being energy-efficient because it doesn't require costs or electricity to supply air (Nusa Idaman Said & Dinda Rita Krishumartani Hartaja, 2015). In practice, anaerobic biofilters need a medium for microorganisms to attach to. Plastic is one of the materials commonly used as a biofilter medium. Plastic media is typically made from polypropylene or polystyrene, as well as recycled plastic materials. Based on their flow paths, this type of media comes in two varieties: vertical flow (flow moves vertically from top to bottom) and cross-flow (flow moves laterally from bottom to top). Cross-flow structured media is typically used in BAF (Biological Aerated Filter) applications (WEF, 2010).

One of the sectors that often uses products made from plastic is the culinary sector. To boost their sales, food vendors usually add plastic spoons to their products as a convenience so that consumers can eat anywhere. Because of this practical nature, the use of plastic spoons can be found in almost every food product.

Along with this situation, the use and production of plastic spoons are increasing. Meanwhile, in practice, plastic spoons

for packaged food are usually used just once and then thrown away. This condition causes an increase in plastic waste. Plastic waste is a material that is hard for microorganisms to break down. Therefore, it's important to find ways to reuse used plastic spoons as an effort to reduce plastic waste. One way is by using used plastic spoons as a medium for anaerobic biofilters.

The purpose of this study is to analyze the effectiveness of the anaerobic biofilter method using used plastic spoons as media to reduce BOD5, COD, and TSS levels in tofu industry wastewater with different retention times of 24 hours, 48 hours, 72 hours, 96 hours, and 120 hours.

II. METHODOLOGY

This study began with the creation of an anaerobic biofilter using used plastic spoons taken from the regular Monday-Thursday study sessions at Nurul Ashri Mosque located in Perum UNY, Jl. Deresan III No. 21, Manggung, Caturtunggal, Depok District, Sleman Regency, Yogyakarta. First, the used plastic spoons were washed until clean, then 60 holes with a diameter of 0.3 cm were made at the tips. The handles of the used plastic spoons were cut by ¾, and then every four plastic spoons were glued together as shown in the following picture:

Figure 1 biofilter media made from used plastic spoons

This arrangement of plastic spoons aims to save space in the reactor, increase the density between the media, make the wastewater flow easier, and prevent the spoons' surfaces from stacking so that the microorganisms can have better contact with the waste.

The anaerobic biofilter reactor uses a plastic tank with dimensions 23 cm x 23 cm x 3.5 cm. The ready biofilter reactor is then filled with 39 pieces of used plastic spoons.

The liquid waste from the tofu industry used for research was taken from an UMKM in Piyungan District, Bantul Regency, with a production capacity of 100-150 kilograms of soybeans per day. Wastewater samples were collected at 2:00 PM WIB, representing the results of the entire production cycle. The wastewater samples were taken directly from the tofu coagulation tank made of stainless steel with a diameter of 80 cm and a height of 78 cm.

Seeding was done by adding 300 ml of 4% NaOH solution to 11.5 L of tofu industry wastewater until the wastewater reached a neutral pH (7). Once the wastewater was neutral, the bacterial starter was activated by dissolving 0.5 g.

The anaerobic biowaste powder is mixed with 50 mL of demineralised water and left for 8 hours. The anaerobic biowaste is then poured into an anaerobic biofilter reactor already filled with biofilter media made from used plastic spoons and 11.5 ml of tofu liquid waste. After the seeding process is complete, it continues to the acclimatisation stage so the microorganisms can survive in different wastewater. Acclimatisation is carried out by continuously flowing diluted tofu industry wastewater with demineralised water into the reactor for three days, alternating with concentrations of 30%, 60%, and 100%. The flow rate used in the acclimatisation process is 7.98 mL/min based on the formula Q=V/t.

The wastewater treatment process in this study was carried out by continuously flowing 11.5 L of wastewater using a downflow-uplow system. The wastewater flow rate used was calculated with the formula Q=V/t, resulting in a flow rate of 7.98 mL/min for 24 hours, 3.99 mL/min for 48 hours, 2.66 mL/min for 72 hours, 1.99 mL/min for 96 hours, and 1.60 mL/min for 120 hours. Wastewater samples were taken after treatment based on the residence time variations and then examined for each studied parameter.

The next step is data analysis. The processed results for each parameter BOD5, COD and TSS will be shown as graphs and discussed descriptively.

III.RESULTS AND DISCUSSION

Before the liquid waste treatment process is carried out, a sampling analysis is first conducted to determine the initial characteristics of the tofu liquid waste. The data from the sampling analysis is obtained from field observations as well as laboratory analysis, the results of which can be seen in the following table:

Table 1 Field observation results

No	Observation	Results
1	pH	4
2	Wastewater temperature	45℃
3	Air temperature	35℃
4	Weather conditions	Partly cloudy
5	Coagulation tank volume	400 Litres

(Source: Primary data, 2025)

Table 2 Laboratory analysis results

No	Parameter	Result (mg/L)	Quality Standard (mg/L)
1	BOD_5	4485,0	150
2	COD	6975,0	300
3	TSS	962,0	200

(Source: Primary data, 2025)

Based on DIY Regional Regulation No.7 of 2016 on Wastewater Quality Standards, it can be concluded that the BOD5, COD and TSS levels in wastewater from the tofu industry in Piyungan district exceed the set quality standards.

1. Results of BOD5 level processing

Based on the image 2 below, it can be seen that the BOD5 processing results are fluctuating. The most optimal processing occurs at a retention time of 120 hours. Meanwhile, at retention times of 48 and 72 hours, there is a decrease in efficiency which causes the BOD5 levels to rise.

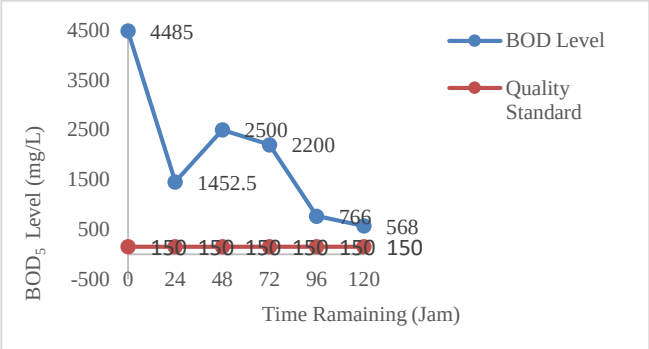

Figure 2 Shows the graph of the processed BOD5 levels

These fluctuating results are suspected to be due to the wastewater preservation process being less than optimal. Before treatment, wastewater samples are first stored at 20ºC. In this condition, the samples in each jerry can have already undergone some degradation by microorganisms, so it is suspected that samples stored for different lengths of time in each jerry can have varying BOD5 levels, making the wastewater samples not uniform. The reduction in BOD5 levels is not only caused by anaerobic biofilter treatment but also by the microorganisms already present in the wastewater sample during the waiting period before treatment. The longer the wastewater waits to be treated, the more degradation continues and increases. To prevent this, the homogenised wastewater sample should be preserved at around 4ºC.

Based on the DIY Regional Regulation no 7 of 2016, the maximum BOD5 level in tofu industry wastewater is 150 mg/L. From data on anaerobic biofilter treatment using used plastic spoons as media, the highest efficiency achieved was 87.36% with a 120-hour retention time at a level of 568 mg/L. It can be concluded that anaerobic biofilter treatment with used plastic spoons has not yet met the BOD5 quality standard.

2. COD level processing results

Based on figure 3 below, it can be seen that COD level treatment results fluctuate. The most optimal treatment occurs at a 120-hour retention time, while at 48, 72 and 96 hours retention time, efficiency drops, leading to an increase in COD levels.

These fluctuating results are suspected to be due to the non-homogeneous wastewater samples as discussed earlier. The fluctuation in COD values is also closely related to the fluctuation in BOD5 values in the previous data, where an increase in COD is accompanied by an increase in BOD5 or vice versa.

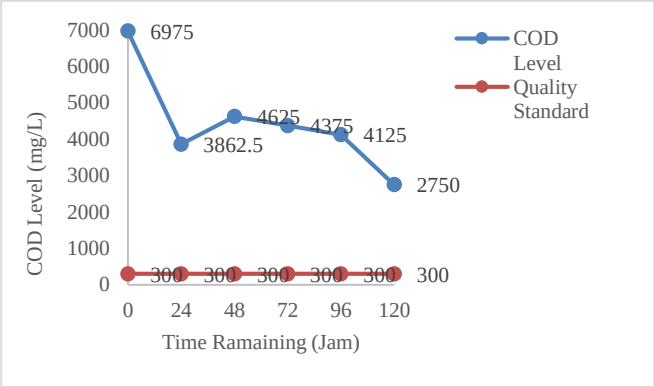

Figure 3 Shows the graph of the processed COD levels

Based on the DIY Regional Regulation no 7 of 2016, the maximum COD level in tofu industry wastewater is 300 mg/L. From the data on anaerobic biofilter treatment using used plastic spoons as media, the highest efficiency achieved was 60.57% at a 120-hour retention time with a COD level of 2750 mg/L. It can be concluded that the anaerobic biofilter treatment with used plastic spoons has not yet met the standard COD limits.

3. TSS level processing results

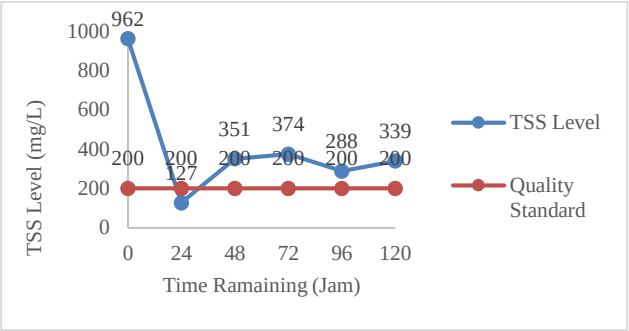

Figure 4 Shows the graph of the processed TSS levels

Based on figure 4, it can be seen that the treatment of TSS levels has fluctuating results. TSS levels drop most effectively at a 24-hour residence time, while at residence times from 48 to 120 hours, the efficiency decreases, causing TSS levels to rise. The primary constituents of TSS are typically the cations calcium, magnesium, sodium, and potassium, as well as the anions carbonate, hydrogen carbonate, chloride, sulfate, and nitrate (WHO, 2003).

These fluctuating results are caused by the biofilm thickness increasing over time. Organic matter can only reach the outer layer of the biofilm, while microorganisms in the deepest layer of the biofilm do not get any organic feed. This causes

the bacteria in the deepest layer of the biofilm to enter the death phase, making the microorganisms lose their adhesion, which leads to the biofilm layer peeling off from the media surface. The peeled-off biofilm layer is carried by the effluent flow and measured as TSS.

According to the DIY Regional Regulation no 7 of 2016, the maximum TSS level in tofu industry wastewater is 200 mg/L. Based on data from anaerobic biofilter treatment using used plastic spoons as media, the highest efficiency achieved was 86.79% at a 24-hour retention time with a TSS level of 127 mg/L. It can be concluded that the anaerobic biofilter treatment with used plastic spoons meets the set quality standards.

IV. CONCLUSIONS

Based on data from treating tofu industry liquid waste using an anaerobic biofilter with used plastic spoon media, it can be concluded that the highest reduction for BOD5 and COD parameters occurred at a residence time of 120 hours with levels of 568.0 mg/L for BOD5 and 2750.0 mg/L for COD. The highest reduction for TSS was at a residence time of 24 hours with a level of 127 mg/L. According to DIY Regional Regulation no 7 of 2016 on wastewater quality standards, only the TSS parameter is below the standard, while BOD5 and COD are still above the standard.

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