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Enhanced Biofilter and Ultrafiltration for Clean Water from the Soy Sauce, Bread, and Sticker Peeling Industries Wastewater

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ABSTRACT

The reuse of wastewater from the combined wastewater effluents of the soy sauce, bread, and sticker peeling industries presents significant challenges due to high organic content and various pollutants. The highest problem is the very high organic content, which is the black organic color of soy sauce that causes a very high total dissolved solids (TDS) (809 mg/L) exceeding the total suspended solid (TSS) (320 mg/L). In addition, BOD_5, COD, total phosphate, color, and total nitrogen are high (2415.08 mg/L; 3019.23 mg/L; 21.79 mg/L, 1477 PtCo, and 458.1 mg/L). The purpose of this research is to analyze anoxic-aerobic biofilter technology, by comparing the effectiveness of biofilters plus pretreatment, namely septic tanks with no pre-treatment, the best effluent that meets the standards, followed by an ultrafiltration process, to recycle it into clean water. The research method used a pilot-scale anoxic-aerobic biofilter reactor with a total volume of 110 L of wastewater. The results showed that the optimal removal of pretreatment modification of septic tank plus biofilter, which can reduce organic content by 90%, this value is greater than without pretreatment, by 78%. The best growing medium is the serrated bioball which has a large surface so that bacteria are easily attached due to the serrations on the surface of the bioball, which is then processed with ultrafiltration, obtained processed water quality according to established standards.

Keywords: enhanced biofilter, ultrafiltration, soy sauce, bread, and sticker peeling industries.

INTRODUCTION

In the soy sauce production process, the quality of wastewater often fluctuates significantly. The process includes various stages such as soaking soybeans, fermentation, and cooking, each generating effluents with different characteristics. For example, effluent from the fermentation stage may contain high concentrations of organic compounds and microbes, while effluent from the cooking stage may have a higher pH and more residual raw materials. Variations in raw materials, changes in production procedures, or interruptions in equipment can cause these fluctuations, affecting parameters such as BOD_5 (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), pH, total suspended solids (TSS) and total dissolved solids (TDS). [Fu, et al., 2019; Cheng, 2020; Gao, et al 2023]

These fluctuations in wastewater quality can have a major impact on the effectiveness of the treatment system. Treatment systems are designed to handle specific characteristics of the effluent, and sudden changes in effluent parameters can upset the balance of the process. For example, a sudden spike in BOD_5 can cause the treatment system to become saturated, reducing its ability to decompose organic matter efficiently. This could result in the resulting water quality not meeting environmental standards and pollution. Among the different water treatment methods, biofiltration is a reasonably inexpensive, low-energy, and chemical-consuming unit process that can be regarded as a suitable and practical technological choice to meet the UN Sustainable Development Goals [Chen, 2023; Hu et al., 2023]. After prolonged operation, microbial metabolism is typically thought to be the primary mechanism responsible for the breakdown and removal of organic materials and other contaminants from the biofiltration process. The efficacy of biofilters is directly correlated with microbial diversity and activity [Hopkin, 1994; Hendrasarie & Trilita, 2019; He et al., 2024], and the microbial community and survivable biomass have a direct impact on wastewater quality [Minarni et al., 2018]. Furthermore, it has been noted that the efficacy of organic matter removal is influenced by the microbial diversity present in the biofilter, which is mostly determined by the operational parameters [Kim et al., 2015; Lie et al., 2016]. Additionally, recent studies have demonstrated the significance of substrate characteristics in identifying key species for biofilters [Hendrasarie & Redina, 2023] and phage-host interactions have been found to have the potential to support the preservation of functional redundancy among microbes engaged in chemical transformation [Metcalf, 2004].

To date, several methods have been researched and/or created to enhance biofilters' capacity for treatment with the goal of boosting their dependability and usefulness. For preliminary treatment for effluents containing high total suspended solids and sludge, using septic tanks is the best option, as septic tanks are designed to separate solids from liquids. The settling process allows the sludge and TSS to accumulate at the bottom of the tank, thus reducing the load on the subsequent treatment system [Hendrasarie, et al., 2022]. In addition, in septic tanks, an anaerobic process occurs, where microorganisms break down organic matter without the use of oxygen, this helps to reduce the amount of organic waste present [Mulyadi, et al, 2023; Nengzi, et al., 2023].

Biofilters using media variation to improve their performance is an emerging technique with growing popularity in the field of wastewater treatment [Praveen et al., 2016; Sekarani, et al., 2020; Son, et al., 2020] In the application of media variation, one of them uses serrated bio balls, which are hollow or protruding plastic balls like rambutan fruits with a complex structure, offering a large surface area for bacterial growth. Due to their lightweight and mobile shape, bio balls provide good circulation in the tank, ensuring maximum contact between bacteria and wastewater. The golf bio balls include high durability and the ability to cope with fluctuations in effluent load [Sun, et al., 2021; Ning, et al., 2023; Patsialou, et al, 2024], then wasp nest shape media, media has a hollow structure that provides a large surface area for microorganisms to multiply, increasing the treatment rate [Zhou, 2019; Wu, et al., 2023; Valenzuela, et al., 2023]. In addition, wasp nests can be obtained from natural sources, making it an environmentally friendly choice and this medium is biodegradable, so it does not produce additional wastewater, as described in Figure 1, The Shape of biofilm growing media in Biofilter

Specifically, to remove the dark black color of soy sauce effluent, high organic, total nitrogen, phosphate, and suspended solid contents, aerobic and facultative anaerobic biofilters are required. In the aerobic biofilter process, aerobic microorganisms break down organic matter and reduce color. Oxygen is required to support this process [Wang, et al., 2023; Zheng, et al., 2023] Whereas the Anoxic process biofilter, evidenced in some cases, the anaerobic process can be used to reduce certain organic compounds before entering the aerobic stage [Yang, et al., 2024].

Ultrafiltration is a semipermeable membrane, Ultrafiltration uses membranes with very small pore sizes (typically 0.01–0.1 microns) to separate particles, microorganisms, and dissolved materials

Fig. 1. The shape of biofilm growing media in biofilter, (a) serrated bio ball, (b) golf bio ball, (c) wasp nest

from water [Xia, et al, 2023]. The process works by pressure, where water is pushed through the membrane so that only clean water can pass through, while contaminants remain retained [Wafula, et al., 2023]. Several successful studies use ultrafiltration, to treat residential, industrial, and sewage water.

The aim of this study evaluate the effectiveness of media types in biofilters, namely rambutan fruit-type bioballs perforated with specific structures, and wasp nests were investigated. Variation of biofilter design on the number of aerobic and anaerobic buildings to treat the integrated waste of soy sauce, bread, and sticker peeling. Subsequently recycled using ultrafiltration, the quality of clean water produced was tested.

RESEARCH METHODS

Wastewater properties

Wastewater samples were collected from the apartment wastewater treatment inlet. The initial characteristics of apartment wastewater are chemical oxygen demand (COD), biological oxygen demand (BOD_5), total dissolved solid (TDS), total suspended solid (TSS), total phosphate (P), total nitrogen (N), and color in successive ranges of 2961.54–3019.23 mg/L; 2207.41–2415.08 mg/L; 696–809 mg/L; 260–320 mg/L; 18.76–21.79 mg/L; 428.1–458.1 mg/L; and 1456–1477 PtCo. While the data of dissolved oxygen (DO); pH and temperature are in the range of 0.1–0.2 mg/L; 4.0–4.2 and 26^{o}C.

Set up and operation of biofilter

The pilot-scale biofilter system was designed to concurrently remove color, total phosphate (P), total nitrogen (N), total dissolved solid (TDS), total suspended solid (TSS), biological oxygen demand (BOD5), and total dissolved solid (TDS). Quantitative research using a continuous system pilot reactor is the technique employed. The pilot-scale biofilter consists of 3 anoxic biofilters with a volume of 30 L each, 2 aerobic biofilters with a volume of 30 L each, a septic tank with 2 chambers as pretreatment (SBio1)with a volume of 30 L; then a settler placed after the biofilter has a volume of 30 L. While Biofilter without pretreatment has the same size (Bio2). In addition, this study compared 3 media for biofilm growth, namely: serrated bio ball (1), golf bio ball (2), and wasp nest shape media (3). With an aeration rate of 14 L/min, this study also varies the Hydraulic Retention times, which are 8 hours, 12 hours, and 16 hours. In enhanced biofilter systems, MLSS should be between 2000 and 5000 mg/L [Hendrasarie & Zarfandi, 2023]. Three copies of the data were gathered. Samples were taken at the feed point.

Seeding and acclimatization

Before proceeding to the main portion of the experiment, preliminary treatment, namely seeding and acclimatization, was completed. The seeding technique was intended to aid microbial development and reproduction in wastewater. The seeding process was carried out organically in batches over 14 days. The wastewater was changed once a day during the seeding process. Microorganisms require specific nutrients in the form of a C:N:P ratio in order to grow and reproduce properly. Microorganisms have a carbon: nitrogen: phosphorus ratio of 100:5:1 [Meng et al, 2023; Niu et al, 2023]. On the tenth day, the MLSS analysis was performed, returning a result of 2046.7 mg/L. MLSS was conditioned in sludge at concentrations ranging from 2000 to 5000 mg/L [Hendrasarie & Zarfandi, 2023].

It is in the Biofilter that acclimatization occurs. Three phases (comparing the percentages of clean water and effluent) were finished in this initial treatment: 30% of wastewater is converted to pure water; 50% of wastewater is converted to clean water; and 30% of wastewater is converted to clean water. Every phase of the acclimatization process involved monitoring and managing chemical oxygen demand. If there was no fluctuation and the experiment reached a removal percentage of 50%, it might move on to the next phase [Jiang et al., 2023; Liang et al., 2023].

Analytical methods

All samples were tested for COD, BOD_5, total phosphate, total nitrogen, TSS, TDS, and color. The analytical procedures were carried out in accordance with established protocols. Standard Methods (2710-D) detailed how to compute the sludge volume index (SVI) after 30 minutes of mixed liquor settlement. The DO, pH, and temperature were measured using probes from a WTW multi-parameter system.

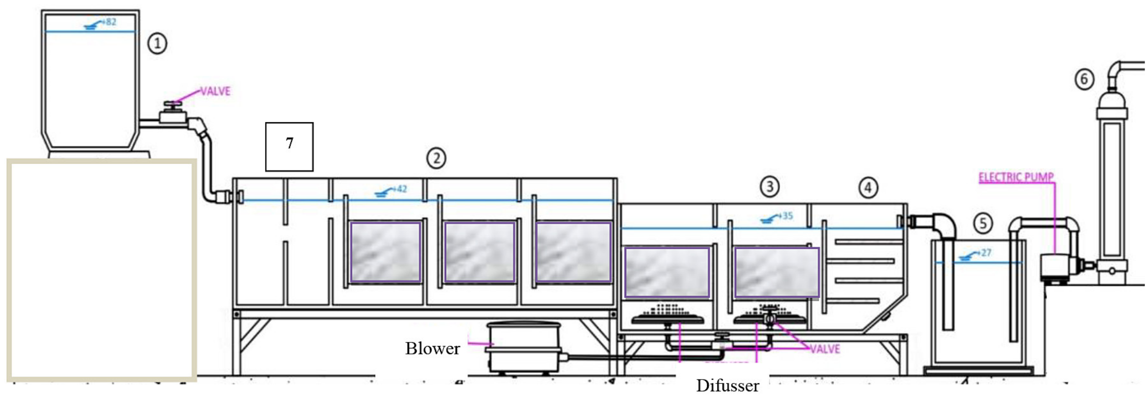

Fig. 2. Configuration of SBio1 with the addition of modified septic tank as pre-treatment: 1 – soy sauce, bread, and sticker peeling wastewater, 2 – biofilter anoxic tank, 3 – biofilter aerobic tank, 4 – settler, 5 – equalization tank, 6 – ultrafiltration tank, 7 – septic tank

RESULTS AND DISCUSSION

Organic matter removal

The discussion part below presents a comparison of the effectiveness of the ability of pre-treatment (Septic tank) plus anoxic-aerobic biofilter to remove COD, BOD_5, TDS, TSS, N-total, P-total, and color to biofilter without pretreatment.

The ability to remove COD and BOD_5

The ability of the septic tank as a pre-treatment plays an important role in separating solids from wastewater. When wastewater enters, solids will settle to the bottom of the tank, forming sludge, while cleaner water will flow to the top. Anaerobic microorganisms in the septic tank play a role in decomposing the organic matter present in the effluent. This happens in the SBio1 reactor, which is proven to help reduce BOD_5 and COD by breaking down organic compounds without the need for oxygen. This can be seen in Figure 3, Reduction of BOD_5 and COD Pollutants in SBio1 (with pre-treatment-Biofilter anoxic-aerobic) and Bio2 SBio1 (without pre-treatment-Biofilter anoxic-aerobic).

This is evidenced in this study, the characteristics of the combined wastewater of soy sauce, bread, and sticker peeling, its turbidity characteristics are very high, but it is easily deposited in the Septic Tank, making it easier for further processing, namely biofilter. This is different from the biofilter design without pre-treatment (Bio2) which is only able to reduce BOD_5 and COD by 81% and 81.8% respectively, which also occurs at a Hydraulic Retention Time (HRT) of 16 hours. In contrast to SBio1 at HRT 8 hours, it was able to reduce BOD_5 and COD by 85% and 83% respectively.

The ability to remove total nitrogen

Biofilters have a significant ability to reduce total nitrogen contaminants through several biological processes that occur in them. Aerobic-anaerobic combination process is usually used to remove nitrogen content in wastewater. For nitrogen removal, under aerobic conditions the nitrification process occurs, where ammonia (NH_4^+) is converted into nitrate (NO_3^-), and under anaerobic (anoxic) conditions the denitrification process occurs, where the nitrate formed is converted into nitrogen gas (Fig. 4).

The anoxic-aerobic biofilter SBio1 effectively reduced total nitrogen at HRT 12 hours was able to reduce total nitrogen which was initially 458.1 mg/L to 21.9 mg/L, while Bio2 at HRT 16 hours was only able to reduce 41.1 mg/L. The ability to set aside total nitrogen, optimal at HRT 12 hours, in SBio1 reached 95.4%, while in Bio2 reached 90.8% at HRT 16 hours.

The ability to remove total phosphate

Biofilters are effective in reducing total phosphate contaminants through a combination of adsorption, biological decomposition, accumulation by microorganisms, and settling. The media in biofilters can function as adsorption media. Dissolved phosphate can be bound to the surface of the media, thereby reducing the phosphate concentration in wastewater. Microorganisms in the biofilter can decompose organic compounds that contain phosphate. Some microorganisms can accumulate

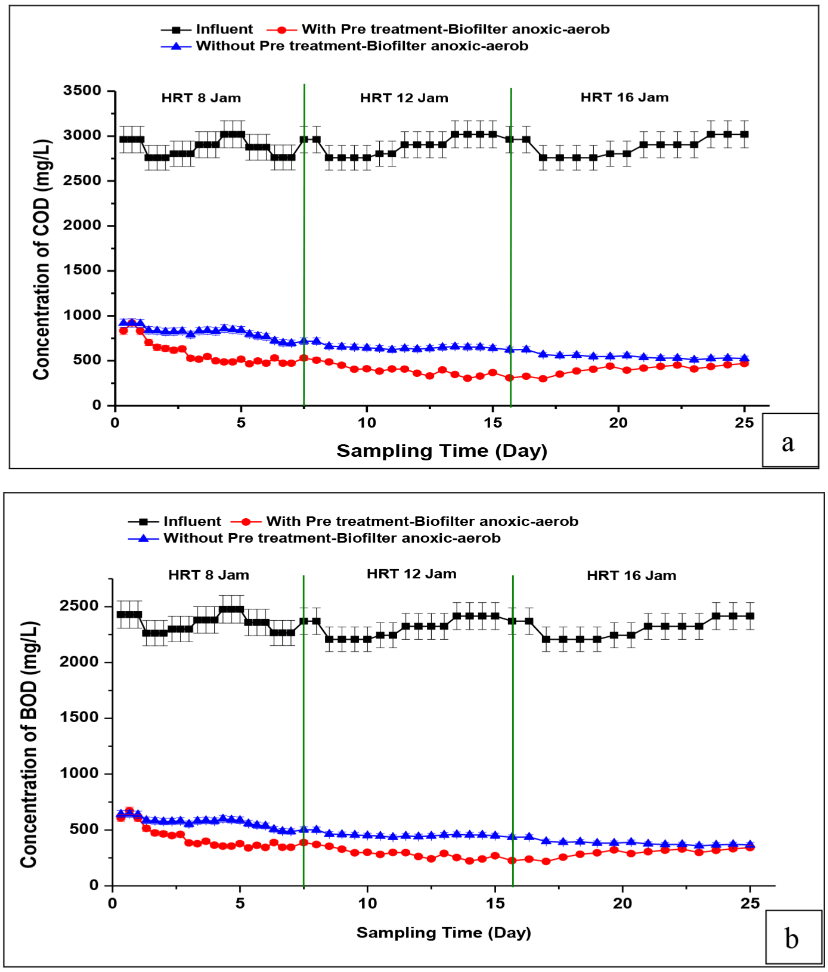

Fig. 3. Pollutant reduction: (a) COD and (b) BOD_5 at SBio1 and Bio2

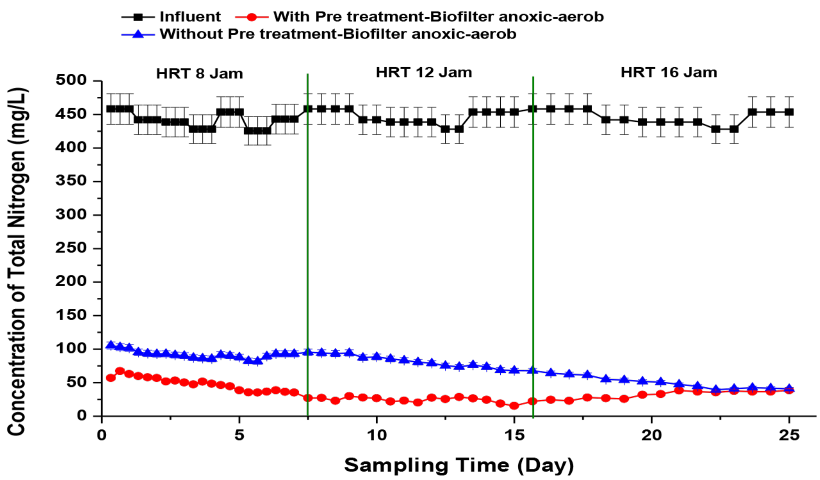

Fig. 4. Removal of total nitrogen pollution in SBio1 and Bio2

phosphate in the form of biomass. When these microorganisms die, the accumulated phosphate is trapped and does not return to the wastewater system. In Figure 5, under both anaerobic and aerobic conditions, decomposition processes can contribute to phosphate reduction. Under anaerobic conditions, some microorganisms can utilize phosphate in their metabolic processes. In SBio1, the decrease in total phosphate reached 90% at HRT 8 hours while Bio2 at HRT 8 hours was able to reduce total phosphate by 70%, this shows that the anoxic-aerobic biofilter can reduce total phosphate.

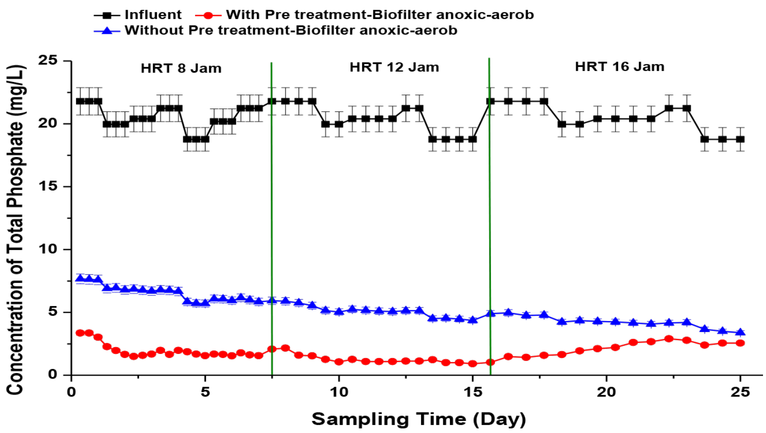

Fig. 5. Total phosphate pollutant removal in SBio1 and Bio2

The ability to remove total suspended solids

Biofilters have a good ability to reduce TSS) through several mechanisms, with a combination of physical filtration, precipitation, microorganism activity, particle aggregation, and decomposition, biofilters are effective in reducing TSS in wastewater, especially in the settler. This can be proven in Figure 6. Decrease in Total Suspended Solid in SBio1 and Bio2. In Figure 6, the TSS content in this wastewater is in the range of 250 to 350 mg/L, this TSS mainly comes from the remains of raw materials used in the soy sauce-making process, such as soybeans, wheat, and other additives, its characteristics are easily broken down by microbes and precipitated. In SBio1, TSS was able to be precipitated at HRT 8 hours by 94.4%, while in Bio2 it also reached 89.3%.

The ability to remove total dissolved solids

Biofilters are not directly designed to reduce TDS) The microorganisms in the biofilter can break down dissolved organic matter, which can help reduce a portion of the TDS. In the combined wastewater of soy sauce, bread and sticker peeling, the resulting TDS was high, but its organic characteristics were able to be reduced by the biofilter.

In Figure 7, the average TDS concentration is 809 mg/L, which comes from amino acids from the soybean fermentation process, sugar, and organic compounds that produce a brown to yellow color that is difficult to remove. SBio1 with HRT 8, 12, and 16 hours, was able to reduce the average by 33%, while Bio2 by 27.4%.

The ability to remove color

Biofilms formed on the surface of biofilter media can capture and accumulate color-causing compounds. Microorganisms in the biofilm play a role in decomposing and removing dyes. By reducing BOD_5 and COD through organic decomposition, the biofilter also contributes to color reduction, as many color-causing organic

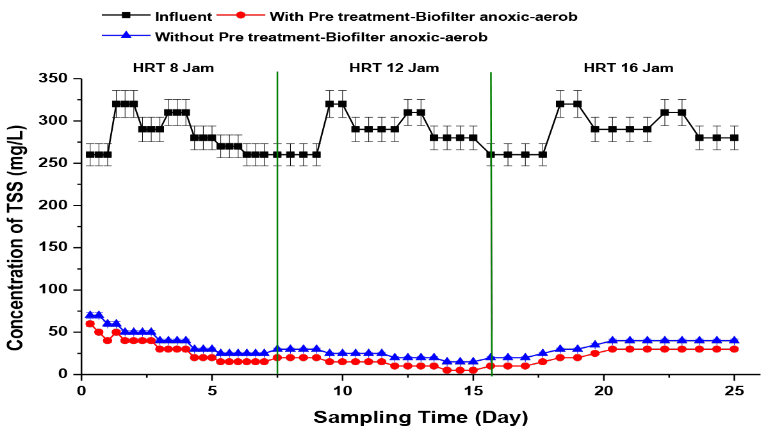

Fig. 6. Total suspended solid removal in SBio1 and Bio2, each equipped with a settler

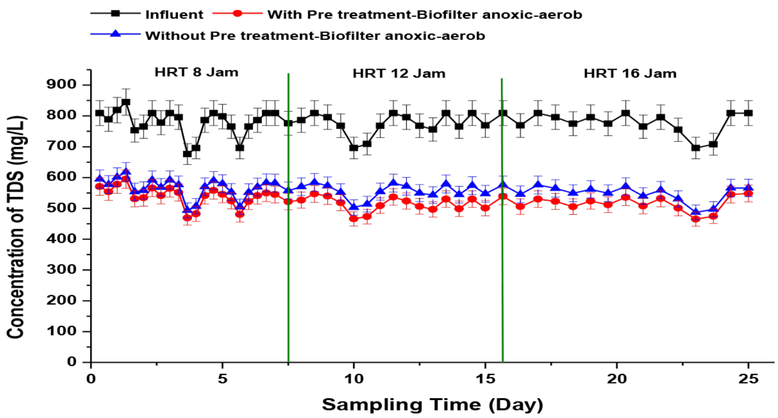

Fig. 7. Total dissolved solid removal in SBio1 and Bio2 which are each equipped with a settlerv

compounds also contribute to the oxygen load. This is explained in Fig 8. Reduction of Color Pollutants in SBio1 and Bio2

In Figure 8, the ability to remove color in SBio1 is effective at HRT 12 hours by 88.4% while Bio2 is 77.8%. The ability to decompose bacteria to remove the optimal color at HRT 12 hours, the yellowish color of this wastewater comes from organic color.

Characteristics of dissolved oxygen, pH, and temperature

pH characteristics

The pH characteristics in the biofilter process are very important because they can affect the performance of microorganisms and the efficiency of wastewater treatment.

In Figure 9, the pH of the raw wastewater in this study is acidic, which is in the range of 4.0. As a result of the research, the pH becomes neutral in the range of 6-7.

Temperature characteristics

Temperature is an important factor in biofilter performance. Maintaining the temperature within the optimal range can increase the activity of microorganisms and the efficiency of the wastewater treatment process.

The average initial wastewater temperature is 27 °C and then increases in the biological process on average at 28.7–29 °C. This temperature plays a role in the proliferation of anoxic and aerobic microbes so that these microbes can decompose the organic content.

Dissolved oxygen characteristics

Maintaining proper DO levels in the biofilter is essential to ensure the effectiveness of the wastewater treatment system and the sustainability of the waste-degrading bacteria. In Figure 11 DO in the initial effluent in the range of 0.2, then increases in the aerobic biofilter in the range of 5–6.8. Optimal DO levels help maintain the

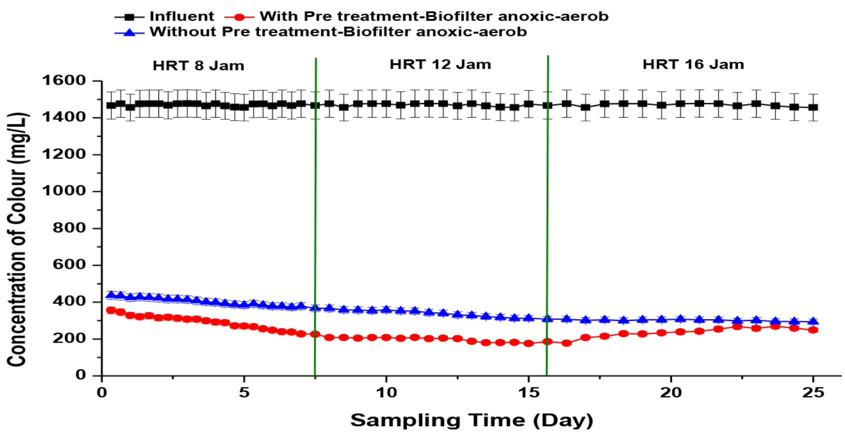

Fig. 8. Reduction of color contaminants in SBio1 and Bio2

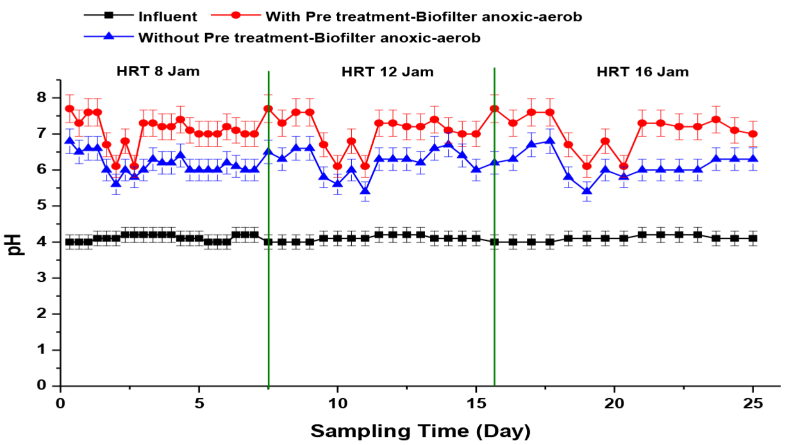

Fig. 9. pH characteristics of the process in SBio1 and Bio2

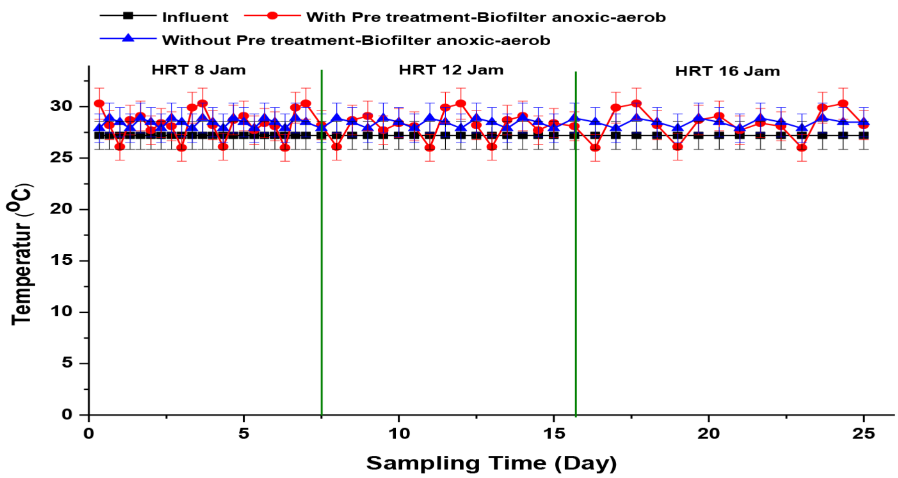

Fig. 10. Temperature characteristics of the process in SBio1 and Bio2

balance of the microbial ecosystem in the biofilter. Excess or lack of DO can cause microorganism imbalance, which has the potential to disrupt biofilter performance. Biofilter performance is affected by the shape and kind of biofilm growth material. This study investigated the effect of media shape on microbial proliferation as biofilm bonded to the growing medium. The growth medium provides a surface area for microorganisms to attach and multiply. Large, porous surfaces

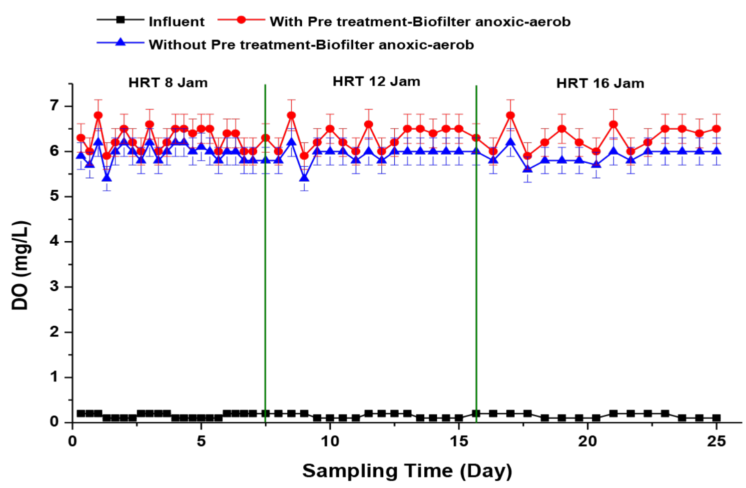

Fig. 11. Dissolved oxygen characteristics of the process in SBio1 and Bio2

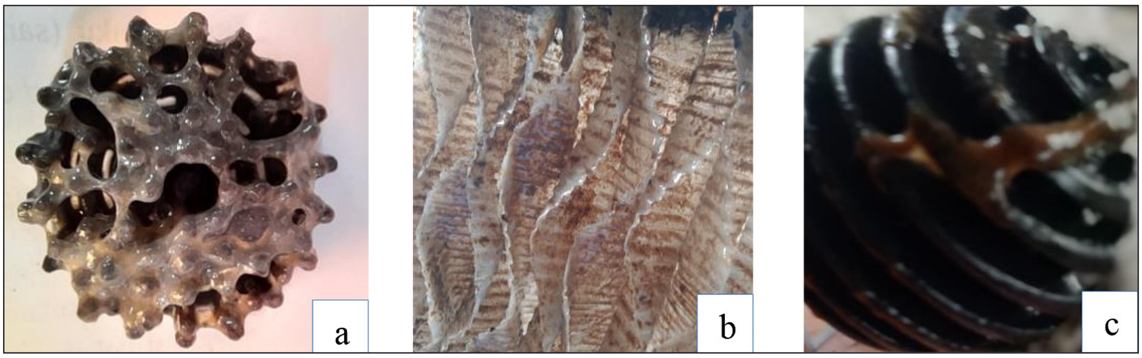

Fig. 12. Biofilm attachment on biofilter growth media, (a) bio ball serrations, (b) wasp nest, (c) bio ball golf

allow for greater microbial populations, which improves treatment efficiency. The growing media used in this study included three variations: bioball serrations, bioball golf, and wasp nest. Biofilm adhesion on biofilter growing medium.

Bioball serrations had an average biofilm thickness of 2.5–3 mm, wasp nets of 1.5–2.3 mm, and golf bioballs of 2– 2.5 mm. The biofilm stuck strongly to the surface of the bio ball serrations, however on the golf bioball, the biofilm adhered only to the outer surface, with the biofilm indentation just slightly adherent. The properties of the biofilm on the wasp net are more difficult to attach because the wasp net's surface is wide, making the biofilm difficult to adhere to. The effect of the shape of the biofilm growing media on the filter media on the ability of microbes to decompose organic contaminants, at HRT 12 hours is described below.

Reduced BOD_5 and COD pollution

One of the key steps in the treatment of wastewater is the decrease of pollutants in biofilters, such as BOD_5 (biochemical oxygen demand) and COD (chemical oxygen demand). Figure 13 shows data collection in the sedimentation basin after the biofilter. In this investigation, the highest serrated bioball biofilm growth media was able to reduce COD organic content by 88% and BOD_5 by 90%. The serrated bio-ball biofilm growth media is specifically intended to promote the development of microorganisms, allowing them to operate more efficiently to eliminate BOD_5 and COD pollutants.

Reduced TDS and TSS pollutants

The shape and kind of biofilm growth media have an impact on TDS and TSS decrease during Biofilter treatment. According to Figure 15, TDS levels on various growing media were only reduced by 38.4% on serrated bioball media. Total dissolved solids is the sum of all dissolved substances in water, including salts, minerals, and organic molecules. TDS reduction in biofilters with biofilms is frequently ineffectual because the solutes in TDS have extremely small molecular sizes and cannot be adsorbed or precipitated by biofilms. Biofilms are more successful in treating bigger particles and organic waste, such as TSS,

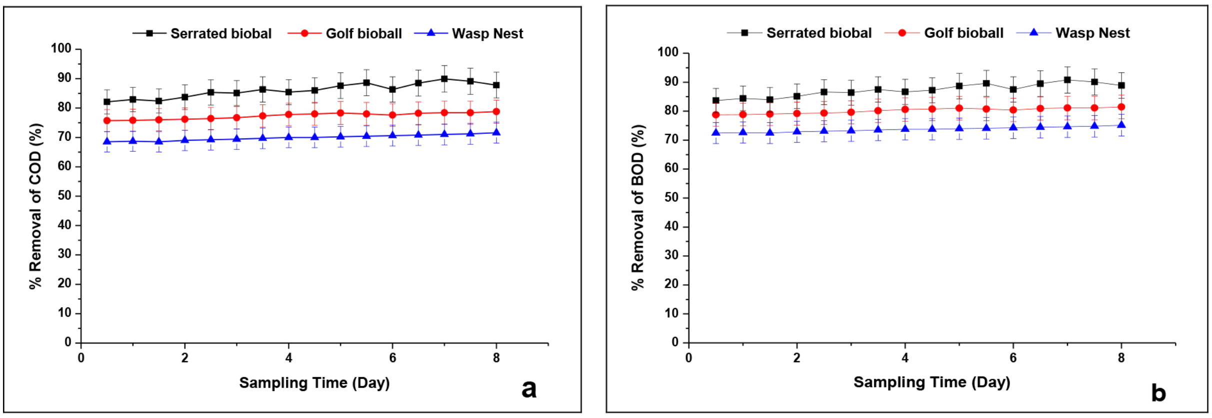

Fig. 13. Reduction characteristics of COD (a) and BOD_5 (b) on various biofilm growth media in a biofilter

which in one study may be reduced to 98.2% using serrated bioball media.

Furthermore, microorganisms in biofilms mostly degrade organic molecules and convert nitrogen and phosphate. This method does not directly remove dissolved salts. Biofilms lack the selective capacity to target specific molecules in TDS, allowing dissolved chemicals to stay in the effluent. If the TDS is caused by dissolved chemicals such as detergents or salts, as was the case in this study's effluent following sticker peeling and bottle washing, the biofilter will be unable to properly remove it.

Reduction of total phosphate, nitrogen, and color

Modifying septic tanks and employing biofilters with various types of biofilm growth media

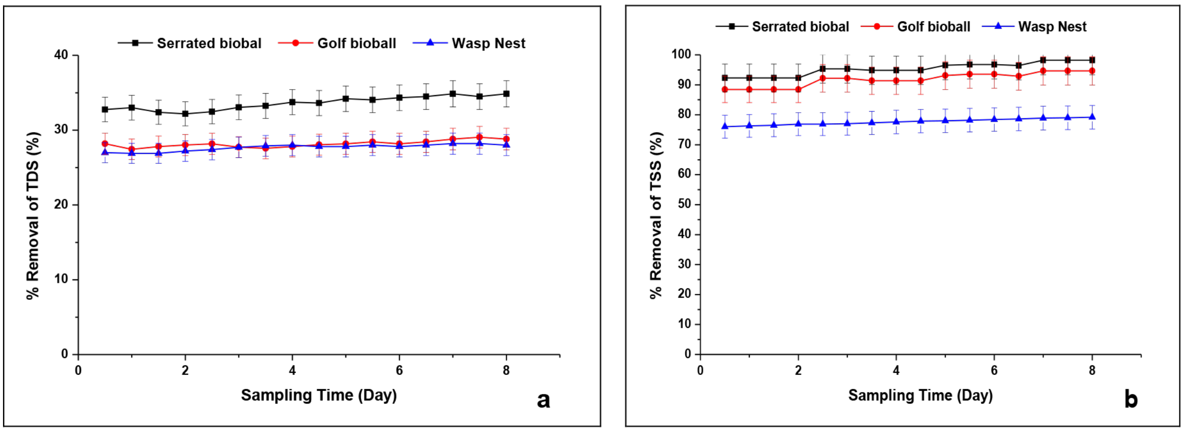

Fig. 14. Reduction of total phosphate (a), total nitrogen (b), and color (c), in the variation of biofilter growth media

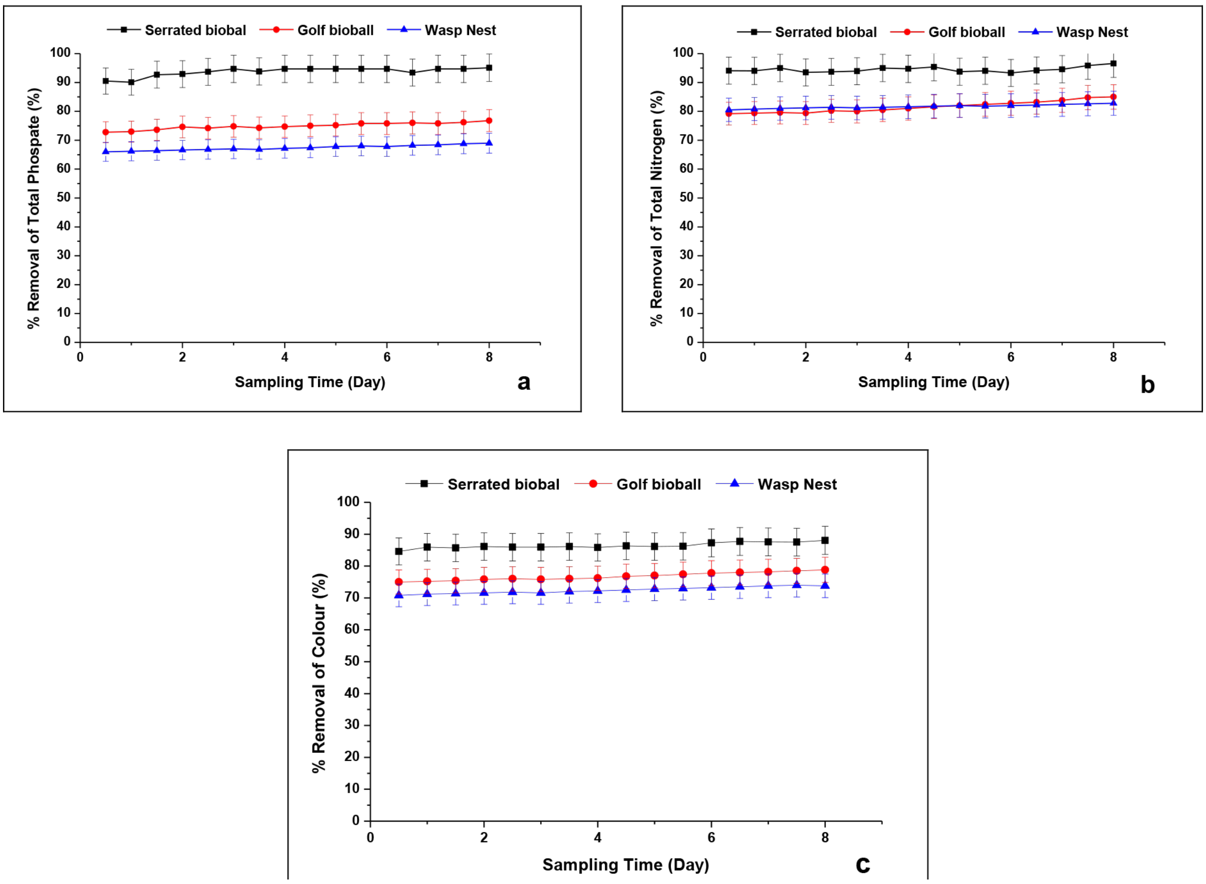

Fig. 15. The reduction of TDS (a) and TSS (b) in the variation of Biofilter growth media

can help reduce total phosphate, nitrogen, and color in wastewater effluent. Figure 14 describes the removal characteristics of total phosphates and color.

From Figure 14, biofilters with biofilms are more effective at removing organic materials and nutrients like nitrogen and phosphate, but they are unreliable for reducing TDS. The use of diverse biofilm-growing media in biofilter technology has a considerable impact on the reduction of total phosphate (95.1%), total nitrogen (94.6%), and color (87.5%) in wastewater. The serrated bioball biofilm showed the greatest reduction in total phosphate, total nitrogen, and color because it was designed to maximize surface area and biofilm formation. On phosphate and nitrogen reduction: Creates a perfect environment for microorganisms, resulting in more successful treatment.

In terms of color, the wastewater in this study has an organic color that is the result of a mix of raw ingredients, fermentation, and processing. Color pollutants in soy sauce wastewater occur for various reasons connected to the manufacturing process and raw materials used. Soybean fermentation creates color molecules such as melanoidin, which results from the Maillard reaction between amino acids and sugars. Microbes produce a variety of organic substances that can contribute color during fermentation, including natural pigments. Fermentation can also produce organic acids and aromatic chemicals, both of which contribute to color. The heating method used in soy sauce manufacture can cause sugar caramelization, which results in dark-colored compounds. Washing and filtering: Raw material residues that have not entirely decomposed might color the effluent.

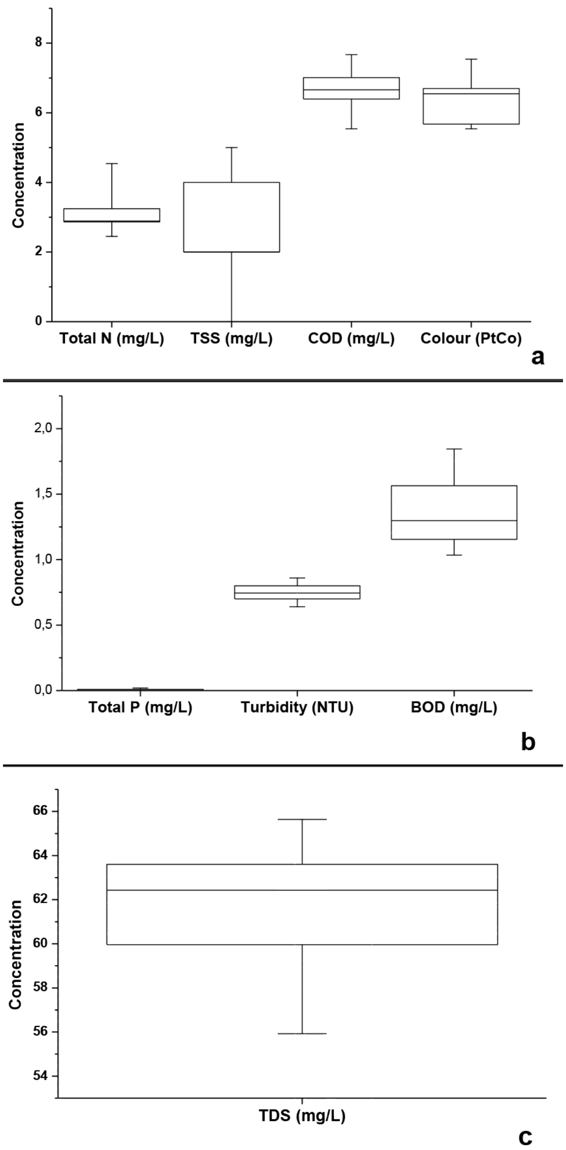

Fig. 16. The concentrations of total nitrogen, TSS, COD, and color (a); total phosphorus, turbidity, and BOD_5 (b); and total dissolved solids in clean water from the ultrafiltration process

Ultrafiltration is used to transform treated wastewater into clean water

Ultrafiltration is one of the most successful methods for recycling wastewater into clean water. This method separates particles, bacteria, and bigger solutes from water using a membrane with microscopic pores. Wastewater that has been treated using biofilters to reduce pollutants is then passed through an ultrafiltration membrane. This membrane's pores range in size from 1 to 100 nanometers. Larger particles, bacteria, and solutes are trapped while water flows through the membrane, allowing clean water and some small solutes to pass through. Ultrafiltration was chosen over reverse osmosis because it produces no reject water. The clean water that results from this method is then disinfected before being utilized to wash soy sauce bottles for use in soy sauce product packaging. Figure 16 shows clean water quality after ultrafiltration treatment.

As shown in Figure 16, all pollution parameters have met the appropriate clean water criteria in Indonesia, specifically Permenkes no. 2 of 2023. Concerning the application of government legislation on environmental health. Ultrafiltration can effectively remove organic pollutants such as colored compounds and other hazardous

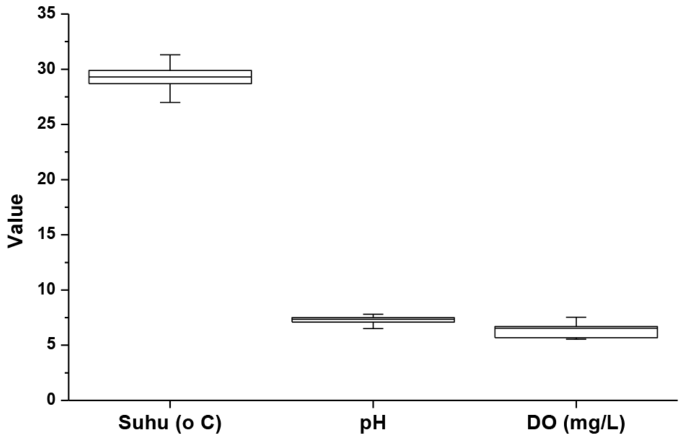

Fig. 17. The pH, temperature, and dissolved oxygen of clean water obtained through ultrafiltration

chemicals. Ultrafiltration may effectively remove impurities without the use of dangerous chemicals. Ultrafiltration can also increase the quality of the generated water, allowing for resource reutilization.

While the characteristics of pH, temperature, and dissolved oxygen (DO) are the characteristics set by the standard. Described in Figure 17 are characteristics of pH, temperature, and dissolved oxygen (DO) of clean water from ultrafiltration

Figure 17 shows that the average pH, temperature, and dissolved oxygen levels are 7-7.35, 26-28°C, and 6-7 mg/L. These characteristics are consistent with the norms established. So it can be used for the bottle washing process in the industry.

CONCLUSIONS

This study discovered that it is critical to use an effective pretreatment system, specifically a Septic Tank, to handle the high levels of pollutants in soy sauce, bread, and sticker peeling effluent. Using an optimum biofilter medium can boost microbial activity, resulting in better wastewater treatment efficiency. Serrated bio-ball growing media outperformed golf bio-ball and wasp nest in terms of microbial elimination of organic pollutants. The usage of septic tanks and anoxic-aerobic biofilters can effectively reduce excessive organic pollution in companies. Using ultrafiltration technology, organic-contaminated wastewater can be recycled into clean water. This procedure not only reduces pollutants in wastewater but also promotes environmental sustainability by utilizing water resources.

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