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Research Paper

Textile Dye Reactive Black 5 (RB5) Bio-Sorption with Moving Bed Biofilm Reactor and Activated Sludge

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Abstract

Reactive Black 5 (RB5) is one of the dyes used in textile industries in Indonesia. However, the high color content can interfere with the condition of water bodies if not treated. This waste treatment process is usually treated with biological treatment processes. Biological processing often used is the MBBR unit and activated sludge. This study aims to determine the RB5 dye's bio-sorption efficiency using MBBR processing and activated sludge. MBBR processing and activated sludge consist of seeding, acclimatization, and running stages. This research was carried out using a real textile wastewater approach by adding 100 mg/L RB5 and adding 1000 mg/L starch solution. The processing results of the seeding stage indicate increasing in biomass. The acclimatization stage with 50% and 75% of wastewater indicates increased biomass and color removal. The RB5 color removal efficiency results in the MBBR unit and activated sludge show 41% and 84% values. The MBBR processing shows fluctuations each time where the desorption process occurs in the color removal. For this reason, the ozone pre-treatment process is conducted in the MBBR unit. The integrated pre-treatment with MBBR results show the same fluctuation as the previous processing with a color removal efficiency of 43% with a color removal efficiency of 43%.

Keywords

activated sludge, color removal efficiency, bio-sorption, RB5, MBBR

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1. INTRODUCTION

Textile wastewater contains very toxic materials when discharged into water bodies (Kant, 2011). Another impact caused by textile wastewater is eutrophication; in this condition, it can reduce the amount of oxygen and the explosion of algal and weed populations. Therefore, environmental impact is an essential problem when textile wastewater discharges water bodies (Safauldeen et al., 2019; Apritama et al., 2020). The materials contained in the textile wastewater are dyes, especially synthetic dyes.

Synthetic dyes are molecules with delocalized electron systems and contain two groups: chromophores and autochromes (Fajrudin et al., 2016). The use of various synthetic dyes is adapted to dyed fiber, the desired color resistance, and other technical and economic factors. Synthetic dyes are widely used in Indonesia's textile industries (Aninda and Efi, 2019; Pratomo et al., 2019). The synthetic dyes commonly used in industry are Reactive Black 5 (RB5). RB5 dye is cheap and easily found in the market; therefore, it is widely used in the textile industry, especially in small and medium industries. However, RB5 dyes in the industry will cause wastewater with a full color that is difficult to process (Chang et al., 2002). Textile wastewater treatment can be done physically, chemically, or biologically. Biological wastewater treatment is usually applied because it is safe, environmentally friendly, and inexpensive (Yanuartono et al., 2020).

There are two wastewater treatment processes biologically, the suspended growth process and the attached growth process. This process is expected to increase the number of microorganisms in biomass in the reactor and increase pollutant removal efficiency. Wastewater treatment that has been used in the aerobic waste treatment process is the Moving Bed Biofilm Reactor (MBBR), with more than 90% color removal (Pratiwi et al., 2018; Spagni et al., 2010; Suryawan et al., 2021) and activated sludge. MBBR is a waste treatment process with activated sludge modified by

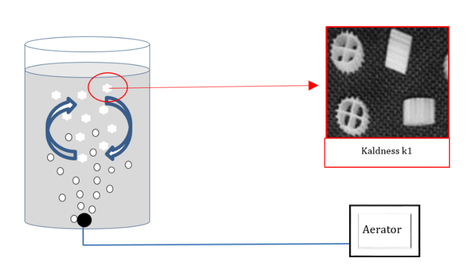

Figure 1. Schematic MBBR Reactor for RB5 treatment

adding media to maximize biofilms' surface area in the reactor (Rusten et al., 2006). The MBBR application has advantages in operations where it produces less sludge than the activated sludge process. In textile-wastewater processing, it can also be improved by pre-treatment of the waste. The pre-treatment to improve biodegradability can be done with the ozone oxidation process (Suryawan et al., 2021; Septiariva et al., 2021). Textile wastewater processing using this process is proven to increase biodegradability (Bilińska et al., 2016), which can simplify biological processing.

This research was conducted to determine the color removal efficiency in textile industries' treatment process with MBBR processing technology and activated sludge. Process efficiency can be improved by ozone pre-treatment.

2. EXPERIMENTAL SECTION

2.1 Materials

In this research, the experiment reactor used was the Moving Bed Biofilm Reactor (MBBR) and activated sludge reactor. The MBBR treatment unit's design consisted of Kaldness k1 media with total media of 50% from total volume, aerator, and 2-liter volume. Whereas activated sludge reactors only use aerators with a volume of 2 liters (Figure 1).

Wastewater used is an artificial mixture of RB5 and starch. Indonesian Research states that the concentration of dyes in textile wastewater is 100 mg/L with a COD content of about 1000 mg/L (Suryawan et al., 2021; Henry Setiyanto ; Agustina and Saraswaty, 2016). The real textile wastewater approach by adding RB5 of 100 mg/L and 1000 mg/L of starch solution. Before the experiment, the wastewater treatment, microorganism seeding, and acclimatization are done on the MBBR reactor and activated sludge.

Microorganism seeding in research carried out naturally by flowing wastewater into the reactor that has been filled with kaldness 1 (k1) media to form a biofilm layer. At the time of the seeding process, oxygen is injected oxygen into the MBBR reactor so that the biological oxidation process by microorganisms. Acclimatization was conducted to obtain a culture of microorganisms that are stable and can adapt to RB5 wastewater. Acclimatization was carried out with a textile wastewater concentration of 50%; and 75%. The acclimation process stopped when it is already in steady condition.

2.2 Methods

The main parameter measured in the seeding and acclimatization process is mixed liquor volatile suspended solids (MLVSS). MLVSS was measured with the gravimetric method at 600°C. The main parameter measured in this study is the color level. The RB5 color was measured at the maximum wavelength. Spectrophotometry can be used to determine the concentration of a solution through absorption intensities at specific wavelengths. The wavelength used is the maximum wavelength that provides maximum absorbance. The color concentration measuring principle using Lambert's Law, absorption is directly proportional to the irradiated cell's thickness; as the cell increases, the absorption will increase. According to Beer, what applies to monochromatic radiation in very dilute solutions, absorption is directly proportional to concentration. If the concentration increases, the number of molecules passed by the beam will increase to increase absorption. These two equations are combined in the Lambert-Beer Law, so it is obtained that the absorption directly proportional to the concentration and thickness of the cell.

3. RESULTS AND DISCUSSION

3.1 Maximum wavelength determination

The maximum wavelength measurement was measured with a color concentration of RB5 20 mg/L. The measurement results for each wavelength are shown in Figure 2. These results indicate the maximum wavelength value at a wavelength of 625 nm. The results are similar to other studies that mention a maximum wavelength value of 620 nm (Sahel et al., 2010; Soltani and Entezari, 2013).

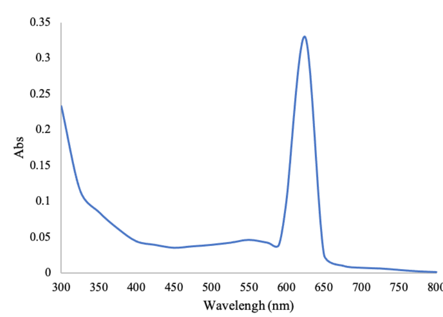

Figure 2. Maximum wavelength measurement results for RB5

3.2 Seeding process

Microorganisms that will be used in RB5 waste will first be cultured or seeding processed. Microorganisms were cultivated from sludge water starter of textile wastewater. The initial MLVSS concentration at the seeding stage is only ±384.75 mg/L and continues to increase to 88-90% at the

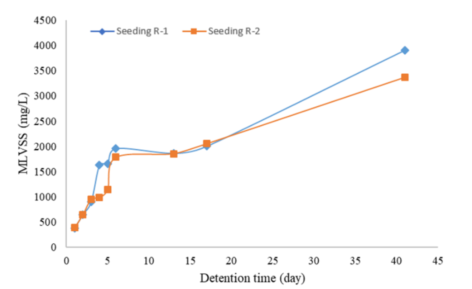

Figure 3. Results of MLVSS measurements during the process of seeding microorganisms with the same characteristics without any differences

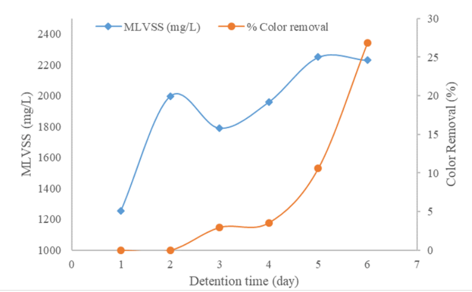

Figure 4. Results of MLVSS measurements during the acclimatization process of 50% artificial RB5 wastewater.

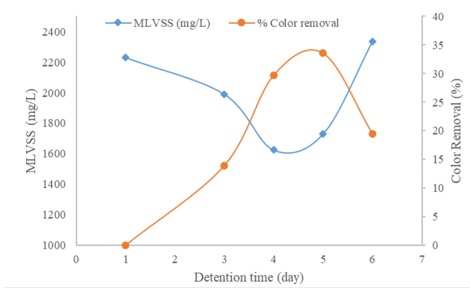

Figure 5. Results of MLVSS measurements during the acclimatization process of 75% artificial RB5 wastewater.

41-day detention time (Figure 3). This experiment was carried out with two reactors that have the same characteristics without any differences. The increase of MLVSS values indicates a biomass increase caused by microorganism activity. The higher the microbial activity in decomposing organic material, the higher the biomass produced (Kriswidatari et al., 2017). Organic substances (in this case, are RB5 dyes and starch solutions) used by microorganisms as the substrate to grow. The attached microorganisms use organic substances available in the MBBR reactor to grow (Afifah et al., 2020; Sofiyah and Suryawan, 2021).

3.3 Acclimatization process

Figure 4 and Figure 5 show MLVSS value increase and color decrease in the acclimatization process. MLVSS measurement results showed a decline in 3 - 4 days of the acclimatization process. Bacterial activity in the attached media K1 is indicated by reducing the MLVSS value, which means the bacteria have begun to stick to the media (Indriyati, 2011). The acclimatization of 75% of wastewater showed a decrease in color concentration within six days. It shows a color desorption process at that time, which causes the removal efficiency to decrease.

3.4 Running process

Figure 6 shows the change of RB5 color concentration, which shows the highest efficiency in activated sludge treatment. MBBR units' treatment color efficiency reaches 41%, while activated sludge units can reach 84%. Efficiency decreases again at a detention time of 210 minutes. Increased concentration in the MBBR unit indicates the desorption process. Desorption opportunities are greater in the MBBR unit compared to the activated sludge unit. Desorption is a removing process of atoms, molecules, or ions entangled on the surface.

Desorption can also be mean as a phenomenon where a substance escapes from the surface. The desorption process can occur when the adsorption process occurred is maximal, the surface of the adsorbent is saturated/no longer able to absorb the adsorbate, and then equilibrium occurs. Previous research of MBBR units in textile wastewater produced a 50% allowance (Park et al., 2010); this value is close to the research results. Previous research can improve the efficiency of color by integrating ozone into textile wastewater treatment with MBBR (Gong, 2016). RB5 wastewater was treated with modified ozone pre-treatment in the MBBR unit to see the desorption process in different treatments. This pre-treatment process's function is to increase the biodegradability of the organics contained in wastewater (Septiariva et al., 2021; Suryawan et al., 2021). The treatment results of ozone pre-treatment showed fluctuations in the same concentration as those without ozone pre-treatment. The color removal results in this treatment only showed an efficiency of 43%. Desorption processes on MBBR media more common than activated sludge processes. Microorganisms in activated sludge and MBBR can work actively or passively. They were actively splitting dyes in the waste that called as biodegradation process while passively adsorbing dyes contained in textile wastewater or often called bio-sorption (Metcalf et al., 1991).

4. CONCLUSIONS

RB5 color removal results using the MBBR process and activated sludge, respectively, were 41% and 84%. Where the desorption process of RB5 color processing in the MBBR unit, even more occurs frequently. The ozone pre-treatment in the MBBR process showed the same results without treatment, where the media capacity of the MBBR unit was not good enough to absorbing RB5 dyes.

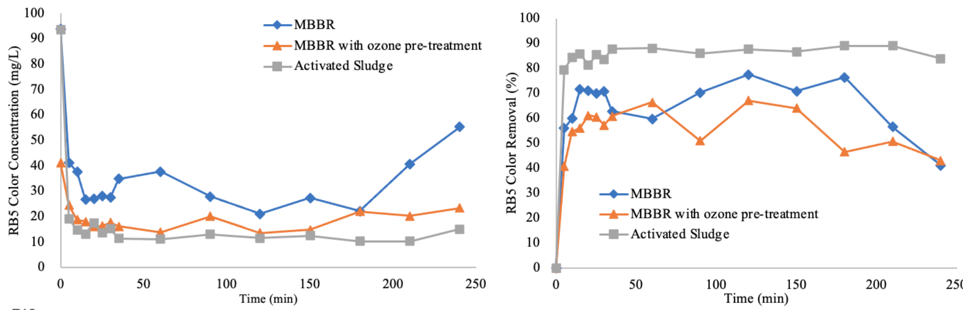

Figure 6. RB5 color concentration and removal in the MBBR unit and activated sludge

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