The Effect of Aeration on Aerobic Biofilter Using Polyethylene Terephthalate Media for Chicken Slaughterhouse Liquid Waste

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***Abstract*— Chicken Slaughterhouse is one of the industries that process live chickens into ready-to-eat chicken meat products. Many chicken slaughterhouses still need liquid waste treatment technology and directly discharge it into the aquatic environment. RPA liquid waste has a high organic content that will cause environmental pollution with unpleasant odors and decay. This study uses an aerobic wastewater treatment method by utilizing aerobic microorganisms in wastewater that are attached to biofilter media to form biofilms. This study aims to reduce the concentration of COD, BOD, TSS, and ammonia and change the pH value of RPA liquid waste with aerobic biofilter treatment using honeycomb media from Polyethylene Terephthalate and to get the best aeration flow rate to reduce the concentration of pollutants from the aerobic biofilter reactor. In this study, the residence time and the addition of air discharge in the aeration process are varied. The results of this study show that there has been a decrease in the concentration of COD, BOD, TSS, and ammonia and changes in pH values following PERMENLHK No 5 of 2014 concerning the quality standards of slaughterhouse wastewater with the best aeration flowrate recommendation is 15 liters/minute.**

***Keywords*—Aerobic biofilter, Chicken slaughterhouse liquid waste, Polyethylene terephthalate**

I. Introduction

The chicken slaughterhouse industry in Indonesia is growing rapidly along with the demand for chicken meat consumption by the Indonesian people. The need for chicken meat as public consumption is increasing from year to year. Based on data from Statistics Indonesia, broiler chicken meat production in 2022 will reach around 3.7 million tons per year and is predicted to increase in the next few years. The high demand for chicken meat has led to the establishment of many chicken slaughterhouses (RPA), but many RPA still need to meet the standards set by the government. The waste generated by the RPA often causes pollution problems in the RPA area. The RPA liquid waste has a fairly high organic content consisting of carbohydrates, proteins, salts, and fats that trigger the growth and development of microbes, causing decay and unpleasant odors [1].

Alternative technologies that can be applied to handle this RPA liquid waste are diverse. One technology that can be used in accordance with the characteristics of RPA wastewater is the aerobic biofilter system. The aerobic biofilter system works by utilizing a biofilm layer of microorganisms. Pollutant compounds present in wastewater, such as organic compounds (BOD and COD), ammonia, phosphorus, and others, will diffuse into the biological layer or film attached to the surface of the medium. At the same time, using oxygen dissolved in water, the pollutant compounds will be decomposed by microorganisms in the biofilm layer and the energy generated will be converted into biomass [2]. The advantages of this aerobic biofilter are that it is easy to operate, produces little sludge, is resistant to flow discharge fluctuations and load fluctuations, produces a high efficiency level in removing pollutant loads in wastewater treatment, and can remove suspended solids well [3]. This aerobic wastewater treatment requires an aeration method by adding oxygen to the waste solution to increase the amount of dissolved oxygen to provide oxygen supply to decomposing microorganisms to reduce the levels of organic substances contained in the wastewater [4]. The process of microorganisms attaching to the surface of the biofilter to form biofilm is influenced by the surface area of the biofilter media. The media used in this aerobic biofilter is honeycomb media made from Polyethylene Terephthalate (PET). PET plastic has the characteristics of small particle size of the constituent material, so the surface area value on the biofilter media from PET plastic becomes large, which has the potential to increase the area where organic matter is attached to become biofilm so that it can improve the performance of aerobic biofilter processing [5]. This research aims to reduce the concentration of COD, BOD, TSS, ammonia, and changes in the pH value of RPA liquid waste with aerobic biofilter treatment using honeycomb media made from Polyethylene Terephthalate and to get the best aeration flowrate performance to reduce the concentration of pollutants from aerobic biofilter reactors.

II. Method

The research was conducted at the Biotechnology Laboratory, Department of Industrial Chemical Engineering, Faculty of Vocational Studies, Institut Teknologi Sepuluh Nopember during the period February-July 2023. The RPA liquid waste will be treated aerobically in an aerobic reactor using honeycomb media made from Polyethylene Terephthalate. This RPA liquid waste treatment will produce wastewater that is in accordance with the quality standards of PERMENLHK No. 5 of 2014.

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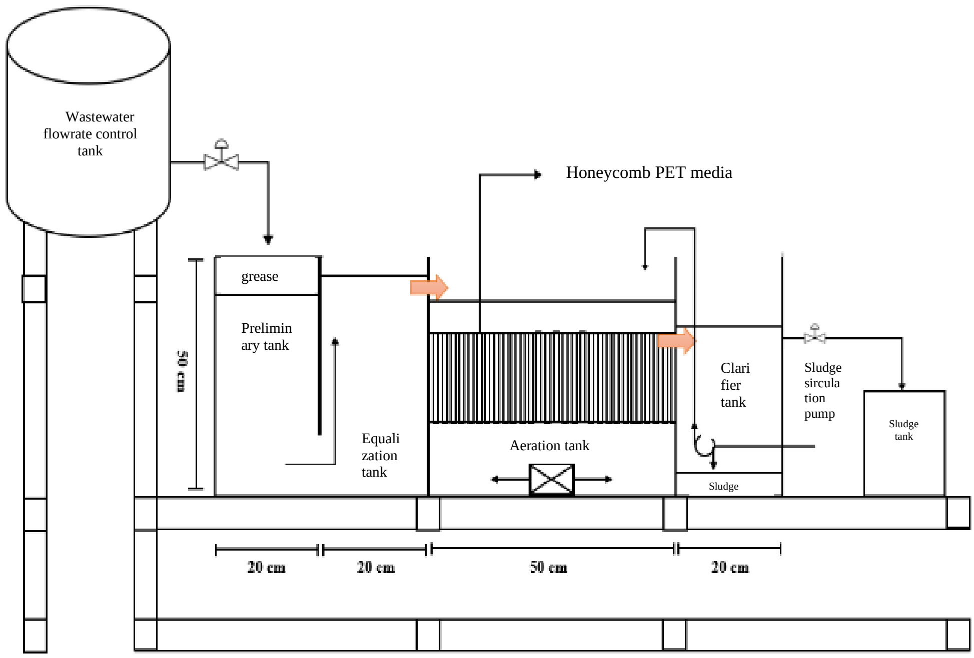

Figure 1. Design of Aerobic Biofilter Equipment

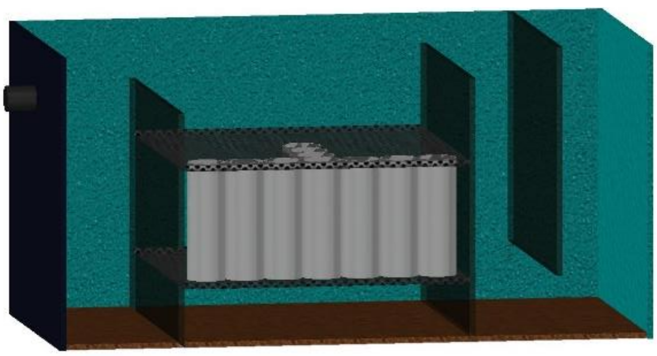

Figure 2. 3D Design of Aerobic Biofilter

The reactor used is made of glass and has a length of 100 cm, a width of 50 cm and a height of 50 cm. In this reactor, several tanks are made with different functions for each vessel.

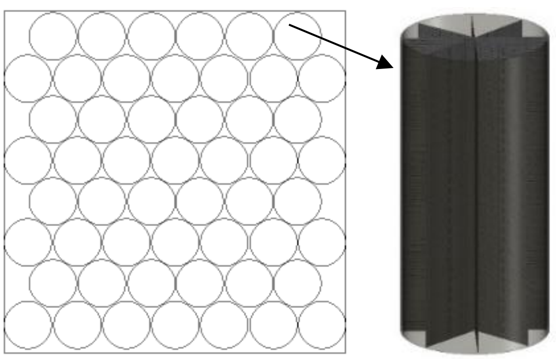

Figure 3. Top View of Honeycomb Media Made from Polyethylene Terephthalate

The media used for this RPA wastewater treatment is honeycomb media made from polyethylene terephthalate. In this study PET plastic bottles will be arranged to resemble honeycomb media so that there are cavities in it as a place for biofilm formation.

In this study, there are fixed variables and independent variables. The selected variables used are residence time for 4 hours, 8 hours, 12 hours, 16 hours, and 20 hours in the aerobic biofilter reactor. In contrast, the independent variables used are aeration flow rate of 5 liters/min, 10 liters/min, and 15 liters/min.

A. Pre-treatment Process

The pre-treatment process carried out to treat this RPA wastewater is the seeding process. This seeding process is carried out by taking aerobic microorganisms which are then put into the reactor along with honeycomb media and given nutrients and oxygen supply from aerators for 2 weeks. The microorganisms used to take from PT REX CANNING. This seeding process is carried out so that aerobic microorganisms can adapt and form biofilms on honeycomb media. RPA liquid waste samples that will be used are taken from UD. ANDULAMIN in Tambaksumur, Waru Kec, Sidoarjo Regency. The samples will be subjected to initial testing to measure the concentration of COD, BOD, TSS, pH and Ammonia.

B. Aerobic Biofilter Operation Process

RPA liquid waste of 100 liters is put into the control tub and flowed to the initial reservoir by opening the valve in the control tub. Furthermore, RPA liquid waste from the initial reservoir will flow underflow into the equalization tank. Then the RPA liquid waste from the equalization tub will overflow into the aeration tub which contains the honeycomb media and the aerator that has been installed. In this aeration tank, RPA liquid waste will be observed with aeration flow rate and residence time variables. After the waste treatment occurs according to the residence time variable, the results of the wastewater will be flowed into the clarifier tub and then flowed into the wastewater collection basin.

III. RESULTS AND DISCUSSION

RPA liquid waste has the initial characteristics listed in Table 1.

TABLE 1.
INITIAL CHARACTERISTICS OF RPA WASTEWATER

Parameter	Analysis Result (mg/l)	Quality Standards*) (mg/l)
COD	2679.68	200
BOD	744.356	100
TSS	290	100
Ph	6.16	6-9
Ammonia	48.662	25

Note: *) PERMENLHK No 5 of 2014

Based on the results of the analysis of the characteristics of the initial RPA wastewater, the parameters can be identified COD, BOD, TSS, pH and ammonia exceed the established quality standards. It shows there is still a high content of organic matter in RPA wastewater. RPA liquid waste produced has a high concentration of organic matter due to its main content of RPA liquid waste is organic material. The content of organic matter contained in This RPA liquid waste comes from blood, fat, dissolved protein and solid material from broilers.

Before starting RPA waste treatment with variations in residence time and flowrate aeration is done seeding first. This seeding was carried out for 2 weeks under conditions aerobic. The purpose of the seeding process is to grow microorganismson the surface of the media used [6]. Microorganisms that used in the seeding process was taken from PT REX CANNING.

Figure 4. Aerobic Microorganism Seeding

Seeding is done by incorporating microorganisms into an aeration tank already contains wasp nest media. During this seeding, the microorganism supplied with oxygen from the aerator. In the seeding process, RPA liquid waste is also streamed slowly as a nutrient; these microorganisms can also adapt to the wastewater to be treated. Microorganisms used are in deep, stable conditions so that only natural seeding is monitored periodically until visible biofilm begins to grow and multiply and stick to the media. The biofilm layer attached to the media can be seen in a way as the formation of a layer of mucus that is brownish-black in color and is not easily separated from it media [7].

In seeding, the F/M ratio is required. The F/M ratio is a parameter used in waste treatment to describe the relationship between the amount of organic matter available in the waste and the number of microorganisms in the treatment system. The F/M ratio is used as an indicator to control the balance between incoming organic matter and the capacity of microorganisms to decompose it. The F/M ratio can be calculated by dividing the organic matter load by using the BOD value in the effluent by the number of microorganisms, the MLSS value in the sewage treatment system.

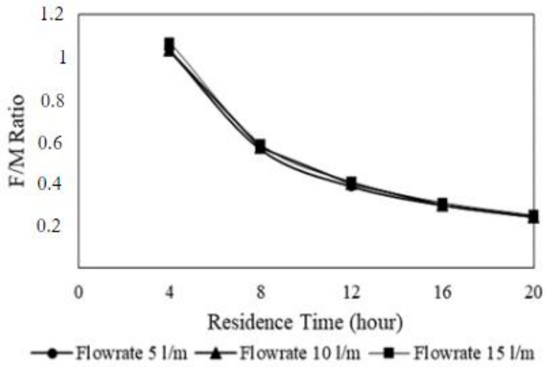

Figure 5. F/M Ratio

In the graph above it can be seen that the range of F/M ratios with aeration flowrates of 5 l/m, 10 l/m and 15 l/m was obtained to produce values in the range of 0.21-0.79 gram BOD/gram MLSS. In aerobic wastewater treatment, the standard F/M ratio is 0.2-0.5 gram BOD/gram MLSS. The low F/M ratio indicates that the microorganisms in the aeration tank are more productive in decomposing the organic content in RPA wastewater. The lower the F/M ratio, the more efficient the waste treatment system. The F/M ratio can be controlled by adjusting the circulation rate of activated sludge from the final settling tank circulated to the aeration tank [8].

The increasing biomass in the reactor can cause a low F/M ratio, while the concentration of waste organic matter remains the same. This situation causes the F/M ratio to decrease. With an increase in the amount of biomass, the amount of degraded organic matter increases so that the removal efficiency increases [9].

The next stage is aerobic treatment of RPA wastewater in the aerobic biofilter that has been made. The results of observations on COD, BOD, TSS, pH, and Ammonia concentrations can be seen in Figures 6-10.

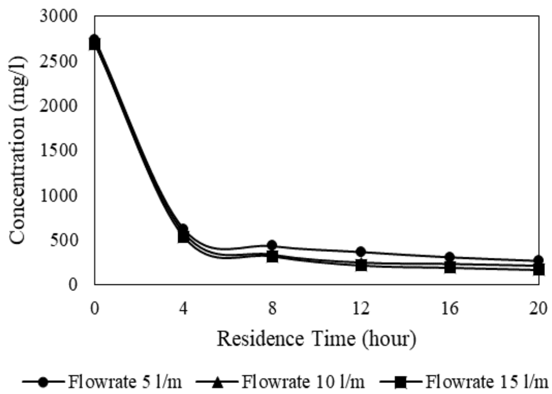

Figure 6. The Change of COD Value with Aeration

Figure 6 shows that the COD concentration decreased using an aerobic biofilter during the waste treatment stage. The best results were obtained at an aeration flow rate of 15 l/m with a residence time of 20 hours a COD value of 161 mg/l, with a removal efficiency of 94.08%.

The result shows that the greater the aeration flow rate and the longer the residence time for the waste, the smaller the concentration value in the waste. The decrease in COD concentration was caused by microorganisms attached to the biofilter media. Microorganisms can degrade organic compounds due to environmental factors and the nutrients provided. Organic compounds in RPA wastewater act as nutrients for microorganisms, which will then be broken down into organic substances that are simpler and easier to decompose. The longer residence time will affect the COD removal because the lower biofilm will be mixed with complex organic compounds to decompose. In contrast, the microorganisms in the upper biofilm will compete for carbon and nitrogen sources, reducing the effectiveness of COD removal [10] .

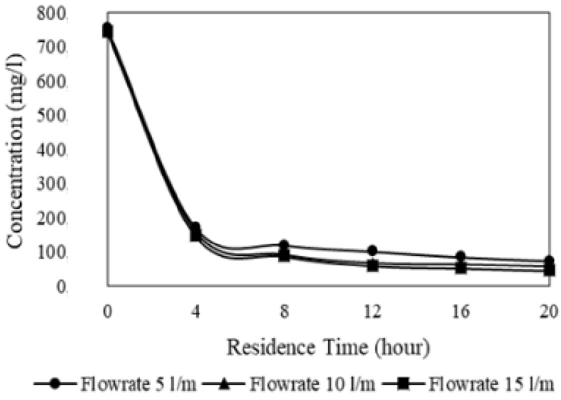

Figure 7. The Change of BOD Value with Aeration

Figure 7 shows that the concentration of BOD decreased during the waste treatment stage using an aerobic biofilter. The best processing results were obtained from an aeration flow rate of 15 l/m with a residence time of 20 hours; the yield was 44.72 mg/l with a removal efficiency of 94.08%.

The decrease in BOD values occurs due to the process of degradation and decomposition of organic matter in the biofilm layer attached to the surface of the honeycomb media with the help of an aeration process which causes reduced concentrations of contaminants [11]. A layer of microorganisms (biofilm) is attached to the surface of the biofilter media using dissolved oxygen in wastewater to decompose organic matter in RPA wastewater. The decrease in the BOD value also shows that the longer the residence time, the longer the contact time of the biofilm layer with RPA wastewater so that microorganisms can decompose more and more organic compounds [3].

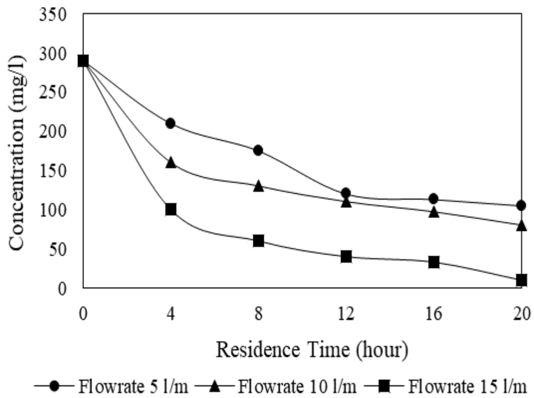

Figure 8. The Change of TSS Value with Aeration

Figure 8 shows that the concentration of TSS has decreased at the waste treatment stage using an aerobic biofilter. The results at an aeration flow rate of 15 l/m with a residence time of 22 hours obtained the best TSS value of 10 mg/l with a removal efficiency of 96.55%.

The large amount of TSS in RPA wastewater can be caused by the degradation process by microorganisms filtered by the media, causing a deposition process in which the particles in the wastewater will slowly drop to the bottom and form precipitates. The decrease in TSS concentration was caused by the attachment of suspended solids to the surface of the biofilm, which decomposed and dissolved in water [12]. In addition, the decrease in TSS concentration can be caused by the effect of air discharge because the more significant the oxygen supply added, the less TSS concentration will be. This is because the turbulence that occurs due to the oxygen supply will make it difficult for the particles in wastewater to settle it will affect the decrease in the TSS [13].

The pH condition is one of the environmental conditions that affect the growth process of microorganisms. The changes in the pH value of each aeration flow rate of 5 l/m, 10 l/m and 15 l/m are shown in Figure 9.

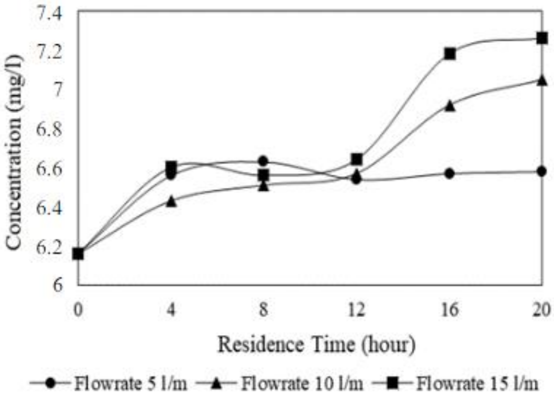

Figure 9. The change of pH Value with Aeration

In Figure 9 above, the results show that the pH of RPA wastewater has increased and decreased but is still within the set pH quality standard range. The increase in pH due to aerobic waste can be associated with the degradation of organic compounds that occur in aerobic processing, where organic compounds are broken down [14]. A pH value that exceeds the quality standard will inhibit the growth of microorganisms. In contrast, a pH below the quality standard will result in the growth of fungi and competition with bacteria in the metabolism of organic matter [15].

pH values in the range of 6-9 can support all biological processes, especially in wastewater treatment processes with high organic matter content. Aquatic organisms prefer a pH close to neutral, which can optimize the decomposition process in the waters. If the water's pH is close to neutral, the BOD value will also decrease [16].

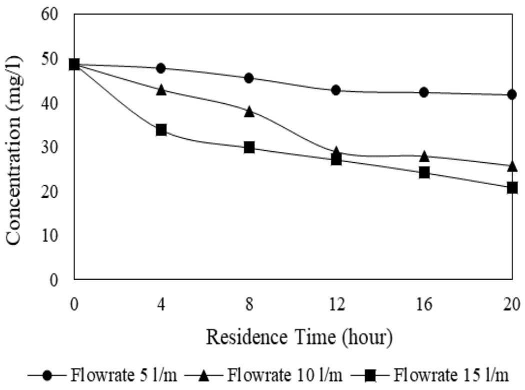

Figure 10. The Change of Ammonia Value with Aeration

Figure 10 shows that the ammonia concentration has decreased at the waste treatment stage using an aerobic biofilter. The results at an aeration flow rate of 15 l/m with a residence time of 22 hours obtained the best results with an ammonia content of 18.97 with a removal efficiency of 60.96%.

Aerobic processing is the process that most influences the reduction of ammonia (NH_3^-N) efficiency. This is because in the aerobic biofilter process, there is a nitrification process. This nitrification process converts ammonium (NH_4^+) to nitrite (NO_2^-), which then becomes nitrate (NO_3^-). Autotrophic and heterotrophic microorganisms carry out these changes. Heterotrophic microorganisms utilize organic compounds as their carbon source, while autotrophic microorganisms consume inorganic carbon such as CO_2. Aerobic waste treatment can degrade organic matter and ammonia into harmless compounds such as CO_2, H_2O, NO_2, NO_3 and new cells [17]. The conversion of ammonium to nitrite is carried out by Nitrosomonas bacteria and then the nitrite formed is converted to nitrate by Nitrobacter bacteria [18]. Both types of bacteria live in an aerobic state that requires sufficient oxygen concentration as a source of energy to support metabolic processes.

IV. Conclusion

Based on the results of the research that has been done, it can be concluded that RPA wastewater treatment with aerobic biofilters using honeycomb media made from Polyethylene Terephthalate can reduce COD, BOD, TSS, ammonia concentrations and changes in pH values in accordance with PERMENLHK No. 5 of 2014. The best aeration flow rate in reducing RPA wastewater pollutants is 15 liters/minute.

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