Seeding Phase of Restaurant Wastewater Treatment with and without Addition of Bioballs

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Abstract: Until now, industrial wastewater and domestic wastewater, including restaurant wastewater have not been managed optimally in Indonesia. A prototype of activated sludge reactor with and without bioballs has been designed and constructed in 2021 but due to several obstacles in operating this aerobic treatment system equipment and ineffective attachment of microorganisms, this research was conducted. The reactor added bioballs (RB) and another reactor without addition of bioballs (RWB) were used to treat the restaurant wastewater from a food industry in Bandung, Indonesia. Parameters observed were MLVSS, COD, and reactor pH. Seeding phase could be conducted successfully in both reactors. The maximum MLVSS in the RB was 79,003 mg/L whereas in RWB was 79,132 mg/L. The COD removal in RB decreased from the highest value of 7,895 mg/L to 4,668 mg/L whereas in RWB decreased from the highest value of 11,941 mg/L to 5,026 mg/L. The values of pH were in the range of 8.3 to 8.6 in both reactors. It means that the function of bioballs as attachment media for microorganism during the seeding phase has not been shown, however, the seeding phase in both reactors could be continued to the next phase, which is the acclimatization phase.

1 INTRODUCTION

The food and beverage industry is one of the fastest growing industries in Indonesia because this industry is a strategic business in meeting everyone's basic needs. The development of the food and beverage industry is accompanied by an increase in the discharge of wastewater from this industry and similar industries into water bodies. Until now, wastewater from industry and domestic purposes originating from household waste has not been managed optimally in Indonesia. Domestic wastewater includes used washing water, kitchen and toilet wastewater, in which this type of wastewater is the biggest contributor to water pollution that must be handled especially because of its high organic matter contents (Amri and Wesen, 2013; Ramadhani et al., 2020).

In compliance with the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016 (Minister of Environment and Forestry of the Republic of Indonesia, 2016), concerning domestic wastewater pollution, there are still many food and beverage industries, and small and medium-sized industries whose effluent waste does not meet the specified quality standards. Domestic wastewater pollution parameters consist of COD, BOD, TSS, pH, ammonia, oil and fat parameters and total coliform. The fulfilment of domestic wastewater quality standards will be realized when the wastewater is treated before being discharged into water bodies.

One of the food industries in Bandung, Indonesia has tried to treat its industrial wastewater by adding a grease trap to catch the oil and grease in its wastewater, but in its biological processing,

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inconsistent results in meeting wastewater quality standards have been found. The biological treatment used is activated sludge treatment where microorganisms that decompose organic compounds in wastewater grow suspended in an activated sludge reactor owned by this industry (Sukmana and Rifa'i, 2020).

One of the wastewater treatment methods containing high concentrations of organic compounds such as wastewater owned by the food and beverage industry is aerobic biological treatment. The aerobic biological treatment method that is widely used by industry in Indonesia is the activated sludge treatment system (Sudarman et al., 2020).

To streamline the performance of microorganisms in the activated sludge treatment system, it is necessary to add bioballs as media for attaching aerobic bacteria. Thus, the performance of microorganisms that grow in suspension can be assisted with microorganisms that grow attached to the bioballs. Decomposition of pollutants in wastewater becomes more effective with the presence of bioball media as a breeding ground for microorganisms (Said and Utomo, 2007).

Bioball media has several advantages, including its ability to minimize the occurrence of clogging and can maintain good aeration (Astuti and Ayu, 2019). In addition, bioballs are lightweight, easy to wash again, and have a fairly large specific area, and they are easy to install (randomly) so that the small Wastewater Treatment Plant (WWTP) package is very suitable (Said and Utomo, 2007). Based on these previous studies, a prototype activated sludge reactor with bioball has been designed and constructed in 2021 (Paramitha et al., 2021). However, due to several obstacles in the operation of the aerobic treatment system equipment and the results of ineffective attachment of microorganisms, this research is proposed.

The complete final results of this study are expected to provide input for the food and beverage industry in solving the problem of inconsistent results in meeting wastewater quality standards of their domestic wastewater treatment. In addition, the results of this study can be used to increase the competence of chemical engineering students of Politeknik Negeri Bandung, in terms of wastewater treatment practices by using treatment system technology that is more up to date.

2 METHODS

2.1 Preparation of Equipment and Materials

The main equipment in this research is a prototype set of activated sludge system with bioballs (RB) and a set of activated sludge system without bioballs (RWB). Each reactor system completed with a feeding tank of 9.1 L and an aeration tank of 15.7 L. The number of bioballs added in the RB was 150 pieces. The diameter of bioball is 3 cm with its surface area of 200 – 235 m^2/m^3. Aerators used in both reactors were Resun 9906 type. By applying these aerators, the DO in both reactors could be maintained $\geq$ 2 mg/L (Budiastuti et al., 2021).

Supporting equipment includes measuring flask, volume pipette, beaker glass, hotplate and stirrer, burette, Erlenmeyer, glass funnel, porcelain cup, desiccator, oven, furnace, and pH meter. Hach tubes, and Hach COD digester were used to measure the COD of the samples.

The chemicals used as nutrients for microorganisms include glucose, KNO_3, and KH_2PO_4. The materials used in the analysis process include $K_2Cr_2O_7$, 98% H_2SO_4, ferrous ammonium sulphate (FAS), ferroin indicator, KH_2PO_4, K_2HPO_4, Na_2HPO_4, $MgSO_4.7H_2O$, $FeCl_3.6H_2O$, $CaCl_2$, NaOH, HCl, aquadest, and filter paper.

Wastewater from a restaurant in the Bandung area, Indonesia was used to represent the food industry wastewater, while activated sludge as the source for starter of microorganisms was obtained from activated sludge of a food industry in West Java, Indonesia.

2.2 Seeding Stage

The seeding process was carried out by growing microorganisms to be suspended and attached to the surface of the bioballs. The seeding process was carried out in a natural way, namely by flowing restaurant wastewater into an aeration tank that does not contain bioballs and an aeration tank contains bioballs to form a biofilm layer that will cover the bioballs. The volume of activated sludge used was 2.75 L for RB and 3.235 L for RWB. To obtain the hydraulic retention time (HRT) in each reactor system of 6 days, the feeding rate in each reactor system was adjusted to the active volume of RB and of RWB.

The seeding process took 12 days with HRT of 6 days. Initial nutrition for microorganisms given was 400 mg COD/L. Nutrients were made synthetically by mixing glucose with nitrogen and phosphorus sources in the form of KNO_3 and KH_2PO_4 at a ratio of 100:5:1 (Hamza et al., 2019). Sampling was carried out once a day followed by checking of pH, temperature, DO, and MLVSS. In addition, the operating temperature was not specially maintained to make it easier for related industries when applying this technology.

2.3 Analysis Stage

The analysis carried out during the seeding stage, and also acclimatization, and main experimental stages was pH, MLVSS, COD, and TSS. Determination of pH was using a pH meter, MLVSS using the gravimetric method, COD using the SNI 6989.73:2009 method, TSS using the SNI 06-6989.3-2004 method. The success indicator of this research is the increase of MLVSS as representation of the growth of microorganisms. Reactor pH is at the range of neutral pH. In addition, the removal of organic compounds in the form of COD were also observed.

3 RESULTS AND DISCUSSION

3.1 Raw Material Characteristics

This study used the main raw materials, namely activated sludge and restaurant wastewater. The restaurant wastewater used is cloudy yellow in colour, emits a distinctive odour from food residue, is runny, and has sediment originating from food scraps that are carried away. Restaurant wastewater was previously tested with COD (Chemical Oxygen Demand) parameters and the value was 9000 mg/L. Therefore, pre-treatment was carried out by diluting restaurant wastewater to 1000 mg/L and 3000 mg/L respectively as feed during the operation stage. Restaurant wastewater that had been diluted was put into a refrigerator, this was done so that no chemical or physical changes occur during the research process. The characteristics of the restaurant wastewater used in this study are listed in Table 1.

Table 1: Wastewater characteristics.

Characteristics	COD (mg/L)	pH	TSS (mg/L)
Restaurant wastewater	9,000	3.24	83
P.68/Menlhk/Setjen/ Kum.1/8/2016	100	6 - 9	30

3.2 Seeding Phase – Reactor with Bioballs (RB)

MLVSS in RB during the seeding stage showed an upward trend (Figure 1). The highest MLVSS value was found on the 9th day of 79,003 mg/L, while the lowest MLVSS was on the 5th day of 57,911 mg/L. The increase in MLVSS in RB occur gradually from day 5 to day 9. If we consider the increase in MLVSS from the first day, during 9 days of operation the MLVSS which represents the concentration of microorganisms has increased by 7,226 mg/L or by 10%. The next test parameter is COD (Chemical Oxygen Demand) which is a parameter of oxygen demand needed by microorganisms in degrading organic compounds in wastewater. The following is the COD curve for RB during the seeding process (Figure 2).

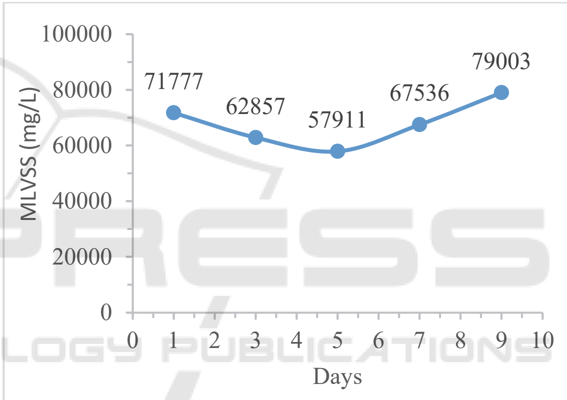

Figure 1: MLVSS during the seeding process (RB).

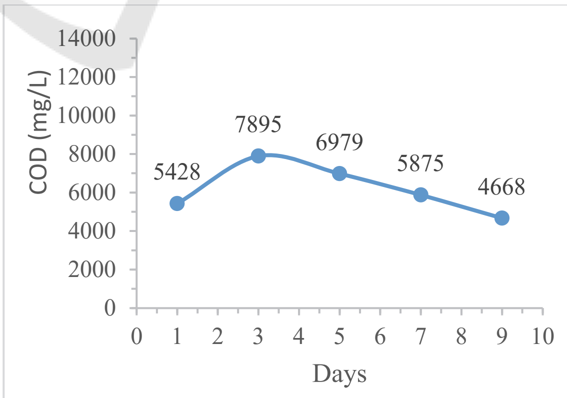

Figure 2: COD concentration during the seeding process (RB).

Based on Figure 2 the COD value of RB during the seeding stage showed a decrease trend starting from the third day. The COD RB value, which was initially 5,428 mg/L to become 4,668 mg/L on day 9 shows a decrease efficiency of about 14%. The next test parameter on RB is pH. The following is the pH curve of the seeding process (Figure 3). Based on Figure 3 the pH in the seeding process in RB is in the range of 8.43-8.62. This proves that the pH obtained is still within the safe limit of neutral pH, which is in the range of 6-9.

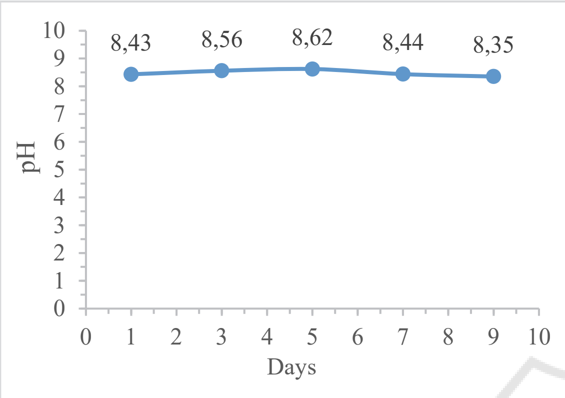

Figure 3: pH during the seeding process (RB).

3.3 Seeding Phase – Reactor without Bioballs (RWB)

Based on Figure 4 the MLVSS value in the RWB during the seeding stage showed an increase. The increase in MLVSS is an increase in the quantity of microorganisms. The highest value of MLVSS in RWB on day 1 was 82,472 mg/L and the lowest value on day 3 was 47,211 mg/L. Even though there was a decrease in MLVSS in the first 3 days, the MLVSS value on the following days increased. For this reason, it is necessary to look at the decrease in the COD value (Figure 5) with a decrease in MLVSS of about 4% for 9 days of operation.

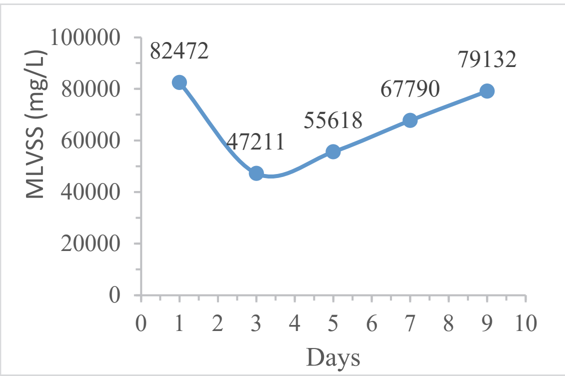

Figure 4: MLVSS during the seeding process (RWB).

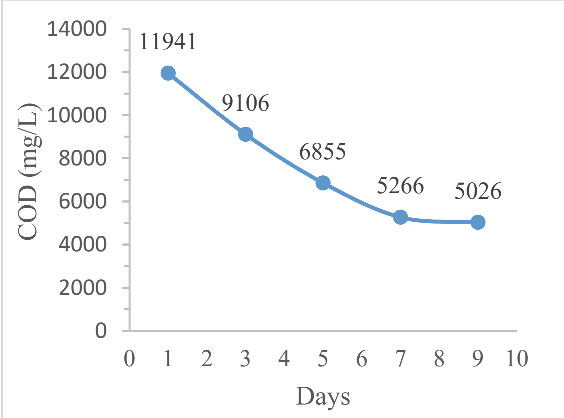

Figure 5: COD during the seeding process (RWB).

Based on Figure 5 the COD value in RWB during the seeding stage showed a decrease. The COD value in RWB was 11,941 mg/L to 5,026 mg/L with a decreasing efficiency of 57.91%, even though on the 7th and 9th days the COD values were relatively constant with a difference of only 4.8%. The next parameter is pH during seeding in RWB which is shown in Figure 6. The pH obtained is still within the safe limit of neutral pH, which is in the range of 6-9. From the result parameters observed in both RB and RWB, both system of reactors are ready to be continued to the next stage, which is the acclimatization stage. During the seeding phase, the function of bioballs to be used as media attachment of microorganisms has not been shown. It will be observed during the acclimatization process and the main experiment, as further processes which can show the real function of bioballs addition in this system.

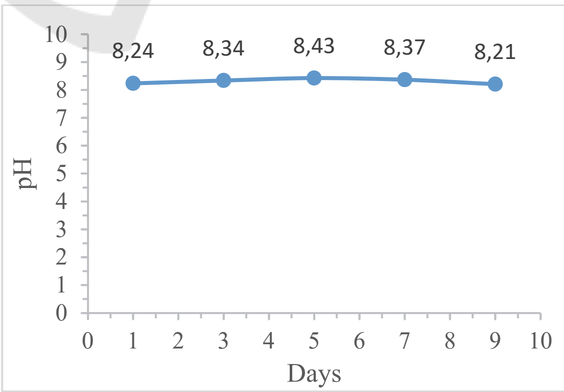

Figure 6. pH during the seeding process (RWB).

Paramitha et al. (2021) found the same observation that during the seeding phase, addition of bioballs has not shown its function. During 15 days of operation, the MLVSS in the activated sludge reactor increased from 585 mg/L to become 1,120 mg/L whereas MLVSS in the activated sludge reactor added bioballs increased from 380 mg/L to become 1,065 mg/L. The removal efficiencies in the form of COD removal were almost the same in both reactor types.

Another group of researchers (Temitope and Abayomi, 2022) observed that degradation of restaurant wastewater treated by a different method, i.e. electro coagulation resulted in low percentages in COD removal. During operation of 30 minutes of retention time only 12.58% removal efficiency was obtained. During operation of 60 and 90 minutes of retention time, removal efficiencies were only 21.13% and 25.83%, respectively. They obtained better improvement of COD removal by increasing the retention time, however, still low results were obtained.

4 CONCLUSIONS

Seeding of restaurant wastewater treatment can be conducted successfully in both reactors, with (RB) and without bioballs (RWB). The maximum MLVSS in the RB was 79,003 mg/L whereas in RWB was 79,132 mg/L. The COD removal in RB decreased from the highest value of 7,895 mg/L to 4,668 mg/L whereas in RWB decreased from the highest value of 11,941 mg/L to 5,026 mg/L. The values of pH were in the range of 8.3 to 8.6 in both reactors. It means that the function of bioballs as attachment media for microorganism has not been shown. However, based on the research results parameters, the seeding phase in both reactors could be continued to the next phase, which is the acclimatization phase.

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