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Canteen Wastewater Treatment by the Activated Sludge added Bioballs

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ABSTRACT

Water pollution has become a serious problem. Water pollution occurs because wastewater is discharged into water bodies without being managed properly. One of the sources of water pollution is domestic wastewater. Industrial sectors produce domestic wastewater derived from the residue of canteen activities. This study aims to treat the canteen wastewater from the food industry located in West Java Province. Initially, the canteen wastewater treatment used a combination of grease trap and activated sludge, but BOD and TSS levels do not meet the quality standards. A prototype of a biological wastewater treatment system, consisting of an activated sludge system and an activated sludge system added bioballs were then made. Bioballs were added to the activated sludge prototype to increase the treatment to enable the achievement of the wastewater quality standards. By combining the activated sludge and bioballs, both suspended and attached microorganisms would grow in this biological wastewater treatment system. The parameters of BOD, COD, TSS were measured in both prototypes of reactors. The microorganisms used were taken from the wastewater treatment plant in this industry. Before conducting the main experiment, the seeding and acclimatization process was done for 15 days at the hydraulic retention time of 48 hours. During this period, MLVSS in the activated sludge increased from 400 mg/L to 1,080 mg/L, whereas MLVSS in the activated sludge and bioballs increased from 580 mg/L to 1,120 mg/L. The main experiments resulted in BOD, COD, TSS reductions of 93.44%, 93.44%, and 92.66% in the activated sludge. In the activated sludge added bioballs, the BOD, COD, TSS reductions were 89.36%, 89.36%, and 83.49%, respectively. It means that the addition of bioballs has not affected the performance of the reactor during this period.

Keywords: *canteen wastewater, activated sludge, bioballs.*

1. INTRODUCTION

Water pollution due to increasing population and industrialization has become a serious problem and is getting more attention. Water pollution problems that negatively affect the environment are caused by wastewater that is not appropriately managed. Wastewater is the residual water that can be produced from industrial activities and domestic activities. Domestic wastewater is wastewater derived from human daily life activities related to water use [1], such as wastewater originating from kitchen activities and toilets. Domestic wastewater is among the largest contributors to water pollution due to its high organic content [2].

Based on the Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 [1], the characteristics of domestic wastewater include COD, BOD, TSS, pH, total coliform, ammonia, oil, and grease. Domestic wastewater that does not meet quality standards is not allowed to be directly discharged into water bodies. Therefore, domestic wastewater must be firstly treated so that the wastewater can meet the quality standards.

Industrial sectors produce domestic wastewater derived from the residue of canteen activities. This research focuses on a problem at canteen wastewater treatment system in one of the food industries located in West Java Province. It can be seen from the characteristics of the outlet grease trap that showed inconsistent results in meeting quality standards. Based on data from October 2019 to March 2020, BOD and TSS levels do not meet the quality standards several times (data are not shown).

By the original design, the grease trap was functioned to reduce oil and grease levels. After the grease trap, the activated sludge system is located and functioned to fulfill the quality standards. In this study, this activated sludge system was added bioballs to reduce BOD and TSS concentrations. Generally, the biological wastewater system is a better method due to its cost-effectiveness and high efficiency [3]. The addition of bioballs is proposed as a place where wastewater decomposing bacteria are attached to the surface of bioballs. The principle of this process is that microbes are growing and developing, and attaching to bioballs media, and forming biofilms [4].

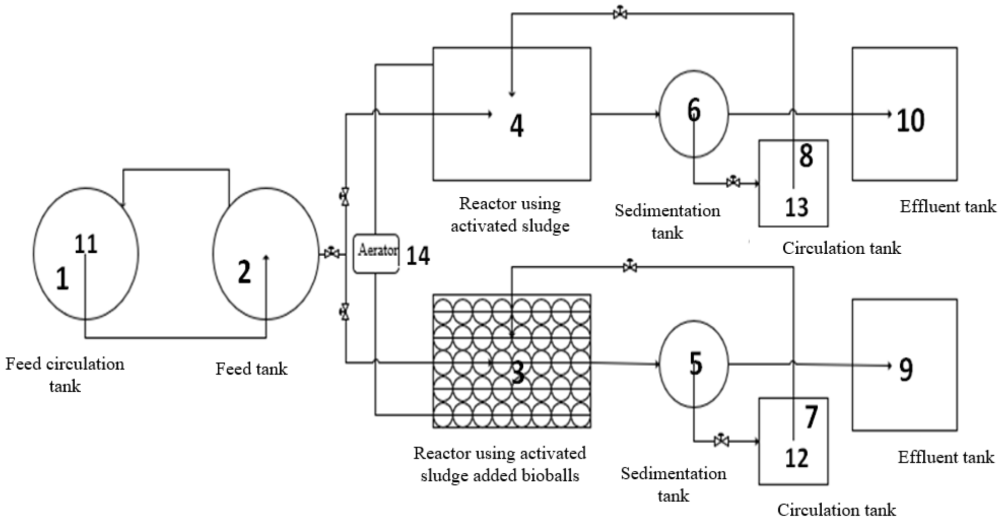

Figure 1 The Schematic Diagram of Biological Wastewater Treatment Systems

The decomposition process of pollutants in wastewater becomes more effective with bioballs media as a breeding place for microorganisms [5]. According to Said [6], the effectiveness of bioballs media can reduce BOD, COD, and TSS levels by about 85-92%, 78-91%, and 80-93%, respectively. Bioballs were combined with an activated sludge process resulting in robust biological processing with attached and suspended microbes.

According to Astuti and Ayu [7], bioballs media has several advantages, including its ability to minimize clogging and to keep the aeration in going well. In addition, bioballs are lightweight, easy to wash, have a large specific area, and easy to install randomly so that for a small wastewater treatment unit, the bioballs addition is very suitable [8].

Therefore, this study researches fabricating a prototype of a biological wastewater treatment system by using the activated sludge added bioballs and a prototype of a biological wastewater treatment system that uses the activated sludge as the control. Then, both systems were analyzed on their performances in decomposing pollutants based on COD, BOD, TSS, and pH parameters.

2. MATERIALS AND METHOD

The influent wastewater used in this study was the canteen wastewater obtained from the food industry located in West Java Province. This industrial wastewater was treated using the biological wastewater treatment system. The biological wastewater system consists of a feed circulation tank, feed tank, aeration tank or aerobic reactor, sedimentation tank, circulation tank, effluent tank, and other supporting equipment. Two biological wastewater treatment systems with different aerobic reactors were fabricated, namely aerobic reactor using activated sludge and aerobic reactor using activated sludge added bioballs. Bioballs were made of plastic with a diameter of about 3 cm. Figure 1 shows the schematic diagram of the biological wastewater treatment systems. Number 11, 12, and 13 represent the circulation pump, return activated sludge pump 1, and return activated sludge pump 2 respectively.

Before conducting the main experiments, the seeding and acclimatization process was done for 15 days at the hydraulic retention time of 48 hours. Microorganisms used were the microorganisms taken from the wastewater treatment plant in this industry. The parameters measured during the seeding and acclimatization process were MLVSS (gravimetry method) and COD (APHA 5520-2005 method). Then, the performance tests of the biological wastewater treatment systems were done with a hydraulic retention time of 24 hours. Analysis of influent and effluent wastewater characteristics was pH (SN 06-6989.11-2004 method), TSS (SN 06-6989.3-2004 method), COD (APHA 5520-2005 method), and BOD (SNI-06-6989.72-2009). The removal efficiencies of COD, BOD, and TSS were calculated as:

$$\text{Removal efficiency (\%)} = \frac{C_i - C_e}{C_i} \times 100\% \quad (1)$$

Ci and Ce are COD/BOD/TSS concentrations of influent wastewater and effluent wastewater, respectively.

3. RESULT AND DISCUSSION

The results discussed are the reactors dimension and the main process description, the seeding and acclimatization process, and the main experiments using the biological wastewater treatment system prototypes.

3.1 The Reactors Dimension and Main Process Description

The dimension ratio of the aerobic reactor and sedimentation tank refers to the existing wastewater treatment plant in this industry. The active volume of the sedimentation tank is 20% of the aerobic reactor. In this study, the active volumes of the aerobic reactor and sedimentation tank were 25 liters and 5 liters. Then, the amount of bioballs required refers to Irfa'i et al. [9], in which the percentage of bioballs volume is in the range of 0-45%. This study used the percentage of bioballs volume of 15%.

The biological wastewater treatment system consists of six components: the feed circulation tank, feed tank, aeration tank or aerobic reactor, sedimentation tank, circulation tank, and effluent tank. Before treating in the aeration tank or aerobic reactor, canteen wastewater was collected in the feed circulation tank. The feed circulation tank served to homogenize influent wastewater so that the quality of influent wastewater was relatively equal. Thus, the workload of microorganisms in the aerobic reactor was not high. Then, the wastewater flowed into the feed tank and was divided into two streams. One stream was flowed to aerobic reactors by using the activated sludge, and the other stream was flowed to the aerobic reactor by using the activated sludge added bioballs. The addition of bioballs in the aerobic reactor created a combination of suspended growth and attached growth of microorganisms. Bioballs were used as a medium for growth and developing microorganisms. In the aerobic reactors, decomposition process of organic wastewater was occurred and formed into simple compounds via an oxidation process. The aerobic reactors were equipped with an aerator to supply the oxygen so that microorganisms were in aerobic condition. After the biological treatment, canteen wastewater was flowed into the sedimentation tank to precipitate the microbial flocs or sludge produced during the oxidation process. Some sludge in the sedimentation tank was recycled and put into the aerobic reactor. Meanwhile, effluent wastewater flowed to the effluent tank and wastewater characteristics were then analyzed.

3.2 The Seeding and Acclimatization Process

The first process in this study was the seeding and acclimatization process. The seeding or microorganisms growth was done naturally by continuously flowing canteen wastewater into the aerobic reactor using activated sludge added bioballs and also to the activated sludge, as a control. This process forms a biofilm layer attached to bioballs media [5] in the activated sludge added bioballs. Whereas, in the control activated sludge, suspended microorganisms were developed.

The acclimatization process aims to adapt microorganisms in the reactor to the original wastewater conditions. The seeding and acclimatization process was carried out in the aerobic reactor using activated sludge added bioballs, while aerobic reactors using activated sludge were only carried out in the acclimatization process. It was done because the activated sludge was obtained from the wastewater treatment plant in this industry that already contained suspended microorganisms.

This seeding and acclimatization process runs for 15 days with a hydraulic retention time of 48 hours. The end of the acclimatization process can be known from the condition of microorganisms. The growth of microorganisms can be seen visually in which the surface of the bioballs was covered with a biofilms layer [10]. Furthermore, the condition of microorganisms can be quantitatively known from the MLVSS concentration and the removal efficiency of COD.

The MLVSS concentration shows the amount of organic material in the form of living or dead microbes, and cell destruction [11]. Good microorganisms conditions can be known from the increasing MLVSS concentration. The MLVSS concentration from day 0 to day 15 was 585 mg/L and increased to become 1,120 mg/L for aerobic reactors using activated sludge and was 380 mg/L and increased to become 1,065 mg/L for activated reactors sludge added bioballs. It indicated that microorganisms started to breed and grow and were able to adapt to aerobic reactors. As a result, decomposition of pollutant compounds present in canteen wastewater was occurred in both reactors.

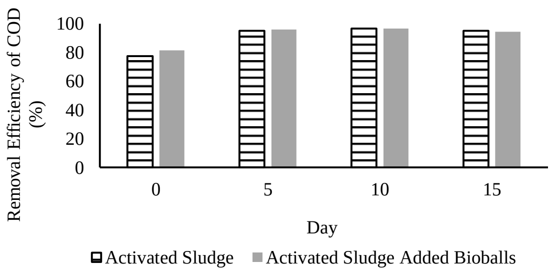

Figure 2 Removal Efficiency during Seeding and Acclimatization Process

The COD parameter was also analyzed during the acclimatization process. The acclimatization process was stopped when the removal efficiency of COD was stable with fluctuations of no more than 10% [12], and the removal efficiency of COD reached 80% [13]. Figure 2 showed removal efficiency of COD on day 0, 5, 10, 15 were 77.41%, 94.94%, 96.54%, 95.08% in the aerobic reactor using activated sludge and 81.48%, 95.93%, 96.05%, 94.41% in the aerobic reactor using activated sludge added bioballs. Based on the data, the removal efficiency of COD on the 15th day was relatively stable with a slight decrease. The stable COD concentration indicated that the microorganisms could adapt well, and the aerobic reactor's condition was stable so that the main experiments could, therefore, begin.

3.3 The Main Experiments

The main experiments were biologically treating canteen wastewater. The observation data listed in Table 1 showed the influent wastewater characteristics derived from the canteen activities of this industry. Canteen wastewater contains materials that are easily decomposed. The characteristics of canteen wastewater measured were COD, BOD, TSS, and pH. Compared to the Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 about the Quality Standard of Domestic Water, it was known that the concentrations of COD, BOD, and TSS exceeded the standard limit of wastewater quality that can be discharged into water bodies while the value of pH was still in the allowable range. Therefore, it was necessary to treat the canteen wastewater.

Tabel 1. The Characteristics of Influent Canteen Wastewater

Parameter	Concentration	Quality Standard*
COD (mg/L)	564	100
BOD (mg/L)	214.32	30
TSS (mg/L)	109	30
pH	6.89	6-9

*) Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 about the Quality Standard of Domestic Water

The main experiments were operated continuously with a hydraulic retention time of 24 hours. The debit of wastewater was determined by dividing the active volumes of the aerobic reactor by hydraulic retention time. The influent debit in this study was 1.04 liters/hour. During the running process, the decomposition of pollutant compounds was occurred in which microorganisms utilized organic compounds for their body metabolism. Table 2 showed the characteristics of effluent wastewater resulting from the biological treatment systems. Based on Table 2, it can be seen that the biological wastewater treatment systems could reduce the BOD, COD, and TSS concentrations of canteen wastewater.

The concentration of COD indicated the amount of oxygen needed to chemically decompose the organic matter with $K_2Cr_2O_7$ as the source of oxygen. The removal efficiency of COD showed a good result as 93.44% for the aerobic reactor using activated sludge and 89.36% for the aerobic reactor using activated sludge added bioballs. The results showed that the COD concentrations had met the quality standards according to the Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 about Quality Standard of Domestic Water, in which the quality standard allowed for the COD concentration is 100 mg/L. However, the addition of bioballs has not affected the performance of the reactor during this period at a hydraulic retention time of 24 hours.

Table 2. The Characteristics of Effluent Wastewater

Parameter		Activated Sludge	Activated Sludge Added Bioballs	Quality Standard*
COD	Concentration (mg/L)	37	60	100
	Efficiency (%)	93.44	89.36	
BOD	Concentra-tion (mg/L)	14.06	22.8	30
	Efficiency (%)	93.44	89.36	
TSS	Concentration (mg/L)	8	18	30
	Efficiency (%)	92.66	83.49	
pH	Value	8.10	8.21	6-9

*) Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 about the Quality Standard of Domestic Water

The same results were obtained in the removal efficiency of BOD and TSS. The removal efficiency of BOD for the aerobic reactor using activated sludge and aerobic reactor using activated sludge added bioballs were 93.44% and 89.36%, respectively. Furthermore, the removal efficiency of TSS for aerobic reactor using activated sludge and aerobic reactor using activated sludge added bioballs were 92.66% and 83.49%, respectively. Both BOD and TSS concentrations were below the maximum quality standards limit.

The pH value affects the growth of microorganisms in the aerobic reactors. Based on the Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 about the Quality Standard of Domestic Water, the range of the pH value for wastewater is 6-9. In this study, the pH value was 8.10 in the aerobic reactor using activated sludge and 8.21 in the aerobic reactor using activated sludge added bioballs. Thus, the pH value was still below the quality standard. However, the pH value deviated considerably from its optimum pH value. In general, the optimum pH value for the growth of the microorganisms in the aerobic condition is about 6.5-7.5 [6]. The deviation will affects the quality of pollutants removal in wastewater. Between the two reactors, the aerobic reactors using activated sludge added bioballs have a deviation of pH value against optimum pH greater than that of the aerobic reactor using activated sludge. So that, it was one of the causes of removal efficiencies of COD, BOD, and TSS for aerobic reactor using activated sludge added bioballs were lower than those resulting from the aerobic reactor using activated sludge.

4. CONCLUSION

Canteen wastewater can be treated by the aerobic reactors using activated sludge and activated sludge added bioballs. The removal efficiencies of COD, BOD, and TSS were 93.44%, 93.44%, and 92.66%, respectively in the activated sludge. In the activated sludge added bioballs, the removal efficiencies of COD, BOD, and TSS were 89.36%, 89.36%, and 83.49%, respectively. The COD, BOD, TSS concentrations, and pH value of effluent wastewater have met the quality standard according to the Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 about the Quality Standard of Domestic Water. However, canteen wastewater treated by the aerobic reactor using activated sludge added bioballs resulted in lower removal efficiencies than those resulting from the aerobic reactor using activated sludge. This may be due to greater pH deviation in activated sludge added bioballs during operation.

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