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Seeding and Acclimatization for Aerobic Processing of Restaurant Wastewater with Sequencing Batch Reactor

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A B S T R A C T

Restaurant wastewater has a relatively high organic matter content, so it needs to be treated to meet the specified quality standard. One of the technologies that can be used in restaurant wastewater treatment is Sequencing Batch Reactor (SBR) technology. The purpose of this study is to set up an aerobic SBR system with seeding and acclimatization treatments to reduce the amount of organic matter in restaurant wastewater when a shock load occurs. The research was done using wastewater from a restaurant in Bandung and activated sludge from the food industry in Bogor as seeds for microorganisms. In this study, the seeding process was carried out by introducing 25% activated sludge and 75% nutrients into the reactor, and the acclimatization process was carried out by introducing a specific ratio of nutrients and wastewater into the reactor gradually until the waste concentration reached 100%. The parameters tested were COD, MLVSS, DO, pH, and temperature. During the seeding procedure, the initial COD value of 3,200 mg/L declined. It began to stabilize on the seventh day, with a COD value of 1,080 mg/L. The COD removal reached a relatively stable condition in the acclimatization process starting on day 2, where COD decreased from the original 1,280 mg/L to 480 mg/L.

INTRODUCTION

The restaurant business is overgrowing in Indonesia, along with the many requests by people who want fast, practical, and varied food service services [1]. This results in increasing wastewater from washing food equipment and food scraps, washing food processing, and other waste from bathrooms and latrines [2].

Wastewater originating from this restaurant business is classified as domestic wastewater consisting of several parameters, including biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), pH, and oil and grease content [3]. Restaurant wastewater has a high organic matter content which microorganisms can degrade, so when discharged into water bodies, it will increase the population of microorganisms and BOD levels [4]. The activity of these microorganisms causes the availability of oxygen in the aquatic environment to decrease and can lead to the death of living things in it [5]. Therefore, it is necessary to do waste treatment first to minimize the impact of pollution on the environment. Treating wastewater with a high content of organic compounds generally uses the activity of microorganisms to decompose these organic pollutant compounds [6].

Sequencing Batch Reactor (SBR) is a technology that can be used in restaurant wastewater treatment because it has a high level of efficiency for degrading organic compounds [7]. In addition, the Sequencing Batch Reactor (SBR) is classified as an efficient technology for wastewater treatment because of its simple configuration [8]. SBR technology, a wastewater treatment system with suspended microorganisms but operated sequentially, is a development of a conventional activated sludge system [9]. The SBR operating cycle, which includes filling, aeration, settling, and effluent discharge, occurs in the same reactor, making wastewater treatment with SBR economical [10]. In addition, the

Sequencing Batch Reactor (SBR) can operate in a narrow area, so it does not require a spacious place [11]. The aerobic SBR operating cycle, which consists of five process steps, is shown in **Figure 1** [12].

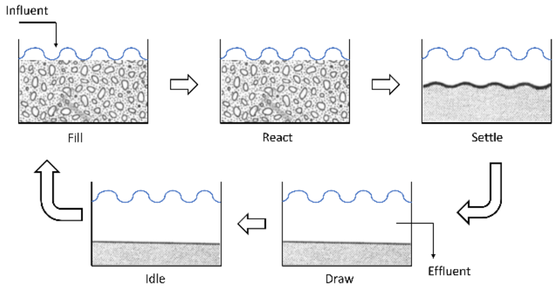

Figure 1. SBR Cycle

In a wastewater treatment plant, organic and hydraulic shock loads can occur. The hydraulic shock load is related to the Hydraulic Retention Time (HRT) parameter, which is the duration the consortium of microorganisms exists in the reactor. As for the organic shock load in the restaurant wastewater treatment plant can occur due to increased restaurant business production, the organic content in the resulting waste will also increase. Therefore, wastewater treatment technology that can handle shock loading is needed.

Based on Purwita and Soewondo [13], the SBR system can handle shock loads due to flow and load fluctuations of wastewater. Therefore, this study will carry out aerobic treatment using SBR with variations in wastewater load. The aerobic SBR method was chosen because of its more straightforward process, especially in maintaining operating conditions.

An essential factor before operating SBR to treat wastewater is the preparation of microorganism seeds carried out during the seeding and acclimatization process. Seeding is done to breed microorganisms that degrade organic compounds in restaurant wastewater. The acclimatization aims so that the microorganisms resulting from seeding can adapt to restaurant wastewater so that the operating process can run effectively and efficiently later. Therefore, in this research, seeding and acclimatization processes were carried out to obtain microorganisms capable of processing restaurant wastewater using a Sequencing Batch Reactor (SBR).

In this study, the COD parameter was tested to see contaminants which are organic and inorganic compounds in restaurant wastewater. The COD parameter was chosen in this study because it includes pollutant content in the form of organic matter and inorganic nutrients, such as ammonia or nitrate in water.

METHODS

This research was conducted at the Industrial Waste Management Laboratory, Chemical Engineering Department of Politeknik Negeri Bandung. The study was carried out in two phases: the preparation and the nursery phases (seeding and acclimatization).

In the preparation stage, the Sequencing Batch Reactor (SBR) was prepared, a laboratory-scale reactor with a maximum capacity of 5 L equipped with an aerator and agitator. The SBR system consists of a feed tank, a pump to drain the waste, and an aerobic reactor equipped with valves for aeration, effluent removal, and sludge removal. The feed tank is used as a reservoir for wastewater feed using a beaker to facilitate reading the volume when entering the influent into the reactor. The aerator hose is connected to two aerator stones inside the reactor. Before the reactor is used, a leak test is carried out by flowing water to all parts of the reactor. The schematic of the tool is shown in **Figure 2**.

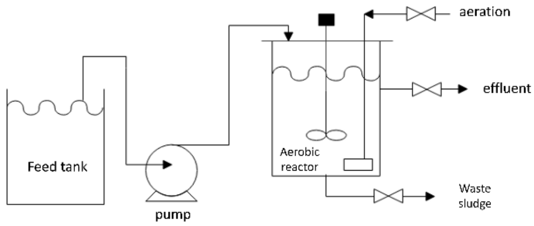

Figure 2. SBR equipment scheme

In addition, wastewater preparation was carried out where the restaurant's wastewater used taken from one of the restaurants in Bandung. This research requires 5 liters of restaurant wastewater. The waste is used as an influent substrate in biological processing during the study. Before processing, the COD, pH, and turbidity values were checked first.

Activated sludge as a source of microorganisms in this study was taken from the food industry in Bogor. The volume of activated sludge used was 1 L. Before the study, the COD and pH parameters were analysed to determine the condition of the activated sludge used.

At the seeding stage, nutrients are added to microorganisms with a C:N:P ratio of 100:5:1 [14]. The nutrients used were glucose as a carbon source, KNO_3 as a nitrogen source, and KH_2PO_4 as a phosphorus source. The sludge's darker color indicates biomass growth [15]. The concentration of nutrients fed into the SBR is 400 mg/L. The seeding stage was carried out until the MLVSS parameter increased, indicating that the microorganism had grown well. Dissolved oxygen or DO concentration is maintained above two mg/L, and consistent stirring speed is carried out at 140 rpm.

As for the acclimatization stage, feed is given with a ratio of wastewater and nutrients of 30:70, 50:50, 60:40; 80:20, and 100:0. Acclimatization was completed when COD experienced a relatively stable decrease, and MLVSS increased. The ratio of wastewater and nutrients fed during the acclimatization stage is 1,000 mg/L.

RESULT AND DISCUSSION

Wastewater Characteristics

This study uses the primary materials, restaurant wastewater and microorganisms in the form of activated sludge. The primary materials used have the following characteristics.

Table 1. Raw Material Characteristics

Raw Material	COD (mg/L)	pH	Turbidity
Restaurant Wastewater	9,000	3,24	67,8
Activated Sludge	3,200	6,64	-

Based on these characteristic tests, the COD value in restaurant wastewater was 9,000 mg/L. The COD value of the restaurant wastewater used in this study is greater than that of the restaurant wastewater tested by Ariani et al. [16], where a COD value of 1,241.44 mg/L was obtained. Both COD values exceed the allowable COD threshold of 100 mg/L. Based on the initial COD test results, where the COD value was immense, dilution was carried out to obtain concentrations of 1,000 mg/L and 2,000 mg/L for use in this study. Restaurant wastewater that has been diluted is then stored in a refrigerator to maintain the stability of the value of its organic compound content.

Wastewater Treatment Process in Sequencing Batch Reactor

Wastewater treatment using Aerobic Sequencing Batch Reactor has the principle of filling influent and removing effluent from the reactor [17]. The influent in this study was in the form of restaurant wastewater. The effluent was supernatant or processed restaurant wastewater from the degradation process of organic compounds contained in restaurant wastewater using activated sludge media. The organic loading decreased continuously in the SBR reactor during the react phase, where the aeration and mixing ran and increased the biological treatment [18]. Then, the phase continued to the settle phase, where the entire reactor tank acted as a batch clarifier without any inflow or outflow [19].

The total time needed in one processing cycle using SBR is 24 hours. In addition to the time in the process, operating conditions must also be maintained during the research to optimize the processing. These working conditions include a pH range of 6 – 8, Dissolved Oxygen (DO) above one mg/L, and a temperature of ±25°C. Data on operating conditions during the study are shown in **Table 2**.

Seeding

Seeding is carried out by feeding 25% activated sludge and 75% nutrients into the reactor. The nutrients provided were glucose as a carbon source, KNO_3 as a nitrogen source, and KH_2PO_4 as a phosphorus source with a C:N:P ratio of 100:5:1. The nutrient is given gradually every day during the seeding process.

The seeding process was carried out for 13 days by providing 375 mL/day of nutrients into the reactor. During seeding, an aeration process is carried out to provide an oxygen supply to the reactor through an aerator. The aeration is done to meet the needs of the growth of aerobic microorganisms. The parameters COD, MLVSS, pH, DO, turbidity, and temperature were tested in this process. The test results are used to evaluate the success of the seeding process.

The pH range in the seeding process was 7.26 – 8.65, with an average of 8.28. As for DO, values range from 4.5 – 9.5, averaging 7.9. The DO concentration is sufficient to meet the oxygen demand of aerobic microorganisms. According to the aerobic processing criteria, the temperature is 23 – 27°C. The temperature data was only obtained until the 9th day because the test was not carried out on the next day's sample due to tool constraints. The temperature ranges from 24.9 – 26°C with an average of 25.4°C. This value follows the criteria for aerobic processing, so special treatment is not carried out.

Table 2. Operating Conditions

Parameter	Process	Value	Average
pH	*Seeding*	7.26 – 8.65	8.28
	Acclimatization	8.6 – 9.4	8.9
Dissolved Oxygen/DO (mg/L)	*Seeding*	4.5 – 9.5	7.9
	Acclimatization	8 – 8.8	8.36
Temperature (°C)	*Seeding*	24.9 – 26	25.38
	Acclimatization	25.2 – 28.3	27.15

The following measured parameters are MLVSS and COD. MLVSS is an approach value to determine the concentration of microorganisms degrading organic compounds. The MLVSS value during the seeding process is shown in **Figure 3.**

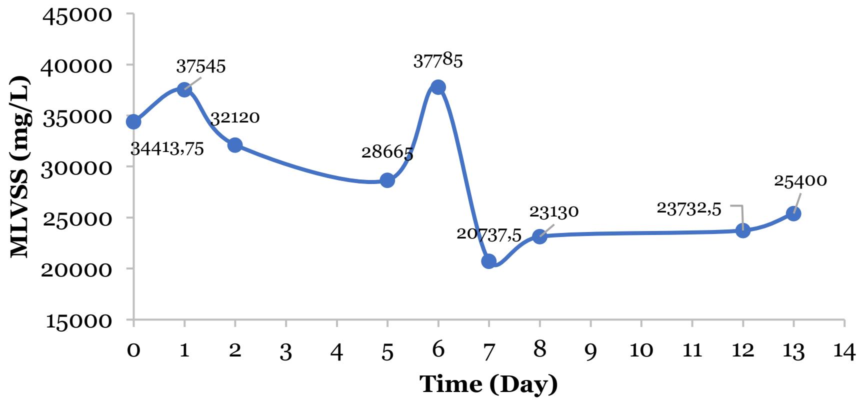

Figure 3. MLVSS During Seeding

Based on **Figure 3**, the MLVSS value at the beginning of the seeding process was unstable and quite fluctuating and tended to decrease until the 7th day. This phenomenon is because microorganisms are still adapting to the nutrient intake provided. However, after the 7th day, the MLVSS value experienced a steady increase, where the MLVSS value, which was initially 0,737.5 mg/L, increased to 25,400 mg/L on the 13th day of measurement. This result is consistent with what was reported by Budiastuti et al. [15], where an increase in the MLVSS value indicates an increase in the number of microorganisms caused by providing adequate nutrients so that the microorganisms begin to grow properly.

COD is the amount of oxygen needed to degrade organic compounds in wastewater. Therefore, the COD value indicates the number of contaminants in wastewater. The following is the COD value curve during the seeding process. Based on **Figure 4,** the COD value during seeding decreased at the beginning of the process and was then relatively stable at a concentration of 1,080 mg/L starting from the 7th day. According to Semarta et al. [20], the seeding process can be stopped when the COD value is relatively stable and fluctuates around 10%.

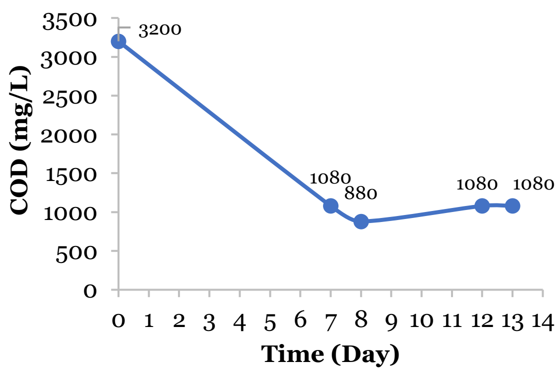

Figure 4. COD During Seeding

The MLVSS values tend to increase, and the COD value also shows stability, starting from the seventh day until the 13th day of measurement. Based on these results, it can be said that the seeding process has been going well so that it can proceed to the acclimatization process.

Acclimatization

Acclimatization is a process that aims to give time for microorganisms to adapt to a new environment [21] or - in this case, restaurant wastewater. The acclimatization is carried out by providing feed in the form of a mixture of nutrients and wastewater in a particular ratio, gradually, starting from the lowest wastewater concentration and then increasing continuously until the wastewater concentration is 100%. This study follows that of Budiastuti et al. [15], where the concentration of nutrients decreases gradually, for microorganisms in the reactor do not experience shock loading, resulting in the suboptimal performance of the SBR reactor. The proportion of wastewater and nutrients used is set up from 30:70, 50:50, 60:40, 80:20, and 100:0. The feed concentration given is 1,000 mg/L, and the feed volume is 375 ml. To maintain the operative volume of the reactor, when the influent is fed, the effluent is removed first with the same volume as the influent. The active volume of the reactor was 4 L. The parameters checked at the acclimatization stage were pH, temperature, DO, MLVSS, and COD.

The pH of the reactor during the acclimatization process was in the range of 8.6-9.4, with an average pH of 8.9. To maintain the operating conditions of the reactor, the pH was corrected using concentrated H2SO4 once on the 14th day. The temperature parameters during acclimatization are within the range of 28.3-25.2°C with an average temperature of 27.15°C. The reactor temperature was maintained at room temperature. Dissolved oxygen levels are within the length of 8-8.8 mg/L, with an average of 8.36 mg/L.

The parameter for the success of the acclimatization process is when the COD removal has reached a relatively stable condition with changes in the feed ratio [22]. Effluent COD during acclimatization is shown in **Figure 5**.

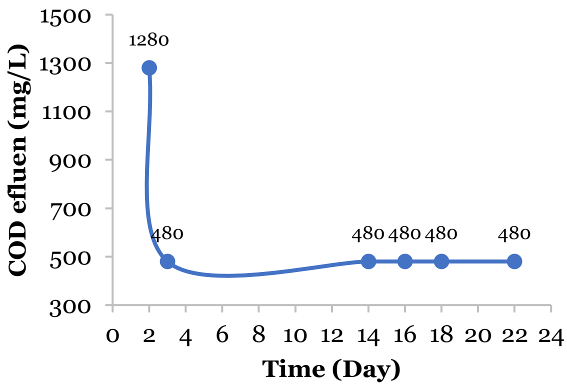

Figure 5. COD During Acclimatization

Based on **Figure 5**, the effluent COD value has decreased, and the condition tends to be stable from the third day to the last day (22nd) when the feed supplied is 100% wastewater. The COD value at first 1,280 mg/L decreased to 480 mg/L on the third day at the acclimatization stage. At the same time, the MLVSS value tended to increase even though it had reduced on the 18th day. The MLVSS value rose again until it peaked on the 22nd day, as shown in **Figure 6**. This fluctuating phenomenon fits with the result from Budiastuti et al. [15], which indicated that microorganisms are still adapting to restaurant wastewater.

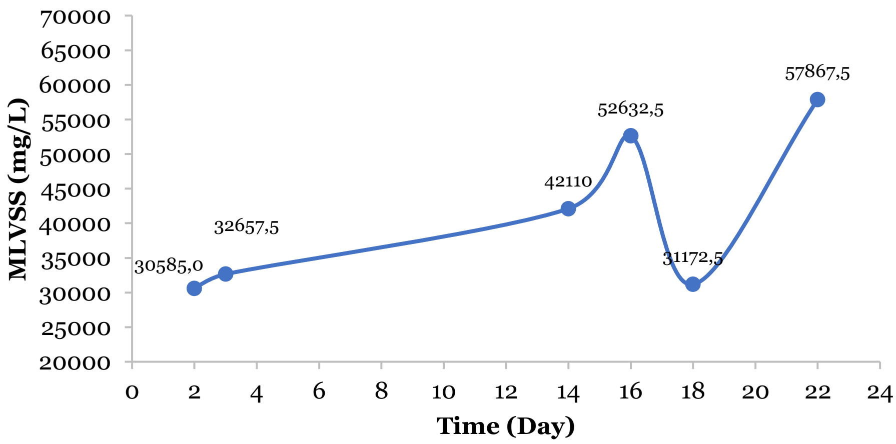

Figure 6. MLVSS During Acclimatization

The lowest MLVSS value was found on the first day at 30,585 mg/L, and the highest measure was on the 22nd or last day, which was 57,867.5 mg/L. The increase in MLVSS and the decrease in COD indicate that the acclimatization process has been completed and can be continued to the following stage: the SBR operation under regular and shock loading.

CONCLUSION

This study set up an aerobic SBR system through seeding and acclimatization to treat restaurant wastewater when shock loads occur. In the seeding process, the initial COD value of 3,200 mg/L declined and began to stabilize on the seventh day, with a COD value of 1,080 mg/L, indicating that the microorganisms had grown well. As for the acclimatization, the COD removal reached a relatively stable condition starting on day 2, where COD decreased from the original 1,280 mg/L to 480 mg/L, indicating that the microorganisms can adapt to new environmental needs. Based on the results of these two processes, the SBR aerobic system is ready to treat restaurant wastewater under regular and shock loads.

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