The effect of time and velocity variation in sequencing batches reactor on cod and bod, removal efficiency in tofu waste

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Abstract. The tofu industry produces liquid waste that can cause pollution if it is not processed first. Tofu liquid waste has the characteristics of containing high organic matter such as BOD and COD so that if it has directly discharged into the environment, it will reduce the carrying capacity of the environment. The purpose of this study was to determine and analyse the effect of variations in times and velocity of sequence batch reactor on the optimization of COD and BOD removal in tofu industrial wastewater by anaerobic bacteria originating from natural sediments. The method used is an experimental method where the method is to find the effect on other things controlled by using artificial waste. The removal of COD and BOD in tofu industrial wastewater can be done by biological treatment process with attached growth using Sequencing Batch Reactor. The reactor inoculated by the septic tank sediment was fed with artificial waste containing a concentration of COD of 7,000 mg/l and BOD of 2,000 mg/l. For 35 days, this reactor will be operated in batches. Results showed a decrease in BOD and COD parameters using a sequencing batch reactor with BOD concentration 176 mg/l and COD concentration 570 mg/l.

1. Introduction

Tofu is a traditional food favoured by almost all levels of society in Indonesia. Tofu contains good nutrition and is rich in protein coupled with a delicious taste, and the price is affordable by all levels of society. The description above has encouraged the rapid growth of the tofu industry in Indonesia. However, most of the industrial locations that are integrated with residential areas have an impact on the surrounding environment. Tofu production in Indonesia is mainly carried out by people belonging to the lower middle class. Tofu production is still done traditionally, so it is often found that there is no tofu waste treatment for household producers. Generally, tofu producers do not process tofu waste due to the high cost and lack of knowledge in waste management [1].

The tofu industry produces liquid waste, which can cause pollution if it is not processed first. The liquid tofu waste is produced from the washing, boiling, pressing and printing process of tofu. Therefore, the liquid waste produced is very high. The characteristics of tofu wastewater include temperature, colour, odour, turbidity, BOD, COD, and pH [2]. Liquid waste disposal from tofu production have BOD of 6,000-8,000 mg/l and COD of 7,500-8,400 mg/l [3].

The most affordable and the simpler processing alternative of liquid tofu wastes is by biological process [4]. Biological wastewater treatment is a treatment method directed at reducing or eliminating specific substrates contained in wastewater by utilizing the activity of microorganisms to remodel
specific substrates. The biological wastewater treatment process can take place in two primary conditions, namely aerobic and anaerobic.

With an anaerobic biological process, the processing efficiency is only around 70%-80%, so that the water still contains a relatively high level of organic pollutants, and the odour is still generated so that this causes problems [5]. Sequencing Batch Reactor (SBR) is a wastewater treatment method that is much easier to operate in the food industry and can treat large quantities of wastewater. The working principle of SBR is filling, reacting, settling and separating, removing, stabilizing [6]. The use of SBR can save costs by more than 60% compared to conventional activated sludge processes [7]. This study will examine the removal of COD and BOD in tofu wastewater using the artificial waste method in the presence of treatment using oxidizing bacteria from a septic tank with variations in the velocity of artificial tofu wastewater where the effects, parameters and impacts will be analysed. This study used bacteria from a septic tank, and the processing was carried out using a batch reactor using variations in velocity; 100 rpm and 140 rpm. The speed used is trial and error and allowed to form sedimentation so that it can be seen how effective this batch reactor is in reducing BOD and COD levels in tofu waste, its relation to developing waste treatment technology that is cheap, fast and easy to operate and has no environmental impact after processing it.

2. Methodology
This research was conducted on a scale of laboratory, which will then be used on a larger scale. Miniature processing with this SBR is operated to get the efficiency of reducing BOD and COD and the relevancy between these two parameters with variations in time and velocity. The liquid waste used in this study is artificial. Waste characteristics used in this study is the characteristics of liquid tofu waste from some household-scale factories in Semarang. The independent variable is the concentration of the mixing process in the batch reactor, 100 ppm and 140 ppm, and the sedimentation time is 4 hours. The dependent variable in this study is the levels of BOD and COD. The control variables are the initial COD concentration and the initial BOD concentration, with the pH and temperature constant. This research will be carried out for 35 days by operating the reactor in batches. Parameters tested are COD and BOD. The source of the microorganisms tested came from a septic tank in one of the settlements in the Tembalang area. The primary raw materials for this research is small household scale tofu waste (1 L), then artificial waste. The supporting raw materials in the research is:

1. BOD analysis using Winkler titration.
   Phosphate buffer (KH2PO4, K2HPO4, Na2HPO4 .7 H2O, NH4Cl), manganese sulphate solution (MnSO4), alkaline iodide solution (NaOH, KI, NaN3), H2SO4 concentrated, sodium thiosulfate solution (Na2S2O3 5 H2O), and starch indicator.

2. COD analysis.
   K2Cr2O7, H2SO4, HgSO4(aq), Ag2SO4(aq), and Aquadest.

Meanwhile, the equipment includes a self-assembled batch sequencing reactor, COD (spectroquant) heating device, BOD incubator, and pH meter.

Preliminary research is intended to determine the characteristics of tofu waste. The characteristics studied were BOD, COD, pH, temperature and DO. The primary research was intended to find the best variation of mixing velocity variation in reducing the levels of BOD and COD contained in tofu waste. Primary data is the results of measurements of BOD and COD before and after processing. Secondary data includes general data and the results of interviews with tofu industry owners. Data collection was obtained from the results of interviews and laboratory examinations.

Tofu wastewater treatment begins with making artificial waste that suits the expected test results in the preliminary test. Before being sent to the SBR treatment tank, the artificial waste must be at a temperature of 25°C and a pH range of 6-8. The suitable artificial waste is then put into the reactor for the mixing process in 3 hours with the variation velocity used is 100 rpm and 140 rpm. After mixing, sedimentation will be carried out for 4 hours. The parameters measured for the treatment of tofu
wastewater using the SBR method are measurements of BOD and COD for measuring the initial and final values of processing with SBR. Here is the framework of this research:

- **Biological treatment is a more profitable treatment by cultivating microorganisms to remove the high content of COD and BOD.**
- **The removal of COD and BOD was carried out using a batch reactor and then adding variations in speed to the artificial waste.**
- **The effect of speed variations in artificial waste on the removal of COD and BOD in the batch reactor will be analyzed.**

**Research Preparation.**
1. Create Artificial Waste
2. Assemble the batch reactor
3. The COD and BOD removal process uses a batch reactor with speed variation
4. The process of sedimentation after mixing process in the batch reactor
5. Measurement of COD and BOD.

**Figure 1.** Framework of the research.

### 3. Results and discussion
This study has three stages: identifying the characteristics of tofu waste, making artificial liquid waste, and then the running stage.

**Table 1.** Test results of tofu waste characteristics.

| No. | Parameter | Unit | Concentration | Maximum Rate* | Explanation                    |
|-----|-----------|------|---------------|---------------|--------------------------------|
| 1   | COD       | mg/l | 7,000         | 100           | It does not meet the quality standard |
| 2   | BOD       | mg/l | 2,000         | 10            | It does not meet the quality standard |
| 3   | pH        | -    | 5.37          | 6.9           | It does not meet the quality standard |
| 4   | Suhu      | °C   | 58.4          | -             | -                              |
| 5   | DO        | mg/l | 1.03          | -             | -                              |
| 6   | TSS       | mg/l | 2910          | 200           | It does not meet the quality standard |

*) Decree of the State Minister of the Environment No KEP-51/MENLH/10/1995

The materials used to make artificial waste are aqua dest, kaolin and glucose. In this study, it was carried out with the same time and 2 variations of speed. Meanwhile, for the acclimatization process, two artificial concentrations of the same were made. Concentration is made with a ratio of 100% of the concentration of the original waste. Then in the final stage, which can be called the running stage, it uses a concentration variation of 100% of the original waste.
Table 2. Variation of 100% bod and cod parameter concentrations.

| Reactor | Speed (rpm) | Time (Hour) | Concentration |
|---------|-------------|-------------|---------------|
|         |             |             | BOD (mg/L)    | COD (mg/L)   |
| Reactor 1 | 100         | 4           | 194.27        | 626.67       |
| Reactor 2 | 140         | 4           | 176.70        | 570          |

Figure 2. Graph of bod and cod removal at the 4th hour.

The graph above shows the removal of BOD and COD concentrations at the 4th Hour at the running stage with different speed variations. In Reactor 1, the speed used was 100 rpm for 4 hours, which resulted in a BOD concentration of 194.27 mg/L and a COD concentration of 626.67 mg/L. Meanwhile, in Reactor 2, using a speed variation of 140 rpm, the BOD concentration is 176.7 mg/L, and the COD concentration is 570 mg/L.

3.1. Effect of Speed Variation
The results showed that the COD removal efficiency at a COD concentration of 7,000 mg/L of 91.85% was 176.7 mg/L. These numbers show that the results of this study using Sequencing Batch Reactor can reduce COD by 91.85% with a speed of 140 rpm.

The calculation of the removal efficiency for the COD concentration can be seen as follows:

Initial COD concentration : 7,000 mg/L
Final COD concentration : 570 mg/L
Removal efficiency % : \( \frac{7000 - 570}{7000} \times 100\% = 91.85\% \)

Meanwhile, the initial BOD concentration was 2,000 mg/L to 176.7 mg/L, so the removal efficiency was 91.11%. So from this figure, it is stated that the use of a Sequencing Batch Reactor can significantly reduce BOD and COD.

Initial BOD concentration : 2,000 mg/L
Final BOD concentration : 176.7 mg/L
Removal efficiency % : \( \frac{2000 - 176.7}{2000} \times 100\% = 91.11\% \)

4. Conclusion
BOD and COD contained in the tofu waste process must be treated before being discharged to the water's surface. The allowance for BOD and COD values can be made using a biological process. The technology that can be used is the Sequence Batch Reactor. The results showed that the Sequence Batch Reactor could reduce the COD value by 91.85% from the initial COD value of 7000 mg/l to 570 mg/l. It also occurs in the BOD parameter. The sequence batch reactor can set the initial BOD value of 2,000 mg/l to 176.7 mg/l with a removal efficiency of 91.11%. From the research, it is known that the
BOD and COD values have not met the specified quality standards. The BOD value is still at 176.7 with a quality standard of 10, while the COD value is 570 mg/l with 100 mg/l.

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