Biogas production from tofu wastewater substrate using HUASB reactors with addition of trace metal

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Abstract. Tofu liquid waste contains a high organic load so that the processing system is needed to reduce the pollutant parameters in the wastewater to fulfill the quality standards. The most suitable treatment for organic loads is anaerobic processing. One anaerobic processing system uses the Hybrid Upflow Anaerobic Sludge Blanket (HUASB) reactor with the consideration that this reactor has the advantage of maintaining high amounts of biomass concentrations, high load rates for operation, good deposition capability, and good solid-liquid separation due to appropriate granulation. The purpose of this study was to determine the effect of adding trace metal FeCl3 to the removal of COD, TSS and biogas production on tofu wastewater treatment at the HUASB reactor. The process of tofu wastewater treatment with the addition of trace metal in the HUASB reactor using a batch circulation system with a reactor volume of 9 liters. The reactor is operated by variations in the concentration of tofu wastewater (75 and 100%) and trace metal concentrations (0.3-0.6 mg/L). The parameters observed in this study were pH, COD, TSS, and biogas produced. The results showed that the optimum biogas production of 8.190 mL at the concentration of tofu wastewater was 75% with the concentration of trace metal 0.6 mg/L and allowance for COD and TSS of 94.09% and 94.02%.

1. Introduction

The tofu industry is one of the fastest growing industries in Indonesia and spread throughout Indonesia from around 84,000 tofu industries [1]. Most of the wastewater produced by the tofu manufacturing industry is viscous liquid which is separate from tofu called whey. This liquid contains high levels of protein, and can decompose immediately. This liquid waste is often discharged directly into the river body without treatment. Characteristics of tofu liquid waste contain high organic content and have a degree of acidity (pH) 3-4. The condition of tofu industry wastewater is one source of pollution if the waste water produced is immediately disposed of without being treated before being discharged into a water body. The right process for treating wastewater from tofu industries is an anaerobic process, because the mechanism of anaerobic processes will reduce the high organic charge complex into a simple compound form. Anaerobic processes have been proven to be processes that are capable of treating industrial wastewater
containing high organic loads. The processing method is inexpensive because it requires low energy, low sludge production and produces reusable energy [2, 3, 4].

Anaerobic processing consists of suspended, attached and hybrid growth. Anaerobic treatment with a hybrid system has the advantage of a microorganism growth system using a fixed and suspended system. One of the anaerobic process reactors that uses a hybrid system is the Hybrid Upflow Anaerobic Sludge Blanket (HUASB) reactor. The HUASB reactor is an improved version of a system that combines with a fixed film reactor [5, 6]. The UASB reactor has a commercial advantage and the effluent can fulfill the standard regulation of the Indonesian government. The UASB reactor is capable of operating at very high load rates with sludge produced easily settled, high biomass concentrations and separate solid and liquid are very good [7]. The HUASB reactor has been used in the research of tofu wastewater using PVC and Bioball as attached system which resulted in the highest COD removal of 86.41% and 85.57% and produce biogas 7.700 mL and 1.510 mL on 24 hour HRT during the acclimatization process [8, 9].

Anaerobic processing uses microorganisms to decompose organic loads, where microorganisms have a very important role in decomposing wastewater. The purpose of this study is to evaluate the addition of FeCl₃ in tofu wastewater treatment using a HUASB reactor with bioball as attached media. The addition of trace metal FeCl₃ as a nutrient source is expected to increase the growth of microorganisms so that biogas production and pollutant removal increase [10]. Trace metal is a component of an enzyme, a bacterial nucleic acid and important for the synthesis of vitamin. The role of trace metals such as Fe is well known, while for each need in wastewater treatment it needs to be clarified. Addition of Trace metal not only prevents process inhibition, but also can increase performance of reactor where can increase higher methane production [10].

2. Method

2.1 Experimental apparatus

Experimental equipment has been designed and developed as shown in Figure 1 [5]. The HUASB reactor has two growth media, namely the attached and suspended media, on the attached growth media using bioball media. The gas that has been produced is separated in the GLSS and accommodated in the biogas collector, then liquid and solids are collected in the clarifier.

![Figure 1. Reactor of hybrid upflow anaerobic sludge blanket-HUASB.](image-url)
2.2 Analytical methods
HUASB reactor was monitored daily, such as pH, gas production, COD and TSS, which were all determined based by American Public Health Association (APHA)[11, 13].

Table 1. Characteristics of tofu wastewater.

| No | Parameter | Value (mg/L) |
|----|-----------|--------------|
| 1  | pH        | 3 – 4        |
| 2  | COD       | 6920         |
| 3  | TSS       | 3640         |

Table 2. Quality standards of wastewater.

| No | Parameter | Value |
|----|-----------|-------|
| 1  | pH        | 6 – 9 |
| 2  | COD       | 300 (mg/L) |
| 3  | TSS       | 200 (mg/L) |

3. Results and discussion
The results will be discussed, namely the Effect of Increased Tofu Liquid Waste Concentration on Biogas Production and the Effect of Addition of Trace Metal to Biogas Production.
3.1. Effect of increasing the concentration of tofu liquid waste on biogas production

The tofu wastewater treatment process is carried out by providing nutrients in stages with 2 variations of tofu wastewater concentration from the lowest, namely 75-100% and 4 variations in the concentration of trace metal 0.3-0.6 mg / L. Processing of liquid waste in the reactor is operated at mesophilic temperatures (27 °C - 35 °C). Based on the figure 2, biogas production obtained the optimum point at the concentration of 75% tofu wastewater with a concentration of trace metal 0.6 mg / L where the maximum biogas production was 8.190 mL and the allowance for COD and TSS was 92.09% and 92.02%. Biogas production is influenced by pH and HRT. Environmental pH is one of the factors that can influence anaerobic processes. Therefore, the pH of the environment in the anaerobic process reactor must be close to neutral between the range 6.5 – 8.2 so that the process can take place well [7]. When the reaction phase of methanogenesis produces methane gas and CO$_2$ pH tends to increase. Therefore, to produce a pH close to neutral high alkalinity is required. For liquid waste containing high protein and amino acids, sufficient alkalinity can be obtained from the decomposition of these compounds which produce NH$_3$ and together with CO$_2$ and H$_2$O gases form alkalinity as NH$_3$CO$_3$[9]. So it does not require the addition of alkalinity to control pH. The amount of COD and TSS allowance is also influenced by proportional residence time,

![Figure 2.](image-url)
HRT (Hydraulic Retention Time). Meanwhile, the optimum point of biogas production in 100% tofu liquid waste is only able to produce biogas at 2,080-2,340 mL. This is because microorganisms experience shock loading (sudden loading) by 100% tofu liquid waste substrate, so that microorganisms experience death over time. This can be seen in the volume of biogas production which is decreasing and the allowance for COD and TSS is 88.02 and 89.97%.

3.2 Effect of addition of trace metal on biogas production
Addition of trace metal will directly be related to the volume of biogas produced. Therefore, the proportional trace metal (micro nutrient) will increase microorganism growth so that the degradation process will be better and can increase biogas production. Figure 2 shows that the trace metal and optimum tofu wastewater concentrations were 0.6 mg/L and 75% respectively, where the percentage of COD and TSS removal reached 94.09 and 94.04% with a volume of 8,190 mL biogas production.

4. Conclusions
Based on the results of this study the conclusions are as follows:
1. Effect of organic load due to the addition of trace metal FeCl$_3$ can reduce the concentration of pollutant parameters (pH, COD, and TSS) to conform to the quality standards set by Permen-LH-5-2014.
2. The optimum point of concentration of trace metal FeCl$_3$ is 0.6 mg / L with tofu industry wastewater 75% with a value of:
   a. pH effluent = 8.1
   b. COD
      - COD effluent = 291 mg/L
      - Removal of% COD = 94.09%
   c. TSS
      - TSS effluent = 101 mg/L
      - Removal of TSS% = 94.02%
And Biogas Production is 8,190 mL

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