MECHTA
International Journal Of Mechanical Engineering Technologies & Applications
ISSN 2722-3213 articles 3, pp. 22 – 30, 2023
V04 N.1

EFFECT OF TRACE METAL $FECL_3$ ON BIOGAS PRODUCTION IN INDUSTRIAL WASTEWATER TREATMENT WITH HIGH ORGANIC LOAD

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Abstract

Wastewater from the food industry that contains a high organic load, such as wastewater from the tofu manufacturing process, requires an appropriate and efficient treatment system to reduce pollutants before being discharged into water bodies. The most suitable treatment for high organic loads is the anaerobic treatment system. The anaerobic treatment process is a system of suspended media, attached media, or the combination thereof as a hybrid. This study uses a Hybrid Upflow Anaerobic Sludge Blanket (HUASB) reactor with the consideration that this reactor has advantages in maintaining high concentrations of biomass, high operating load rates, good decomposition capabilities, and good solid-liquid separation due to suitable granulation. The purpose of this study was to determine the effect of the addition of the trace metal $FeCl_3$ on biogas production and the ability to remove pollutants in the tofu industrial process wastewater treatment in the HUASB reactor. The operation of the reactor uses variations in the concentration of tofu industrial waste water (75 and 100%) and trace metal concentrations (0.3–0.6 mg/L). The optimum biogas production was obtained with 8190 mL at a concentration of 75% tofu industrial waste water, a trace metal concentration of 0.6 mg/L $FeCl_3$, and removal of COD and TSS of 94.09% and 94.2%, respectively. The role of the trace metal $FeCl_3$in the anaerobic process shows that it is a source of nutrition for increasing the growth of microorganisms in anaerobic systems so that biogas production and pollutant removal are increased.

Keywords: Trace Metal, $FeCl_3$, Biogas, High Organic Load.

1. INTRODUCTION

The effluent from the food industry has a large organic load. If the treatment system is not handled effectively, there will undoubtedly be an issue with pollutant pollution in water bodies. For instance, one of Indonesia's industries with the quickest rate of growth is the tofu industry, which has about 84,000 companies operating there [1], [2]. In the city of Medan, there is no tofu industry that uses a sewage treatment system, so the process waste water is directly discharged into water bodies without being treated first. Whey, a sticky liquid that separates from the tofu, makes up the majority of the wastewater produced by the tofu producing industry. The high protein content of this liquid allows for quick decomposition. If the waste water generated is dumped into water bodies without first being cleaned, the state of tofu industrial wastewater is one source of pollution. Chemical oxygen demand (COD) in the range of 7520–11450 mg/L is a characteristic of the tofu industry's waste water, which is characterized by its high organic content [3] when the pH is between 3 and 4 [4].

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Received on: 2022-12-06
Revised on: 2022-12-28
Accepted on: 2022-12-28

DOI: 10.21776/MECHTA.2023.004.01.3

The optimum treatment method for processing waste water from the tofu industry is an anaerobic process since the waste water from the tofu industry comprises a high organic load [5–10]. Complexes with a high content of organic materials are broken down into simpler compounds by the anaerobic process's degradation mechanism. The ability of the anaerobic method to handle industrial wastewater with high organic contents has been indicated [11]. The treatment process is less expensive since it uses less energy, creates little sludge, and generates energy that may be used again [12–15]. Growth that is suspended and attached constitutes anaerobic treatment. The benefit of anaerobic treatment with a hybrid system is that it uses a fixed and suspended system for the development of microorganisms. The Hybrid Upflow Anaerobic Sludge Blanket (HUASB) reactor is one of the anaerobic process reactors that makes use of a hybrid system. The system that combines with a fixed film reactor has been upgraded with the HUASB reactor [16, 17]. Because it can run at extremely high load levels with the resulting sludge being relatively simple to settle, having a high biomass content, and efficient solid and liquid separation, the UASB reactor provides commercial advantages and the effluent can meet regulatory standards [18]. The HUASB reactor has been used in the research of tofu liquid waste with a PVC attached system and bioball, which produces the highest COD removal of 86.41% and 85.57% and produces 7700 mL and 1510 mL of biogas at 24 hours HRT during the acclimatization process [11].

Microorganisms are used in anaerobic treatment to break down organic loads since they are crucial to the breakdown of wastewater. This study's objective was to assess if adding the trace metal $FeCl_3$to the HUASB reactor's connected media would improve the treatment of tofu industrial effluent. It is expected that the inclusion of the trace metal $FeCl_3$as a source of nutrients will promote the growth of microorganisms in anaerobic systems, increasing biogas generation and pollutant removal. A trace metal is required for the production of vitamins, bacterial nucleic acids, and enzymes. Although the function of trace metals like Fe is well recognized, there are still many needs in wastewater treatment that require clarification. In addition to preventing process inhibition, the inclusion of trace metals enhances reactor performance, which can increase methane production [18–22].

2. MATERIALS AND METHODS

2.1. Experimental apparatus

Figure 1 illustrates the design and development of the experimental apparatus [4, 11, 23]. In the HUASB reactor, there are two types of growing media: attached media and suspended media. The attached growth media is a container for the growth of microorganisms and is filled with bioball material. The clarifier is equipped to accept the liquid and solid after the generated gas has been separated in the gas liquid solid separator (GLSS) and collected in the biogas collector.

Figure 1. Hybrid HUASB Reactor

2.2. Seeding and acclimatization

The seeding process was carried out outside the HUASB reactor and then flowed to the inlet to continue seeding inside the HUASB reactor. After one week, seeding and acclimatization were carried out simultaneously in the HUASB reactor process (Figure 2). The acclimatization process was carried out so that microorganisms were able to adapt to the waste water of the tofu industry in the reactor, so that a large number of micro-organisms are able to degrade pollutant compounds with high organic loads and grow in suspension media and media attached to the HUASB reactor. The acclimatization process began at the lowest concentration of waste water and increased to the actual concentration of waste water while also adjusting the hydraulic retention time (HRT).

Figure 2. Process of external seeding to seeding and acclimatization process in huasb reactor

2.3. Analytical methods

Observations of the process in the HUASB reactor are carried out every day on the parameters of pH, biogas production, chemical oxygen demand (COD), and total suspended solids (TSS), which are carried out according to American Public Health Association (APHA) standards [24]. Each treatment from the inlet was carried out based on variations in concentration and hydraulic retention time (HRT). The characteristics of the tofu industrial wastewater used for research have a pH between 3 and 4, COD values of 6920 mg/L, and TSS (Table 1). While the standards required by the Indonesian National Standard (SNI) [25] are pH between 6 and 9, COD 300 mg/L, and TSS 200 mg/L (Table 2),

Table 1. Characteristics of tofu wastewater

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

Table 2. Quality standards of tofu waste water of Standar National Indonesia [25]

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

3. RESULTS AND DISCUSSION

The anaerobic process of the HUASB reactor for the treatment of tofu industrial process wastewater was carried out in stages at a concentration of 75% and 100% of the tofu industrial waste water. The processing was carried out with variations in the addition of the trace metal $FeCl_3$from 0.3 to 0.6 mg/L. The addition of the trace metal element $FeCl_3$affects the anaerobic treatment process for biogas production [18–22]. The addition of trace metals is a strategy in the anaerobic treatment process to increase biogas production [19–22]. The treatment process in the reactor was operated at a mesophilic temperature (27–35 °C). The highest biogas production was 8190 mL, which was obtained at the optimum concentration of 75% of the tofu industrial wastewater and at a trace metal concentration of 0.6 mg/L (Figure 3). When biogas production is high, it shows that the methanogenesis stage takes place at an optimum where the pH behavior is in a methanogenic environment, as shown in Figure 4, and an increase in biogas production is achieved by using the trace metal $FeCl_3$ because $FeCl_3$ functions as an additive [18–22, 26–27].

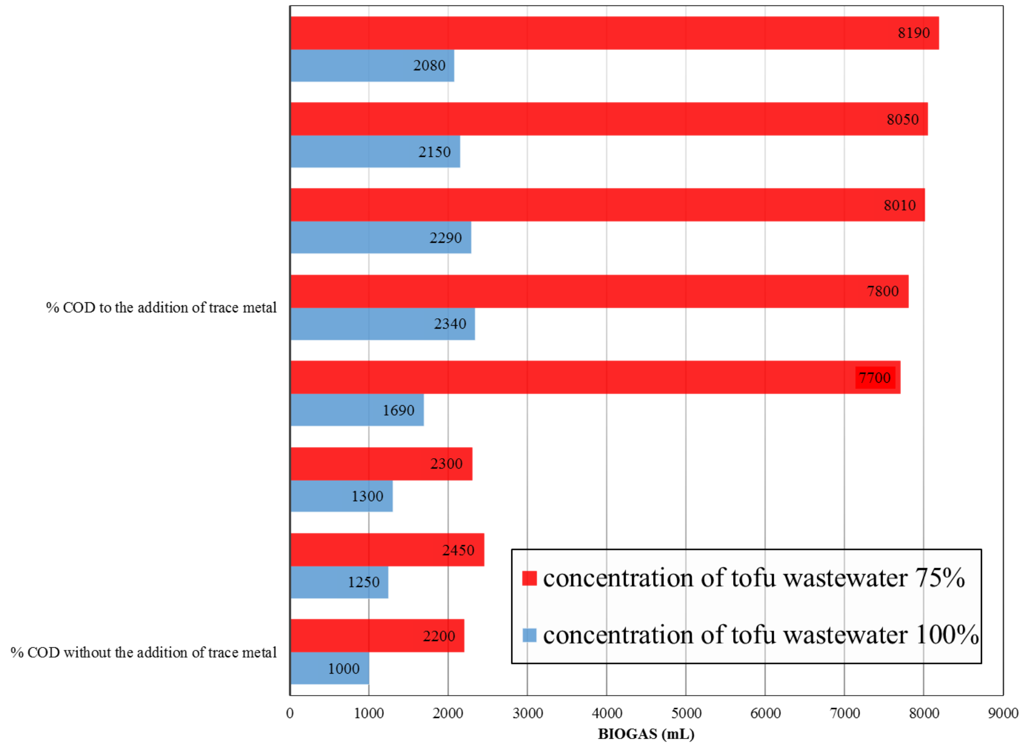

Figure 3. Effect of addition of trace metal **$FeCl_3$** on biogas production

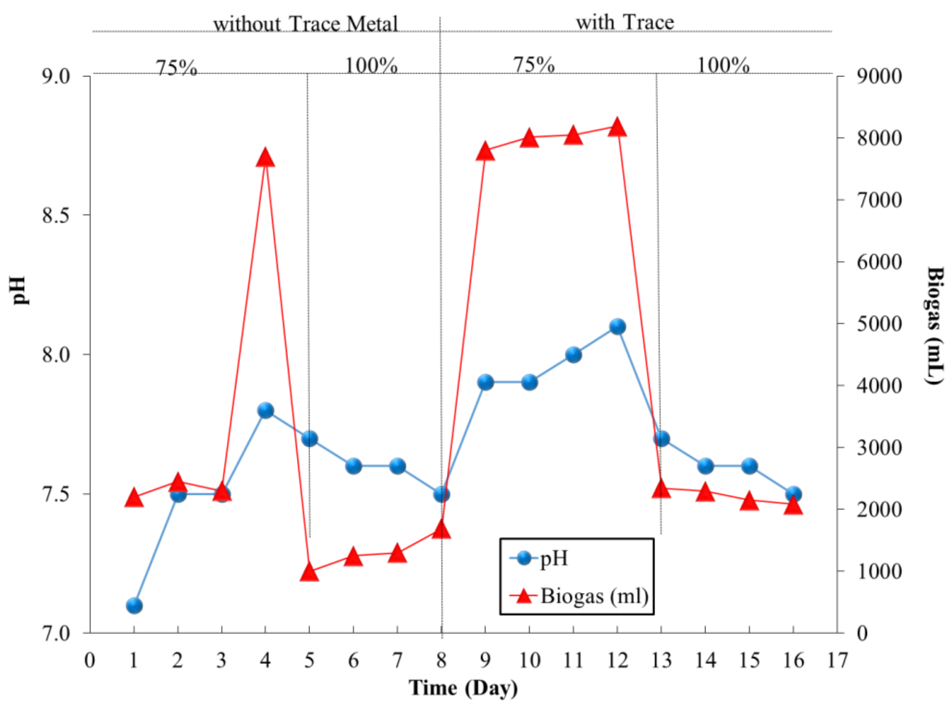

Figure 4. Biogas production, pH profile on the addition of trace metal

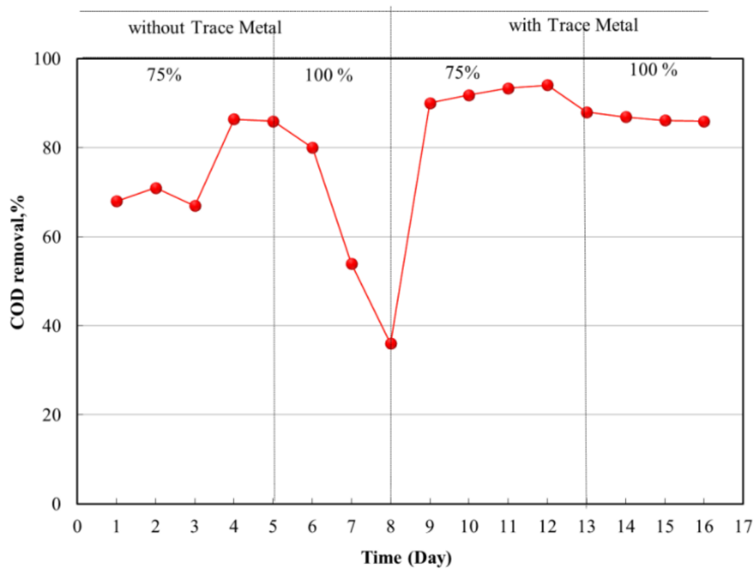

Figure 5. Removal of COD to time on addition of trace metal $FeCl_3$

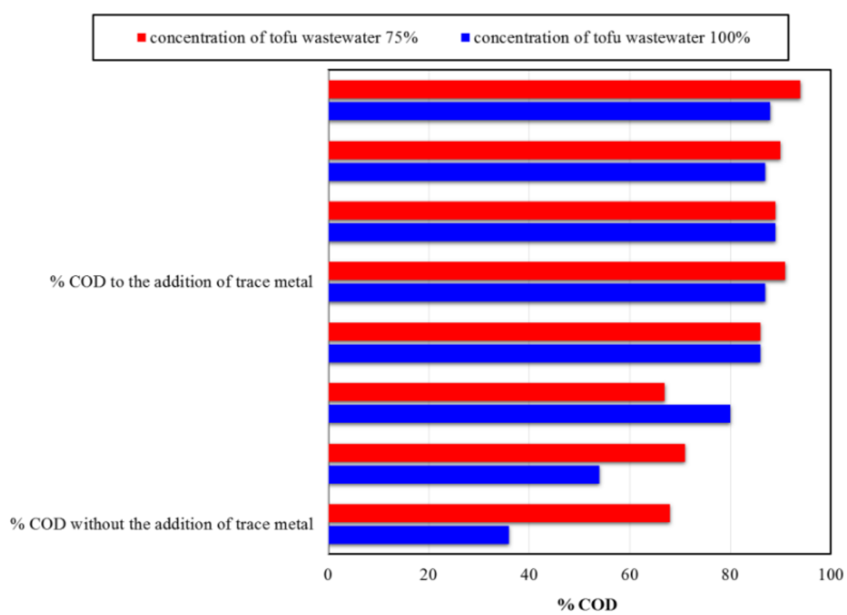

Figure 6. Effect of addition of trace metal $FeCl_3$ on COD removal

One of the most significant elements affecting anaerobic processes is the pH of the surrounding environment. Therefore, for the anaerobic process reactor to function successfully, the environmental pH level must be close to neutral, in the range of 6.8–8.2 [18]. High alkalinity is necessary to achieve a pH that is close to neutral since the pH tends to rise during the methanogenic reaction phase, which yields methane and CO2. The degradation of these compounds yields NH3, which, when combined with CO2 and H2O,

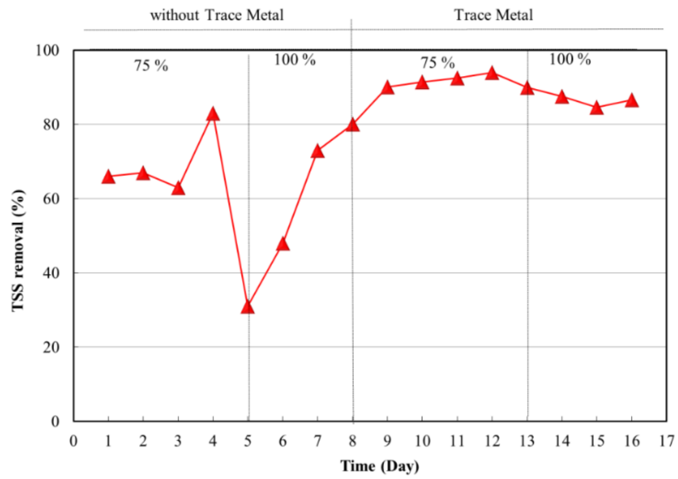

Figure 7. TSS removal in preparation for the addition of trace metal FeCl3.

gases produce alkalinity as NH3CO3 in wastewater with a high protein content [18, 28–30]. Therefore, the addition of alkalinity is not necessary to control the pH. In the highest biogas production, the highest COD and TSS removal also occurred, namely 94.09% and 94.02% (Figures 5 and 6). COD and TSS allowances were influenced by proportional HRT (Hydraulic Retention Time), where the acclimatization process was very dominant in determining HRT optimization. The ideal interval for producing biogas from liquid waste containing 100% tofu, however, is only 2080–2340 mL. This is because 100% of the tofu industry's waste water substrate suddenly loads bacteria, causing them to die slowly over time. This is demonstrated by the reduction in biogas volume and the elimination of COD and TSS. The anaerobic process of adding trace metal $FeCl_3$ in the HUASB reactor produced results superior to previous studies, where the treatment of tofu wastewater using the HUASB reactor without the addition of trace metal produced the highest biogas of 7700 mL and the highest removal of COD and TSS of 86.4% and 67%, respectively [4, 11].

4. CONCLUSION

The addition of the trace metal $FeCl_3$ affects the overhaul of the organic load and reduces the concentration of pollutant parameters so that it can reach the SNI quality standard. The optimum concentration of trace metal $FeCl_3$ was 0.6 mg/L in 75% tofu industrial wastewater, 8190 mL of biogas production, 291 mg/L COD waste, 94.09% COD removal, 94.02% TSS removal, and at pH 8.1.

5. ACKNOWLEDGMENTS

Thank's to Prima Indonesia University, Medan, for financial support so that the research and writing of this article can be completed and published.

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