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ANALYSIS OF REDUCTION OF COD (Chemical Oxygen Demand) LEVELS IN TOFU WASTE USING ACTIVATED SLUDGE METHOD

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Abstract

This study aims to reduce COD (Chemical Oxygen Demand) levels in tofu waste using activated sludge. The method used to conduct this experiment is to use the fermentation method by grouping the tofu dregs samples into three groups. Then the tofu dregs sample was added with 1:3 activated sludge and incubated for two days, four days, and six days. The results showed that samples with an incubation period of 2 days had effectiveness in reducing COD levels in tofu waste as much as52.3%; during the incubation period of 4 days can reduce COD levels by 75.5%, and during the incubation period for six days have 79.8% effectiveness in reducing COD levels. A significant increase in the decrease in COD levels on the sixth day indicates that the microbes in activated sludge can multiply optimally to decompose waste and reduce COD levels optimally. In addition, the incubation time on the sixth day of the nutrients required by microbes increased, thereby increasing microbial activity. So it can be concluded that the incubation process of tofu dregs with activated sludge for six days is effective in reducing COD levels and can overcome environmental pollution problems.

Keywords: *Activated Sludge, COD (Chemical Oxygen Demand), Tofu Waste.*

1. Introduction

Tofu dregs are a liquid waste by-product of tofu production. Tofu is a food favored by various groups of people, so based on data, it is revealed that the whole world produces 14 tons of tofu dregs [1]. So far, the tofu dregs made from production are thrown away without prior processing. If the waste is disposed of on the ground or waters, it will cause environmental pollution. Furthermore, tofu waste disposed of will cause an unpleasant aroma and cause the foam to cover the surface of the waters [2]. So that waste is essential to be treated before being disposed of.

In treating waste, we also need to use the right way and under the characteristics of the waste to be processed [3]. Such tofu waste contains carbohydrates and protein [4] so that the selection of tofu waste treatment methods is more effective. It is carried out anaerobically, namely by fermentation using activated sludge [5]. The choice of the process is based on the substances contained in the tofu dregs that are useful for increasing the reproduction and growth of microorganisms so that they will improve the quality of the fermentation process [6]. The anaerobic fermentation process is a process that converts organic compounds into methane (CH4) and carbon dioxide (CO2) in the absence of oxygen (O2). The decomposition of organic compounds through this anaerobic process occurs through three stages:

- the hydrolysis reaction stage
- the acid formation reaction stage
- the methane formation reaction stage

The hydrolysis reaction is the process of dissolving organic compounds that are initially insoluble and decomposition of these compounds into compounds with molecular weights small enough to pass through the cell membrane. Waste also still has benefits, such as producing silica particles from agricultural waste [7].

In this fermentation process, microorganisms are attached to a medium in the form of activated sludge. The media used is intended for the attachment of microorganisms so that microorganisms will adhere and breed on the media [8]. Anaerobic activated sludge treatment is able to degrade COD (Chemical Oxygen Demand) [9]. The decrease in COD levels produced will be calculated using the stoichiometric concept so that it will be known how effective the use of activated sludge is in the fermentation process of tofu waste. The process of calculating the reduction in COD levels is the application of the stoichiometric concept. COD or Chemical Oxygen Demand is the amount of oxygen needed to break down all organic matter contained in water. COD is widely used to measure oxidase-able inorganic and organic matter in natural waters, domestic and industrial wastes. The COD concentration observed in unpolluted surface water was in the range of + 20 mg/l. Water bodies that receive effluent are usually in the range of 200 mg/l. Industrial wastewater has a COD value of around 100 – 60,000 mg/l. The government has also set regulations through the Minister of the Environment of the Republic of Indonesia No. 5 of 2014 concerning wastewater quality standards that the COD quality standard unit for wastewater is 350 mg/L [10]. With the waste treatment, it is hoped that it will reduce the COD level in accordance with the optimal threshold set by the government so that when the waste is disposed of, it does not pollute the surrounding environment and is environmentally friendly. So that our aim in conducting this research is to analyze the decrease in COD levels in tofu waste by using activated sludge, the novelty in this research is in the method we use, including (1) using 1:3 activated sludge volume so that it is more effective and efficient, (2) using an anaerobic reactor so that during the research process it does not cause air pollution, mainly this research was conducted in a laboratory, (3) the data is processed and analyzed based on the application of students' understanding of the stoichiometric concept.

2. Materials and methods

This tofu waste treatment research uses the principle of fermentation using activated sludge under anaerobic conditions. This research activity was also carried out on a laboratory scale, meaning that the sample used was still small. There are four stages in sewage treatment with an activated sludge system, including an aeration tank, a settling tank, sludge recirculation, and the removal of residual sludge. In this study, the scale of the variation of the ratio of activated sludge to wastewater in an anaerobic reactor was 1:3 with a bulkhead distance of 10 cm and with three treatment times, namely two days, four days, and six days.

Table 1. Variation of Data Treatment

Treatment	Time (Days)	Bulkhead Distance (Cm)	Activated Sludge Height
P1	2	10	1:3
P2	4	10	1:3
P3	6	10	1:3

The consideration of using an insulated anaerobic reactor is that the reactor's shape is practical and simple, it gives the advantage of better contact between the existing activated sludge and wastewater (upflow and downflow). Moreover, it is suitable for tropical areas because it deals with mesophilic microorganisms.

Tofu liquid waste as an influent has flowed to an anaerobic reactor. After that, the anaerobic waste has flowed into the aerobic reactor. Samples were taken from 3 points; influent, anaerobic wastewater, and aerobic waste. Observations were made at conditions that were considered a steady-state. Data were collected twice in the morning at 06.00 and noon. In this research, the focus of research is COD (Chemical Oxygen Demand). COD testing is carried out by carrying out the oxidation process by a solution of $K_2Cr_2O_7$ in a boiling acid state. Furthermore, silver sulfate (Ag_2SO_4) was added as a catalyst to accelerate the reaction. Furthermore, the analysis of dissolved COD was preceded by the preparation of COD reagents (standard solution of potassium dichromate, standard solution of FAS, indicator of ferroin, sulfuric acid solution of silver sulfate), standardization of FAS, blank solution. First, 5 ml of liquid waste was taken and then diluted to 50 ml in a measuring cup. Next, take 2 ml of sample and 2 ml of blank in COD tube. 0.04 mg $HgSO_4$, 1 ml potassium dichromate, and 3 ml sulfuric acid-silver sulfate solution are added. The solution was heated for 2 hours at 170°C and then cooled for 30 minutes. Next, 8 ml of distilled water and 2 - 3 drops of ferroin indicator in Erlenmeyer were added. Next, the titration was carried out with Ferro Ammonium Sulfate until the green color slowly turned to brick red.

The equation calculates COD concentration:

$$\text{COD (mg } O_2\text{/l)} = \frac{(ab) \times c \times d \times p \times 1000}{\text{ml sample}} \quad (1)$$

Information:

a = volume of FAS used for blank titration (ml)

b = volume of FAS used for sample titration (ml)

c = normality of FAS solution (ml)

d = weight of oxygen equivalent (8)

p = dilution

3. Results and Discussion

Based on the research conducted, the following data were obtained:

Table 2. Titration Results

Treatment	Influent	Effluent anaerob	Effluent aerob
P1	6500	4700	3100
P2	4900	2200	1200
P3	9900	3800	2000

Because liquid tofu waste has a high COD value, it can be treated through an anaerobic process. Tofu waste is one of the organic wastes. If thrown away, this waste will be difficult to decompose by natural means because bacteria cannot decompose waste [11]. So we need another way to decompose the waste, namely by using activated sludge. This is because the minimum limit of influent COD concentration to achieve successful anaerobic treatment is 1000 mg/l [12]. Waste treatment with an anaerobic process is expected to decompose complex organic compounds into simple organic compounds. The COD reduction of liquid tofu waste was carried out using an insulated anaerobic reactor with a 10 cm bulkhead distance. The selection of a partition with a distance of 10 cm aims to form a flow so that contact between tofu waste and activated sludge does not occur only on the surface but is comprehensive and suitable for the tropics because it is associated with mesophilic microorganisms, with the hope that with sludge interaction [13] and maximum waste, the process of reducing COD levels is also maximal. Anaerobic effluent is then collected into an aerobic reactor using broken bricks.

Broken brick was chosen because it does not require continuous monitoring and is more practical, making it more effective and economical. These brick fragments were selected for measurement carried out at 3 points, namely: influent, anaerobic effluent, and aerobic effluent. Variations of experiments carried out in anaerobic reactors are variations in residence time: two days, four days, and six days. The incubation time was chosen for 2, 4, and 6 days based on the type of waste used and the treatment technique we chose. Of the three samples used were treated with the same conditions, only the incubation time was different. Following the research objectives, variations in the selection of incubation time were carried out to determine the most effective time to reduce COD levels. Based on influent data, anaerobic effluent and aerobic effluent were generated from the study. The highest influent data is in the sample with an incubation time of 6 days, 9,900, while the smallest is in the sample with an incubation time of 4 days, which is 4,900. Moreover, it went back up on the sixth day. The high influent value in the sample with an incubation period of 6 days indicates a relatively high content of organic compounds in the waste so that the availability of organic matter as a carbon source, energy source, electron acceptor, and growth factor in the bioenergy process for microbes has been fulfilled [14].

Meanwhile, the effluent data for both anaerobic and aerobic have the highest value in samples with an incubation period of 2 days. Likewise, the smallest effluent value was in aerobic and anaerobic effluent samples during the 2-day incubation period of 2,200 and 4 days of 1,200. The influent and effluent values are obtained from the results of data processing with the concept of stoichiometry. To carry out the next step, influent data and effluent data are used to calculate COD levels. The results of COD measurements for tofu liquid waste are presented in Table 3 as follows:

Table 3. COD Decrease Result Data

Treatment (P)	Influent (mg/l)	Anaerobic Effluents (mg/l)	Efficiency (%)	Aerobic Effluent (mg/l)	Efficiency (%)	COD Reduction (%)
P1	6500	4700	27,7	3100	34	52,3
P2	4900	2200	55,1	1200	20,4	75,5
P3	9900	3800	61,6	2000	47,4	79,8

Based on the data are shown in table 3, the most effective treatment for reducing COD is the treatment in P3 treatment with an incubation period of 6 days, namely with an anaerobic efficiency value of 61.6%, aerobic efficiency of 20.4%, and a decrease in COD levels as much as 79.8%. . In reducing COD levels, the ongoing process has an optimal time. And the incubation period for six days of samples added with activated sludge is the best time. Anaerobic remodeling process, in principle; Complex organic matter is broken down into simple organic acids and further decomposed in the form of gas. The anaerobic process can reduce the organic content of concentrated organic waste, making it suitable for anaerobic biological treatment [15]. The efficiency of P2 and P3 in anaerobic reactors is always higher than in aerobic reactors because the rate of fermentation in anaerobic systems is usually higher than in aerobic systems. This is because the equilibrium (%) anaerobic efficiency (%) aerobic efficiency (%) COD reduction (%) between substrate and product is difficult to maintain. CO_2 formed in the anaerobic system and will affect the rate of fermentation out of the system so that there is a positive effect. In contrast to the efficiency in P1, where the value of anaerobic efficiency is smaller than that of aerobic efficiency. Because the rate of fermentation in anaerobic systems is usually always lower than in aerobic systems, this is because of the equilibrium (%) anaerobic efficiency (%) aerobic efficiency (%) COD reduction (%) between substrate and product is difficult to maintain. CO_2, which is formed in the anaerobic system and will affect the rate of fermentation, cannot get out of the system, resulting in a negative effect [16]. The difference in the results of the P1, P2, and P3 treatments occurs because the temperature difference due to the activity of the bacteria at each incubation time will affect the efficiency [17]. The difference in efficiency results is also influenced by the concentration of the reacting waste and activated sludge. The longer the concentration increases [18] so that during the incubation period, the COD reduction efficiency is at the highest level compared to days 2 and 4.

In the waste treatment process with the main aim of reducing COD levels in the waste so that the waste discharged does not pollute the aquatic environment [19]. The growth rate of microbial biomass in treatment I with an incubation period of 2 days had the lowest COD reduction value. This is because the composition of the sludge that reacts with tofu waste is still small, so that microbial activity is still low [20]. The use of activated sludge cannot be separated from the environmental conditions of the biomass source, and the variety of microbes originating from a polluted environment is less than that of a less polluted environment. Bacterial activity is increasing day by day until it reaches its maximum point on the sixth day.

In polluted waters generally have high levels of organic matter so that it contains many heterotrophic microorganisms, heterotrophic microorganisms will use the organic matter for metabolism [21]. In addition, there is sufficient availability of food (organic material) for microbes so that the growth of microbial biomass increases. So it can be concluded that the longer the incubation, the higher the microbial load due to microbial cells undergoing division or reproduction [22]. Microbes need enough time to reproduce if the required components are available enough, then microbes will grow rapidly, just as microbes need nutrients for growth. Based on the analysis of the decrease in COD levels in the 3rd treatment with an incubation period of 6 days is the maximum time for bacterial activity.

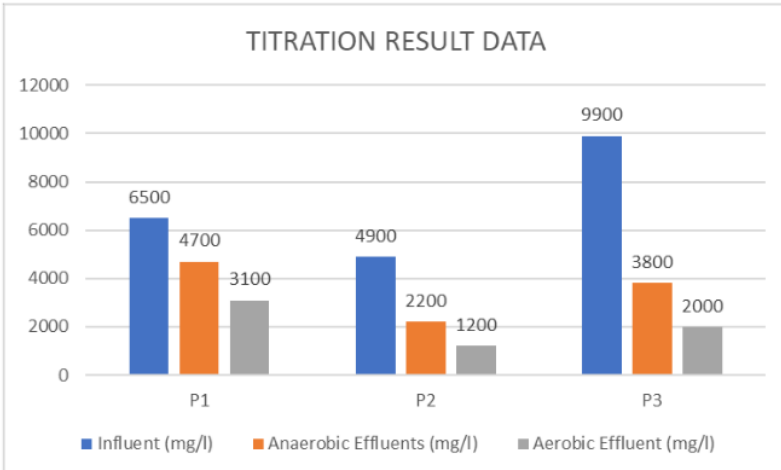

Figure 1. Titration Result Data

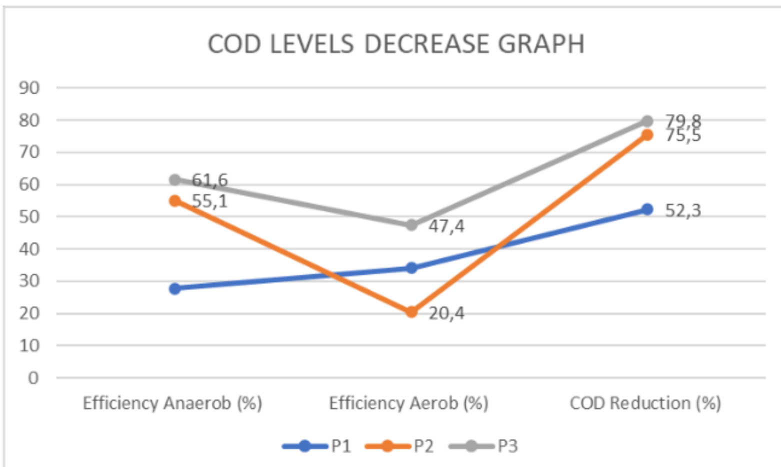

Figure 2. Graph of Decrease in COD Levels at P1, P2, P3

Based on Figures 1 and 2, the incubation period within six days has high effectiveness compared to days 2 and 4. The aerobic efficiency values at P2 and P3 are lower when compared to anaerobic efficiency. In contrast to P2 and P3, in P1 Aerobic efficiency is higher than anaerobic efficiency. For the decrease in COD levels at P1, P2, P3, the value is always higher when compared to the aerobic and anaerobic efficiency values. So it can be said that the reduction in COD levels in each treatment is better than the aerobic and anaerobic efficiency [23]. The results of this study indicate that the trend of decreasing COD concentration gradually indicates that the organic matter contained in wastewater is mostly biodegradable [24]. The longer the contact time between wastewater and activated sludge, the degradation process of organic pollutant parameters [25] can last longer so that the reactor performance will be better [26], and the resulting effluent concentration will also be lower [27].

The difference in the efficiency of each treatment was due to the different incubation periods. The addition of sufficient nutrients will meet the needs of microbes for their food, so that microbial growth will increase [28]. As a result, the COD value of the tofu industrial wastewater will be lower, and its effectiveness will be higher. The incubation process of waste and activated sludge provides the highest level of effectiveness, up to 79.8%, in reducing the COD value of tofu industrial wastewater. This is because the ability of microbes to oxidize organic matter in the tofu industrial wastewater is greater than the others [29]. Such research has also been carried out by [30] using membranes based on Ghassoul and Hydrotalcite (GHTM) in the retention of polyphenols (organic pollutants) that treat wastewater in olive mills.

Tofu waste can not only be processed by reducing COD levels. Tofu waste can also be used as raw material for biogas because of the methane produced from the waste, similar to research [31] which uses household waste as raw material for biogas. Waste treatment can be applied in everyday life by everyone, including students. So that simple waste management can also be used as an alternative for student practicum activities during online lectures [32][33].

4. Conclusion

Based on the data from the research conducted, it can be concluded that the most effective time to reduce COD levels is six days using a ratio of 1:3 activated sludge, the bulkhead width is 10 cm, and have an effectiveness of 79,8% in lowering COD levels in activated sludge. Tofu waste treatment using activated sludge has proven to be effective, so it is important to do it before the waste is disposed of.

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