The Effect of Concentration of Personal Care Pollutant in Domestic Wastewater on the Efficiency Removal of COD and Ammonium in Batch Reactor

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Abstract. One of the dominant compound in a personal care product is sodium lauryl sulfate (SLS). So in this study, SLS is used as a pollutant that might influence the anaerobic digestion treatment. The effect of SLS on the efficient removal of ammonium (NH₄⁺) and COD can be investigated with anaerobic batch reactors. In these reactors, house septic tank sediments were contacted with artificial wastewater with ammonium concentration 30 mg NH₄⁺-N/L and 300 mg/L COD concentration. Reactors are operated for 15 days with variations of SLS concentration 0, 5, 10, 50, 100 mg/L. The best COD removal efficiency and the rate is in the 5 mg SLS/L with the efficiency value of 99.6% and a reduced rate of 19.67 mg/L. The efficiency and rate of COD removal continue to decrease with increasing SLS concentrations. Meanwhile, the best ammonium (NH₄⁺-N) removal efficiency and the rate is in the 0 mg SLS/L with an efficiency value of 73.32% and a reduced rate of 1.30 mg/L. The magnitude of the efficiency and removal rate of ammonium also decreases with increasing SLS concentration. Temperature and pH values for all reactors are in the range of 26-28°C. The pH values in the five reactors were relatively the same both without and with the addition of SLS concentrations.

1 Introduction

One of the problems with dealing with a more complex range of wastewaters is that they can contain materials that are toxic to the anaerobic digestion process [1] Detergents, in general, are a class of compounds that have a history of disrupting the performance of anaerobic digesters [2]. Khalil et all. (1998) have studied that anionic and non-ionic detergents affected anaerobic digestion. In this research use glucose-based feed. This research found that process effectivity was halved at the concentrations of 20-50 mg/l [3]

Biological treatment is carried out by removing organic compounds and ammonium using microorganisms from anaerobic bacteria. Biological processing can be carried out on batch anaerobic reactors and the growth method of microorganisms suspended growth. To obtain good and optimal growth and activity of microorganisms, it is necessary to create environmental conditions following the environmental characteristics favored by microorganisms in the reactor, in this case, the anaerobic bacterial group.

To ensure the success of the removal of ammonium and COD by anaerobic bacteria can be demonstrated by decreasing the concentration of COD (Chemical Oxygen Demand) and ammonium
during this stage. Anaerobic bacteria use organic compounds as carbon and nitrogen in the form of ammonium are consumed by anaerobic bacteria as the energy sources and constituents of the body's cells.

This research will examine the removal of COD and ammonium in wastewater using artificial waste in the presence of processing using anaerobic bacteria from various sources which were tested first followed by treatment of sodium lauryl sulfate (SLS)-variation in artificial domestic wastewater where the effects, parameters, and impacts will be analyzed. To see the effect of sodium lauryl sulfate (SLS) concentrations variation on COD and ammonium removal process by anaerobic bacteria can be indicated by the value of remove sulfate concentration, pH, temperature, the concentration of COD (Chemical Oxygen Demand) and concentration ammonium (NH4⁺-N) contained in water.

2 Method
This research is carried out with experimental methods. It aims to find the influence of a particular treatment on others under controlled conditions [1]. In general, the part of the study treated is called a variable (everything that is varied) free (independent variable), and dependent variable (dependent). The independent variable of this study is the SLS concentration - while the dependent variable of this study is the concentration of COD and ammonium. The waste used is made by an artificial method in which the method of making this waste follows the characteristics of domestic wastewater which contains COD and ammonium. To calculate how much weight each material is needed to make artificial waste for the acclimatization stage according to the desired characteristics: 1) Insert 8 L of distilled water into the container (bucket), 2) Add the constituent materials of artificial domestic wastewater into the container. The constituent materials include 0.802 gr NH4Cl and 1.870 gr sugarcane (C12H22O11). Then pour 2.040 gr NaHCO3 into the container while stirring until pH of 7. Then pour into a reactor measuring 8.5 L.

For the running stage, these following are steps on how to make artificial domestic wastewater: 1) Insert 1 L of distilled water into the container (bucket), 2) Add the constituent materials of artificial domestic wastewater into the container. The constituent materials include 0.153 gr NH4Cl and 0.267 gr sugarcane (C12H22O11). Then pour 0.720 gr NaHCO3 into the container while stirring until pH of 7. Then pour into a reactor measuring 1.5 L.

The addition of the mass of each ingredient depends on the concentration of ammonium and COD. In this study, adjustments were made to the characteristics of artificial domestic wastewater. The distilled water volume can be adjusted to the desired volume of wastewater.

Sediment extraction of household septic tank is carried out following what is stated in SNI 03-7016-2004. The test is done by washing the sources by adding tap water to the sediment, then stirring evenly and silence. Water that has been separated from the sediment is then drained. This method is carried out 3 times to ensure that no other substances are contaminated in the sediment. Subsequently, contacting each of 100 mL of the slurry which had been drained with artificial waste with a concentration of ammonium + 40 mg / L and COD + 300 mg / L in magnitude in a batch reactor with a volume of 1500 ml for 7 days, observed various parameters reviewed to see the most effective sulfate reduction process. The parameters tested were pH, sulfate concentration, temperature, and DO.

Furthermore, the source of the bacteria will be grown first in the seeding and acclimatization stage. This stage was carried out by contacting sediments with artificial waste in an anaerobic react with a volume of 8500 liters which was operated batch with for 14 days.

At this stage, nutrition is given as NH4Cl as a source of N (Nitrogen) [2] and sugarcane [3] as the source of carbon. with a COD concentration is 300 mg/L and 40 mg/L NH4⁺-N to support growth for anaerobic bacteria. Besides, pH control at the reactor is 6-7.5 due to range this pH is the optimum pH range for anaerobic bacteria to be able to grow. After the seeding and acclimatization stage, the next test is the influence of SLS concentration to COD an ammonium removal process.

In testing the effect of variations in SLS concentration, the reactor used anaerobic batch. In reactor anaerobic batch it takes 5 reactors with a volume of 1500 ml, namely:
1. R0 (variation of SLS concentration 0 mg/l) In the control reactor there was no addition of SLS.
2. R5 (variation of SLS concentration 5 mg/l) In the reactor there was the addition of SLS at a concentration of 5 mg/l.
3. R10 (variation of SLS concentration 10 mg/l) In the reactor there was the addition of SLS at a concentration of 10 mg/l.
4. R50 (variation of SLS concentration 50 mg/l) In the reactor there was the addition of SLS at a concentration of 50 mg/l.
5. R100 (variation of SLS concentration 100 mg/l) In the reactor there was the addition of SLS at a concentration of 100 mg/l.

The study was conducted for 14 days to determine the effect of variations in the SLS concentration in the COD and ammonium removal process. In each test, the effect of SLS concentration variation was measured by pH, ammonium concentration, COD concentration, and temperature. Measurements of ammonium concentration are routinely carried out following SNI 06-6989.30-2005 and routine COD concentration measuring is carried out following the procedures in SNI 6989.2-2009. The research was carried out using batch laboratory-scale reactors. The batch reactor is used in seeding and acclimatization stages also in running stages. Each stage is carried out for 14 days.

3 Results and discussions

3.1. Effect Sodium Lauryl Sulfate (SLS) concentration variations on cod and ammonium removal process

To observe the effect of SLS variation concentration, the authors conducted a test using a household tank sediment as the source of bacteria in the analysis of the potential for COD and ammonium removal process. Then proceed with the running stages in the reactor anaerobic batch for 14 days.

3.1.1 Running anaerobic batch reactor. The running phase is done after the seeding and acclimation stages. The reactor in this stage is operated in batches for 14 days for each variation of SLS concentration. The results of running from these five reactors are divided as follows:

- pH

  This parameter is controlled during the running stage. The value of pH is the most important parameter in determining the success of the anaerobic process. The value of pH for 14 days at each reactor is illustrated in figure 1 below:

![](image)

**Figure 1. pH Value**

Based on figure 1, pH values in reactors with the addition of SLS were similar to the control reactor. The reactors with the addition of SLS not affected the pH values with the control. The values of pH in the first day is in a neutral range. These results are caused by the addition of NaHCO3 as a pH buffer. Then ph values in five reactors declined on the 6th day in the range of pH 6.3-6.5 and then
increased on the 15th in the range of 6.43-6.79. This condition can support the growth of anaerobic bacteria, in which optimum pH is in the range 6-7.6.

- Temperature

This parameter is controlled during the running stage. The value of temperature is the most important parameter in determining the success of the anaerobic process. The value of temperature for 14 days at each reactor is illustrated in figure 2. below:

![Figure 2. Temperature](image)

Based on figure 2, the temperature showed the same tendency for reactors with or without addition SLS. The temperature in five reactors was relatively stable in the range of 26.1-27.6. This condition can support the growth of anaerobic bacteria. According to Mustami [4] which state that the optimum temperature for the anaerobic process is in the mesophilic temperature range (25-40˚C).

- COD

This parameter is used to observe bacteria activity through oxygen needed to degrade organic compounds in wastewater during the running stage. The value of pH for 14 days at each reactor is illustrated in figure 3. below:

![Figure 3. COD Concentration](image)

Based on figure 3, the best efficiency COD removal was found in the reactor with the addition of 5 mg/L SLS, which was then continued by the reactor control reactor. In the reactor 5 mg/l, anaerobic bacteria grow and multiply quite well in the running process. Meanwhile, with an addition of SLS more than 5 mg/l tends to inhibit the anaerobic process because SLS may have a toxic effect on the growth of anaerobic bacteria. Higher SLS concentration slower is COD decrease. According to Sun’s research [5] with the addition, 5 mg/g surfactant can increase the breakdown of organic compounds, whereas the 15 mg/g surfactant exhibited an inhibitory effect. Furthermore, according to Wandzel’s research [6] which states the higher content, the slower is COD decreases.
- Ammonium (NH$_4^+$-N)
This parameter is controlled during the running stage. The value of ammonium (NH$_4^+$-N) for 14 days at each reactor is illustrated in figure 4 below:
Figure 4. Ammonium (NH$_4^+$-N) Concentration

Figure 4 shows the performance of ammonium concentration removal in five reactors. In the reactor control with no addition of SLS, the ammonium removal efficiency at the level 73.32% with an average reduction rate of 1.30 mg NH$_4^+$-N/l.day. At the addition of 5 mg/l SLS, the efficiency and rate of ammonium removal were indeed lower than the efficiency and rate ammonium removal at the reactor control. the efficiency and rate of ammonium removal in R5 at the level 58.26% and 1.07 mg NH$_4^+$-N/l.day. At R10, R50, and R100, the efficiency and rate of ammonium removal were indeed lower than the reactor control and reactor 5. It can be seen that the higher SLS concentration, the slower efficiency and ammonium removal rate.

4 Conclusion

Based on the results of the analysis and discussion in the previous chapter on the effect of variation of SLS concentration on COD and ammonium removal process by anaerobic bacteria, it can be concluded that the addition of 5 mg/l SLS, the value of efficiency and COD removal rate higher than reactor control. Whereas, the addition of SLS concentration more than 5 mg/l tends to inhibit the anaerobic process. The variations of SLS concentration has a significant effect on the efficiency and ammonium removal rate in batch.

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