Study of anaerobic biofilter tofu wastewater treatment with bioball media and phytoremediation by kiambang (*salviniamolesta*)

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Abstract. Small and medium industries such as tofu industry are characterized as industries with high levels of pollution because it lacks or does not have a wastewater handling system. Tofu wastewater contains high level of chemical oxygen demand (COD) and total suspended solid (TSS). If referring to the standard quality of wastewater, tofu wastewater requires treatment before being discharged into water bodies. This research aims to find out the effect of residence time and plant mass variation on the efficiency of reducing COD and TSS in tofu wastewater. This research used anaerobic reactors with bioball media and phytoremediation reactors using kiambang (*salviniamolesta*) with plant mass variations of 50, 100, 150, 200 and 250 grams. The research begins with the process of seeding to breed microorganisms derived from tofu wastewater then proceed with running on the anaerobic reactor until the reduction in COD reaches 60% - 70%. On the 6th day of running, the reduction in COD has reached 66.66% so that it can be continued flowing tofu wastewater to the phytoremediation reactor. The process of running on phytoremediation is done with variations in plant mass and residence time of 0, 1, 2, 3, 4, 5, 6, and 7 days. The results showed that the variation of residence time affected the level of COD and TSS reduction. In phytoremediation reactors, the best plant mass in reducing COD levels is 250 grams with removal efficiency at D-7 reaching 59.61% while the best plant mass in reducing TSS levels is 50 grams with removal efficiency at D-7 reaching 89.41%.

1. Introduction

The amount of wastewater produced from industrial processes varies greatly. Both in terms of supervision of the industry, the size of the industry, water usage, and availability of wastewater treatment [1, 2, 3]. The existence of tofu industry is quite helpful in absorbing labor so that it can improve the economy of the community, but on the other hand the resulting wastewater can pollute the environment if it is directly discharged into water bodies without any prior treatment [4]. Liquid waste generated from the tofu industry mostly comes from the washing process, soaking, and liquid in the production process. The wastewater contains high levels of Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). Where tofu wastewater contains BOD around 5643-6870 mg/L and COD content around 6870 mg/L - 10,500 mg/L. If the results are compared with PERMEN LH No. 5 of 2014 [5], with a limit of COD of 300 mg/L and BOD of 150 mg/L, further processing of tofu wastewater is necessary because it exceeds quality standards [6].
Treatment is needed to reduce pollutant parameters in wastewater to meet quality standards so that it does not pollute the environment. One type of treatment that can be done to treat wastewater is anaerobic treatment. This treatment utilizes microorganisms in wastewater to decompose organic substances where this processing also produces by-products in the form of biogas which can be used as an energy source [7, 8, 9, 10]. In the process of treating wastewater containing high biodegradable organic compound pollutants, it usually uses the activity of microorganisms to decompose these organic compounds. Biological processing can be done by aerobic or anaerobic. The aerobic process is used for wastewater with a BOD load that is not too high, while the anaerobic process is used in vacation water with a very high BOD load [11].

There are several processes used in treating tofu wastewater so as not to pollute the environment. One example is the phytoremediation process, in which phytoremediation is a way of working plants that can change pollutants in wastewater to be less or no longer harmful to the environment. Some of the benefits obtained from the phytoremediation process are in terms of lower costs, fairly easy maintenance and operation, and have quite high efficiency. Kiambang is a good remediator plant in remediating both organic and inorganic waste because it has high hyper accumulator properties and fast growth [9]. Kiambang morphologically has a relatively small diameter of leaves (measuring 2-4 cm) but has a long and thick roots. Based on this, kiambang is expected to actively absorb pollutants but will not prevent the penetration of light into the waters [12].

The research that will be carried out is a decrease in levels of BOD, COD and TSS using kiambang (salviniamolesta) with phytormediation methods of tofu wastewater after anaerobic process. Anaerobic processes are carried out because tofu wastewater contains high levels of BOD, COD and TSS, so the appropriate biological treatment process is to use anaerobic processes. The study was conducted in batch with an anaerobic biofilter system attached system. The media used as a place to grow and develop bacteria is biofilm. The choice of media because biofilm has a large enough specification area, easy installation making it suitable for small-scale WWTP, and also can minimize the occurrence of clogging or blockage. Furthermore, the research will continue with the phytoremediation process with kiambang plants because it is an easy and efficient process. Kiambang plants are used because they have the ability to reduce COD and TSS in tofu wastewater and are easy to find.

2. Method

This research uses anaerobic bio filter bioball media and phytoremediation systems with kiambang plants (salviniamolesta) consisting of seeding, acclimatization, and running stages. The sample used was tofu waste water taken from UD Ponimin located on JlCintaKarya Padang Bulan, Medan. Tofu wastewater is treated anaerobically and using a batch system. This research was carried out with variations in plant mass and residence time to determine the effect of mass and residence time on the ability of kiambang plants to reduce levels of Chemical Oxygen Demand (COD) and Total Suspended Demand (TSS). Planned residence times for this study were 0, 1, 2, 3, 4, 5, 6, and 7 days. For plant masses 50, 100, 150, 200 and 250 grams are used. This research was conducted at the North Sumatra Environmental Engineering Laboratory. For testing carried out at the Environmental Health Engineering Center (BTKL) located on Jl. Kyai Haji Wahid Hasyim No.15 Babura, Medan Baru, Medan City, North Sumatra and the Industrial Chemical Technology Polytechnic Laboratory (PTKI) on Jl Menteng VII Medan.

Fixed variables from this research are tofu wastewater and kiambang plants. For the change variables used are plant mass 50, 100, 150, 200 and 250 grams and the residence time used is 0, 1, 2, 3, 4, 5, 6, and 7 days. Parameters to be tested from the study is Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS). This research uses a batch system where 5 reactors are needed. One glass reactor measuring (50 x 30 x 30) cm as a container for anaerobic processes. Five plastic reactors with 5 L capacity as phytoremediation reactors of kiambang with mass variations of 50, 100, 150, 200 and 250 grams and one plastic reactor as a container for control water.
2.1. Seeding process in anaerobic reactors
Tofu waste water is put into an anaerobic reactor with a volume of 40 liters. The seeding process is carried out in batches and the outer surface of the anaerobic reactor is closed using carbon paper. The seeding process is carried out for 20 days. Based on research by Ningrum about processing fecal waste with wasp nest biofilter media with seeding time for 10 days can reduce COD levels by 95%, this proves that the growth of microorganisms occurs. During the seeding process temperature, PH and COD concentrations were tested to determine the substrate concentration in the reactor. The success of the process can be seen from the decrease in COD where the COD condition has been steady state, that is fluctuation in COD decrease of ± 10%.

2.2. Running process in anaerobic reactors
After the seeding process has been running constantly and signs of bacterial growth have been seen, then proceed with the running process. Furthermore, the COD and TSS tests were carried out on tofu wastewater before running. The running process is done by a batch system where the experiment is carried out with a planned residence time i.e. until the COD decreases to 60% -70%. Then the COD and TSS measurements were made at the anaerobic reactor outlet.

2.3. Acclimatization process in kiambang plants
Kiambang plants are selected based on the type of plants that are still fresh where the leaves do not wilt and the color of the leaves has not started to turn yellow. Kiambang plants are put into a phytoremediation process reactor that contains clean water for 4 days before clean water is replaced by tofu wastewater. Based on research, the selection of time for 4 days so that plants are neutralized properly. Furthermore, the process of replacing clean water with tofu wastewater is carried out in stages until replaced by 100%. This change process lasted for six days.

2.4. Process running of phytoremediation
Before entering the phytoremediation reactor, it is necessary to test the COD and TSS levels obtained from the anaerobic reactor outlet. The running process can be done after the acclimation process has been running stable. This process uses a batch system in which 5 reactors are used according to the mass variation of 50, 100, 150, 200 and 250 grams, and one reactor as a control reactor. The COD and TSS levels were then tested at the outlet of the phytoremediation reactor.

3. Results and discussions
The results will be discussed in 6 subsections, they are result of anaerobic reactor bioball media, results of running anaerobic reactor bioball media, results the phytoremediation process uses kiambang, effect variation of kiambang mass and residence time on COD decrease in phytoremediation processes, effect variation of kiambang mass and residence time on TSS decrease in phytoremediation processes, and kiambang plant growth.

3.1. Results of anaerobic reactor bioball media
Breeding or seeding is the first step carried out in the anaerobic process where at this stage the propagation of microorganisms is carried out with bioball media. The inoculum is obtained from sludge that comes from a tofu wastewater outlet before being discharged into water bodies. The seeding process is carried out for 20 days with a batch operating system. Wastewater is left in the anaerobic reactor to form biofilms in the bioball media layer.

The purpose of seeding is to seed bacteria by inserting waste water into the reactor so that bacteria contained in the media can oxidize organic pollutants contained in the wastewater so that they are able to breed microorganisms contained in the reactor [11]. Inspection of the seeding stage is seen visually from bacterial growth by forming biofilms on bioball media. In addition, a COD test was also carried out until the COD value in a steady state or fluctuation in COD decreased to 10%.
Based on observations made during the seeding stage, a black biofilm layer began to form on D-6. According to Filliazati [9] when a black-brown mucus layer is formed and is not easily separated, it can be ascertained that there has been growth of microorganisms on the media. It can be seen on the 6th day that the surface seeding stage of the media is almost completely covered by a biofilm layer.

![Figure 1](image1.png)

**Figure 1.** pH conditions in the anaerobic reactor seeding process.

In monitoring during the seeding process, it is necessary to analyze the COD value until the COD reaches a steady state. Based on the results of research conducted, the COD value obtained on the first day is 2714.5 mg/L. COD measurement analysis is carried out in order to find out how much the decrease in organic load and increase in microorganism growth in the reactor [12],[13]. According to Bulan [14], the COD value in the anaerobic reactor continued to decrease from D-0 of 2714.5 mg/L to D-20 of 224.4 mg/L. This is because metabolic processes occur in microbes where high carbon values are needed for microbes as an energy source in order to grow and adapt.

COD value continued to decrease from D-0 to D-20 with the greatest efficiency decrease in COD occurred at D-20 was 91.73%. The seeding process was stopped at D-20 because the COD value was already in steady state at D-16, D-18 and D-20 where each COD value was 252.96 mg/L, 228.68 mg/L and 224.4 mg/L. The reduced COD value during the seeding process indicates that microbes are able to adapt to wastewater so that it can degrade organic materials contained in wastewater. The stable value of COD indicates that microorganisms are able to adapt well in the wastewater reactor and indicate that the condition in the reactor is stable and ready to operate to set aside the parameters of pollutants in the wastewater to be treated. Thus, the seeding process can already be stopped to subsequently enter the running stage [10].

![Figure 2](image2.png)

**Figure 2.** COD analysis in the seeding process of anaerobic reactor.

3.2. Results of running anaerobic reactor bioball media

After going through the seeding process for 20 days, the next process that is carried out is running in the anaerobic reactor until the COD reduction reaches 60% -70%. Running process is done by a batch system. The parameters measured in the running process are COD, TSS, pH and temperature. At this stage it is
expected that a decrease in COD can be continued to the next stage which is phytoremediation using kiambang plants. The running process is done by adding waste water to the anaerobic reactor.

There is a relationship between COD removal and residence time. It is seen that the highest COD concentration value occurred on day 0 of 1346.4 mg/L and the lowest COD value occurred on day 6 which was 448.8 mg/L. The results showed that the allowance for COD concentrations at D0 = 1346.4 mg/L, D1 = 1183.2 mg/L, D2 = 775.2 mg/L, D3 = 652.8 mg/L, D4 = 530.4 mg/L, D5 = 530.4 mg/L, and D6 = 448.8 mg/L. And for the highest efficiency of removal COD concentrations occurred on the 6th day that is 66.66%. From the research it was found that the longer the residence time in the anaerobic reactor, the COD value decreases and the efficiency is greater.

![Figure 3. COD analysis in the running process of anaerobic reactor.](image1)

The concentration of COD in wastewater shows the amount of oxygen needed for microorganisms to decompose organic materials contained in wastewater chemically. Decreased TSS levels that occur due to the processing carried out by microorganisms attached to the bioball media of organic substances in tofu wastewater [16]. The decrease in TSS levels during the running process is caused by the processing of organic substances found in wastewater such as proteins, carbohydrates and fats that are attached to biofilter media by microorganisms [17].

![Figure 4. TSS Analysis in the running process of anaerobic reactors.](image2)

It can be seen that the value of TSS continues to decline. The value of TSS concentration reduction at D0 = 613 mg/L, D1 = 557 mg/L, D2 = 475 mg/L, D3 = 407 mg/L, D4 = 395 mg/L, D5 = 368 mg/L and D6 = 333 mg/L. The highest TSS value occurred on day 0 which is equal to 613 mg/L. Whereas the lowest TSS value occurred on the 6th day which was 333 mg/L. The results obtained showed that the highest efficiency occurred at H6 that is 45.67%. From the results obtained it is known that the longer the residence time, the lower the TSS levels contained in the reactor. In the study of Wardhani et al (2014) succeeded in reducing TSS in tofu wastewater treatment with pond technology - biofilms using fish and bioball netted biofilter media with an average TSS value of 62% -74%. The residence time used in this study was 0, 1 and 5 hours. It is known that the highest efficiency occurs at the contact time of 5 hours that is equal to 74.30%. From the above contact time it can be seen that the greatest efficiency occurs at the longest contact time.
3.3. Results the phytoremediation process uses kiambang

After passing the anaerobic running process, the COD and TSS values produced are still not below the quality standard according to PERMEN LH No.5 of 2014. Therefore, it is necessary to conduct further treatment of wastewater generated from the running process. The method chosen as the next treatment is phytoremediation. Phytoremediation technique itself is defined as a technology for cleaning, reducing and removing pollutants both in the soil and in water with the help of plants.

The first step taken in the phytoremediation process is neutralization. At this stage the plants are allowed to stand for four days in clean water like the research that has been done previously by Ponty [18] and it is hoped that the impurities in the plants will be released. Neutralization is carried out by using 5 reactors in which each reactor contains 5 liters of clean water and contains plants according to predetermined variations, namely 50, 100, 150, 200, and 250 grams. The next stage carried out after the neutralization process is complete is the acclimatization process. According to Ponti [18], the acclimation process is an adaptation process carried out for plants and microorganisms for wastewater to be treated. Provision of water in stages aims to avoid the occurrence of shock loading or sudden loading that can kill microbes. Substitution of clean water with wastewater to be treated is done in stages and for 6 days until 100% of clean water is replaced with wastewater to be treated [18].

In the process of neutralization and acclimatization, pH values affect plant growth. Based on the PP No.82 of 2001 Concerning Water Quality Management and Water Pollution control, the pH value for class IV classification is the water used to irrigate plants in the range of 5-9. While based on the results of the study found the pH value during acclimatization is in the range of 5.6 - 6.2. Thus, the pH conditions in the phytoremediation reactors are still in the pH range for plant growth.

![Figure 5. pH value in the acclimatization process with kiambang.](image1)

Besides pH, temperature is also a factor that influences plant growth. Kiambang are plants that like the tropical climate where the plants experience optimum growth at water temperatures of 20 °C-30 °C. Kiambang plant shoots will die if it is at temperatures above 43 °C and below 3 °C. Based on the results of the analysis of the temperature in the phytoremediation reactor is in the range of 28 °C - 31 °C, so it is still in the optimum range for the growth of kiambang.

![Figure 6. Temperature value in the acclimatization process with kiambang.](image2)
The COD value entered in the acclimatization process is the COD value from the outlet of the anaerobic reactor running process that is 448.8 mg/L. In the five phytoremediation reactors, wastewater was put in the same concentration of COD and TSS. At the acclimatization stage, there has been a decrease in COD concentration until the COD value has not exceeded the quality standard according to the PERMEN LH No.5 of 2014 where the standard quality of the COD parameter is 300 mg/L. The value of COD concentration in the acclimatization process decreased from 448.8 mg/L to 224.4 mg/L (50 gram), 199.92 mg/L (100 grams), 183.6 mg/L (150 grams), 163.2 mg/L (200 gram) and 232.56 mg/L (250 gram). Even though the value of COD concentration in the acclimatization process has been below the quality standard, but the process of running phytoremediation is still being done to determine the ability of kiambang plants in reducing the COD and TSS parameters found in tofu wastewater.

3.4. Effect variation of kiambang mass and residence time on COD decrease in phytoremediation processes

COD measurements are carried out every day for one week. COD measurements were carried out in 6 phytoremediation reactors. Namely the reactor variations in plant mass 50, 100, 150, 200, 250 grams and one control reactor. The COD value in the control reactor on the 7th day was the biggest value because no treatment was carried out at 236.64 mg/L. Based on the results of the COD analysis that has been done, it can be seen that the COD concentration is increasingly decreasing and the COD removal efficiency is increasingly increasing. The most optimum COD removal was found on the 6th day with 250 gram plant mass variation was 71.4 mg/L. Whereas the highest COD value was found on day 1 with variations in plant mass of 250 grams was 232.56 mg/L.

![Figure 7. COD analysis in the running phytoremediation process.](image_url)

In the mass variation of 50 grams of COD decreased from 0 to 7 days by 224.4 mg/L - 107.2 mg/L with an efficiency of 52.23%. For 100 grams decreased COD levels from day 0 to day 7 amounted to 199.92 mg/L - 100.57 mg/L with an efficiency of 49.69%. For 150 gram plant mass, COD decreased from day 0 to day 7 by 183.6 mg/L - 97.92 mg/L with an efficiency of 46.67%. While the plant mass of 200 grams from days 0 to 7 had a COD decrease of 163.2 mg/L - 93.84 mg/L with an efficiency of 42.5%. And the last for 250 gram plant mass decreased COD from day 0 to day 7 amounted to 232.56 mg/L - 93.94 mg/L with an efficiency of 59.61%.

Based on research it is known that each plant mass has a considerable amount of COD reduction. However, the greater amount of plant mass will also result in competition between plants. The large number of plants will lead to competition between farmers, each of which will fight over the materials needed by plants such as water, light and [19]. The competition between plants will result in disruption of photosynthesis. The process of photosynthesis that is not good will affect the decrease in levels of pollutants in water. The change in leaf color is a result of disruption of the process of formation of chlorophyll or better known as chlorosis [19]. This has resulted in the death of kiambang on the 7th day which causes an increase in COD levels. Where, the condition of the leaves is brown and the wastewater is getting blackened.
3.5. Effect variation of kiambang mass and residence time on TSS decrease in phytoremediation processes

TSS measurements are carried out once a day for one week with 5 variations in plant mass 50, 100, 150, 200, and 250 grams. TSS testing is conducted at the Laboratory of the Center for Environmental Health and Disease Control Techniques using a spectrophotometer.

![Figure 8. TSS analysis in the running phytoremediation process.](image)

Based on the results of TSS analysis that has been done, it is known that the mass variation of 50 grams of TSS decreases from 0 to 7 days by 595 mg/L - 63 mg/L with an efficiency of 89.41%. For 100 grams decreased TSS levels from day 0 to day 7 by 521 mg/L - 75 mg/L with an efficiency of 85.6%. For 150 gram plant mass, TSS decreased from day 0 to day 7 by 549 mg/L - 93 mg/L with an efficiency of 83.06%. While the 200 gram plant mass from day 0 to day 7 decreased TSS by 550 mg/L – 152 mg/L with an efficiency of 72.36%. And the last for 250 gram mass decreased TSS from day 0 to day 7 by 572 mg/L - 149 mg/L with an efficiency of 73.95%.

Based on research data, the longer the contact time that occurs, the greater the decrease TSS. Thus, there is a relationship between contact time and decreased levels of TSS. This proves that kiambang plants can reduce TSS levels in tofu wastewater. According to Ruhmawati [20], the decomposition of organic matter, the absorption of organic substances by plants, and the deposition of the results of the decomposition of organic substances are the causes of decreased levels of TSS in water. Phytodegradation process is a mechanism for aquatic plants in bioremediation. In the process of phytodegradation, there is a decomposition of contaminants in wastewater caused by microbial activity at the roots of aquatic plants. Microbes live from carbon sources found in plants. Contaminants that are absorbed by aquatic plants are then continued to be distributed into several plant organs.

3.6. Kiambang plant growth

Kiambang (salviniamolesta) is a type of plant that floats on the surface of the water. This plant can live in the tropics, sub-tropical and warm temperatures throughout the world. Kiambang in general can be found in waterways, rivers, rice fields and ponds. This plant is a type of weed that can multiply quickly and can adapt to various environmental conditions [21].

| Table 1. Change wet weight of the plant |
|---------------------------------------|
| Plant mass D-0 | Plant mass D-7 |
|----------------|---------------|
| 50 gram        | 48.5 gram     |
| 100 gram       | 98.6 gram     |
| 150 gram       | 120.5 gram    |
| 200 gram       | 155.2 gram    |
| 250 gram       | 195. gram     |
Based on the table 1 it can be seen that kiambang experienced a decrease in wet weight on the 7th day. At the beginning of the study the plants were weighed with variations of 50, 100, 150, 200, and 250 grams. Plants with a variation of 50 grams experience a decrease in wet weight that is not too large, which is 48.5 grams. For the variation of 100 grams, the wet weight decreased to 98.6 grams. For 150 gram plant mass, the wet weight decreased to 120.5 grams. Whereas the 200 gram plant mass experienced a large decrease in wet weight which was 155.2 grams. And the last variation in mass of 250 grams has decreased to 195.6 grams. It can be seen that plants with greater variation experience greater decreases in wet weight due to plant death. This happens because the greater the mass of the plants the plants will compete with each other to fight over the nutrients and other ingredients needed.

From the research carried out it is known that plants with a mass of 250 grams are more effective in reducing COD levels. Where a 250 gram plant mass decreased the COD value from day 0 to day 7 by 232.56 mg / L - 93.94 mg / L with an efficiency reaching 59.61%. As for the TSS, the best reduction occurred in 50 gram plant mass. Where plants with a mass of 50 grams can reduce TSS levels from days 0 to 7 by 595 mg / L - 63 mg / L with an efficiency of 89.41%. This shows that kiambang plants are effective in reducing the levels of COD and TSS contained in tofu wastewater and it is known that all variations of the mass of the kiambang plants used starting from 50, 100, 150, 200, and 250 grams can reduce the levels of COD and TSS up to below the quality standard.

4. Conclusions
- The anaerobic biofilter reactor of the bioball media is able to set aside the COD and TSS parameters found in tofu wastewater. In the anaerobic reactor seeding process the COD concentration decreased COD from day 0 to day 20 with a removal efficiency of 91.73%. Whereas in the running process of anaerobic reactor on the 6th day the efficiency of COD concentration removal was 66.66%.
- It is known that the best mass of the kiambang plant in reducing COD levels is a plant with a mass of 250 grams with an efficiency of 58.06%. As for the TSS content of kiambang, the best to use is a plant with a mass of 50 grams with a removal efficiency of 89.41%.
- From the results of the study note that there is a relationship between the efficiency of the removal of COD and TSS concentrations with residence time. The most effective residence time for reducing COD and TSS levels in tofu wastewater using kiambang plants is 6 days for all variations of plant mass, because on the 7th day the plants have begun to wilt and even experience death.

Reference
[1] Irvan, Trisakti B, Sosanty F and Tomiuchi Y 2016 Asian J. Chem. 28 377-380
[2] Trisakti B, Irvan, Zahara I, Taslim and Turmuzi M 2017 AIP Conf. Proc. 1840 7
[3] Trisakti B, Irvan, Mahdalena, Taslim and Turmuzi M 2017 IOP Conf. Ser: Mater. Sci. Eng. 206 8
[4] Yanqoritha N, Turmuzi M, Irvan, Fatimah, and Derlini 2018 Oriental Journal of Chemistry 34 (3) 1653-1657
[5] Peraturan Menteri Lingkungan Hidup No. 5 Tahun 2014
[6] Sungkowo TH, Elystia Shinta, Andesgur Ivanaini 2015 JOM FTEKNIK Volume 2 No.2
[7] Irvan I, Trisakti B, Sidabutar R, Lubis AH, Cahyani SE, Zusri AS and Daimon H 2020 Combination of CSTR and membrane process in treating palm oil mill effluent (POME) AIP Conf. Proceed. 2197 110003
[8] Irvan, Trisakti B, Nainggolan RM, Hasibuan R and Daimon H 2019 Study of gravity thickener as sludge separator in fermentation of palm oil mill effluent to biogas at pilot scale AIP Conf. Proceed. 2085 020027
[9] Irvan, Trisakti B, Maulina S and Daimon H 2018 Production of biogas from palm oil mill effluent: Effect of recycle sludge Oriental Journal of Chemistry 34 (1) 161-168
[10] Maulina S, Irvan, Trisakti B and Daimon H 2018 Development of anaerobic digestion of palm oil mill effluent with heated recycle sludge *Rasayan J. Chem*, 11 (3) 1151-1158

[11] Rahadi B, Wirosodarmo R, Harera A 2015 *Jurnal Sumberdaya Alam dan Lingkungan*

[12] Simatupang I, Fatonah S, Irianı D 2015 *JOM FMIPA* Volume 2 No. 1

[13] Rahmawati A, Zaman B, Purwono 2016 *Jurnal Teknik Lingkungan* Volume 5 No.4

[14] Filliaziati M, Apriani I, Zahara TA 2013 *Pengolahan Limbah Cair Domestik Dengan Biofilter Aerob Menggunakan Media Bioball dan Tanaman Kiambang*

[15] Ningrum IH 2018 *Studi Penurunan COD Dan Amonia Pada Limbah Cair Tinja Menggunakan Biofilter Anaerob Media Sarag Tawon*. Medan : Universitas Sumatera Utara

[16] Said NI 2017 *Teknologi Pengolahan Air Limbah Teori dan Aplikasi*. Jakarta : Erlangga

[17] Anggraini D 2014 *JSAL* Volume 1 No.3

[18] Putri I 2017 *Studi Penurunan COD Dan Fosfat Pada Air Limbah Laundry Buatan Menggunakan Biofilter Anaerobikaerobik Tercelup Dengan Media Bioball*. Medan : Universitas Sumatera Utara

[19] Bulan R 2018 *Pengaruh Variasi Beban Organik Pengolahan Limbah Cair Industri Tahu Menggunakan Reaktor Anaerobik*. Medan : Universitas Sumatera Utara

[20] Sato A, Utomo P, Abineri HSB 2015 *Seminar Nasional Sains dan Teknologi Terapan III Institut Teknologi Adhi Tama Surabaya*

[21] Rizki N, Sutrisno E, Sumiyati S 2014 *Penurunan Konsentrasi COD dan TSS pad Limbah Cair Tahu dengan Teknologi Kolam (pond) – Biofilm Menggunakan Biofilter Terjaring Ikan dan Bioball*

[22] Ariani W, Sumiyati S, Wardhana IW 2014 *Studi Penurunan Kadar COD dan TSS pada Air Limbah Cair Rumah Makan Dengan Teknologi Biofilm Anaerob-Aerob Menggunakan Media Bioring Susunan Random*

[23] Ponty AJ 2018 *Studi Perbandingan Kemampuan Tanaman Eceng Gondok Dan Kangkung Air Dalam Menurunkan COD Dan Amonia Dari Pengolahan Lanjut Biofilter Anaerob Media Sarang Tawon*. Medan : Universitas Sumatera Utara

[24] Herlambang P, Hendriyanto O 2016 *Jurnal Ilmiah Teknik Lingkungan* Volume 7 No.2

[25] Ruhmawati T, Sukandar D, Karmini M, Roni T 2017 *Jurnal Pemukiman* Volume 2 No. 1