International Seminar of Research Month 2021
Volume 2022
http://dx.doi.org/10.11594/nstp.2022.2446

NST PROCEEDINGS

OPEN ACCESS

Conference Paper

Tofu Wastewater Treatment with Variation of Air Rate in Aeration Suspension System

Rizka Novembrianto *, Restu Hikmah Ayu Murti , Firra Rosariawari

Environmental Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, Indonesia

*Corresponding author:
E-mail: rizka.tl@upnjatim.ac.id

ABSTRACT

There are many small-scale industries in Indonesia. It is also rare to find a tofu industry that has wastewater treatment. This contributes to water pollution and worsens river water quality if it is not treated first. This study aims to treat small-scale tofu industrial wastewater easily to reduce its organic content with a suspension aeration system. Modified seeding process with the addition of a small amount of Calcium Carbonate to raise the pH. The seeding process was carried out for 20 days with the highest MLSS value of 1136 mg/L. Furthermore, the acclimatization process was carried out for 11 days for reactor stability with a COD removal percentage of 83.15%. The running process was carried out in an aeration tank for 18 hours and continued with the best recirculation at 5 hours with an oxygen rate of 12 L/min. The best achievement in decreasing COD content was 89.79%, TSS was 74.14% and N-Total was 69.55%.

Keywords: Tofu industry, suspended aeration, organic content

Introduction

In Indonesia, tofu and tempeh are usually produced using traditional technology. The number of tofu and tempeh consumption per capita per week increased by 3.80% and 2.06% consecutively in 2017, compared to 2013 (Nugroho et al., 2019). Enhancement consumption of tofu and tempeh is directly proportional to the amount of production in the tofu industry and related to the amount of waste generated. Tofu liquid waste generally consists of high organic components, such as COD 7,500-14,000 mg/L, TSS 638-660 mg/L, and Nitrate (NO_3) 3.5-4.0 mg/L (Nur et al. 2020). This figure has exceeded the required limit government in the Regulation of the Minister of the Environment No. 5 of 2014 concerning Water Quality Standards Waste.

The tofu industry with small-scale businesses uses energy that has efficiency low energy but has the potential risk of high levels of pollution. This matter is due to the unavailability of wastewater treatment for the small-scale tofu industry (Anwar, 2020). Tofu wastewater can also cause unpleasant odors, and contamination of surface waters, and groundwater (Belén et al., 2012). Damayanti et al, (Damayanti et al., 2004), mentions several risk analysis of wastewater from tofu factory activities from environmental components such as water quality, aquatic flora, land flora, and water fauna and land fauna. Generally tofu industrial wastewater, the water is channeled directly into water bodies without having to go through processing first so that it can pollute the environment. This can reduce the carrying capacity and environmental capacity (Ahmad & Adiningsih, 2019). In Article 1 point 14 Ministry of Environmental Number 32. The year 2009 states that environmental pollution is a measure of the limit or level of the environment by human activities so that it exceeds the environmental quality standards that are has been determined.

How to cite:
Novembrianto, R., Murti, R. H. A., & Rosariawari, F. (2022). Tofu wastewater treatment with variation of air rate in aeration suspension system. *International Seminar of Research Month 2021*. NST Proceedings. pages 298-306. doi: 10.11594/ nstp.2022.2446

This study examines the processing of tofu waste to decrease and manage COD, MLSS, DO, and temperature levels so that they do not contaminate the environment when thrown into rivers or other suitable locations by simple reactors in a few days. Because it just takes a few days and only requires simple reactors, this method could be a feasible option for the tofu industry.

Material and Methods

The tofu wastewater used in this study was collected from a tofu manufacturing plant in Bohar, Sidoarjo, Indonesia. Two distinct reactors, seeding, and acclimatization were employed in this study. The pH that was applied in this study was 3.3, which is the natural pH that tofu factories produce. In this study, we compared the rate of air in degrading wastewater which was added with CaCO3 (Azhari, 2016) to accelerate the increase in pH. Up to pH 5.5. This research used testing Indonesia's Standard water quality test. The test analysis method in this study uses the appropriate standard method in Table 1.

Table 1. Standart methods

Parameters	Standart Method
COD	SNI 6989.73 - 2019
TSS	SNI 6989.3 - 2019
N-Total	Kjedhal
MLSS	Gravimetry

This research has been done by following Figure 1. Before entering the process of raw wastewater the parameters were analyzed, this aims to know the initial condition of wastewater. The seeding process was the first process to treat the wastewater to grow the bacteria (Kahar et al., 2017), and continue to acclimatization and Aeration process. The organisms were placed in an anaerobic bioreactor before the process began to ensure their survival. The seeding procedure is used to increase and develop the population of microorganisms in the substrate that will be treated in the bioreactor

This research was carried out as shown in Figure 1 below. In the process of growth of micro-organisms, COD, MLSS, and pH parameters were tested. During acclimatization, COD, DO and pH tests were carried out and during the deposition process by running recirculation and sedimentation detention times of 1,2,3,4 and 5 hours, COD, TSS, and N-Total tests were carried out.

Calculation of percent removal on the parameters of COD, TSS, and N-Total with the following calculations;

$$Persen\ Removal\ =\ (1-\ (\frac{Cin}{Cout})\ )x\ 100\ \%$$

where Cin = the concentration of incoming wastewater and Ceff is the treated wastewater. This wastewater treatment process consists of three segments seeding, acclimatization, and running processes.

a. Microorganism breeding process
   The sample was seeded using a blower pump with an air rate of 4 L/min with an air hole diameter of 5 mm in a 10 L reactor. The air holes were made large to reduce and prevent excessive foaming due to air bubbles from the reactor. blower pump. Then check COD, MLSS, pH, and temperature. The seeding process was carried out for 20 days.
b. Process Adaptation to wastewater (acclimatization)
   After the seeding process, an acclimatization process is carried out which serves to gradually adapt the microorganisms to the new wastewater. On the first day of acclimatization by entering wastewater into the reactor with a concentration of 20%, on the second day, it was 40% and until the 5th day, it was 60%, 80%, and 100% respectively. Then treatment for several

days until it reaches stability in treating wastewater. During the acclimatization process, the aeration contact time was used for 24 hours by checking DO, COD and pH, and temperature.

c. Treatment Process (Running)

For treatment during the running process by adding $CaCO_3$ until it reaches pH 5.5 (Azhari,2016) in the wastewater before entering the reactor. During the aeration process for 18 hours with variations in air rates of 4, 8, and 12 L/min. After 18 hours in the aerator, the wastewater flowed into a sedimentation tank with recirculation of 100 L/min for 1,2,3,4, and 5 hours to test samples on COD, TSS, and N-Total parameters.

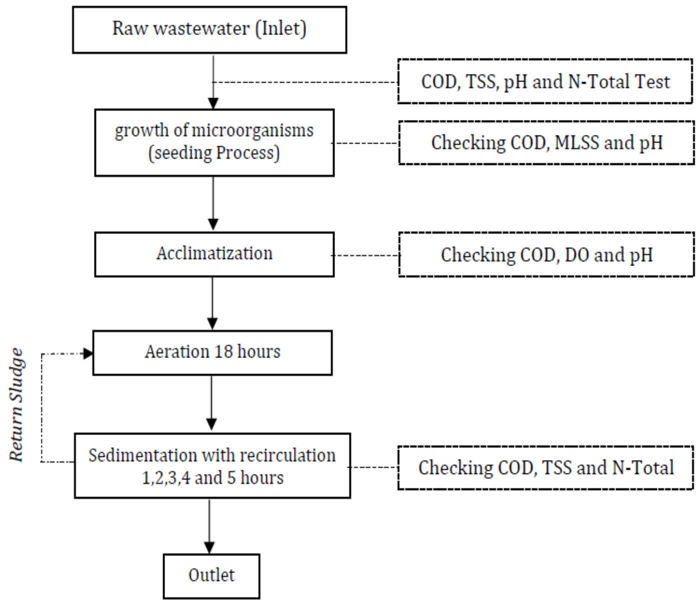

Figure 1. Flowchart research methods

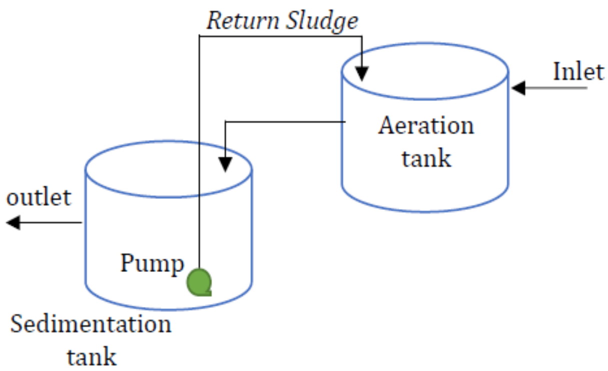

Figure 2. Reactor Process

Results and Discussion

The initial results of the tofu industrial wastewater can be seen in Table 2. Analysis of wastewater has a very high organic content and contributes to polluting the environment. The characteristics of wastewater are as follows:

Table 2. Preliminary analysis of wastewater

Parameters	Result (mg/L)
COD	6390
TSS	1300
N-Total	310

Results of the wastewater shown in Table 2 above, shows that the wastewater is far from the quality standard of the Minister of Environment Regulation No. 5 of 2014 with COD parameters of 300 mg/L, and TSS of 150 mg/L.

Seeding and acclimatization process

The seeding process is carried out for 20 days and continues with acclimation for 11 days. COD was one important parameter in aerobic digestion because it represents the presence of all forms of organic matter in water (Islam et al., 2019). The growth of microorganisms carried out in suspension is very effective in controlling the odor of wastewater. But generally, use attached growth in the seeding process.

Table 3. Results of the analysis during the seeding process

Day	Parameter			
	COD (mg/L)	MLSS (mg/L)	nperatur (°C)	pH
1	4705	455	29.3	7.8
2	4156	590	29	7.9
3	3803	610	29.6	8.5
4	2647	733	31	8.7
5	2490	933	29.3	9.1
6	2325	800	27.8	8.8
7	1864	700	27.3	8.9
8	1460	800	28.5	8.8
9	1390	620	27	9.0
10	1411	650	26.5	8.6
11	1568	460	31.2	8.6
12	1411	360	30	8.8
13	3670	400	28.7	7.9
14	1602	644	30	8.1
15	1135	736	29.2	8.4
16	815	1020	31	8.6
17	450	1120	30	8.6
18	423	1050	29.4	8.7
19	352	1120	28	8.8
20	302	1136	28.5	8.9

By adding oxygen to the wastewater. pH tends to increase rapidly to pH 7.8 in 1 day. It can be seen that the consortium microorganisms work at a pH ranging from 8.5 to 8.9 in the degradation process.

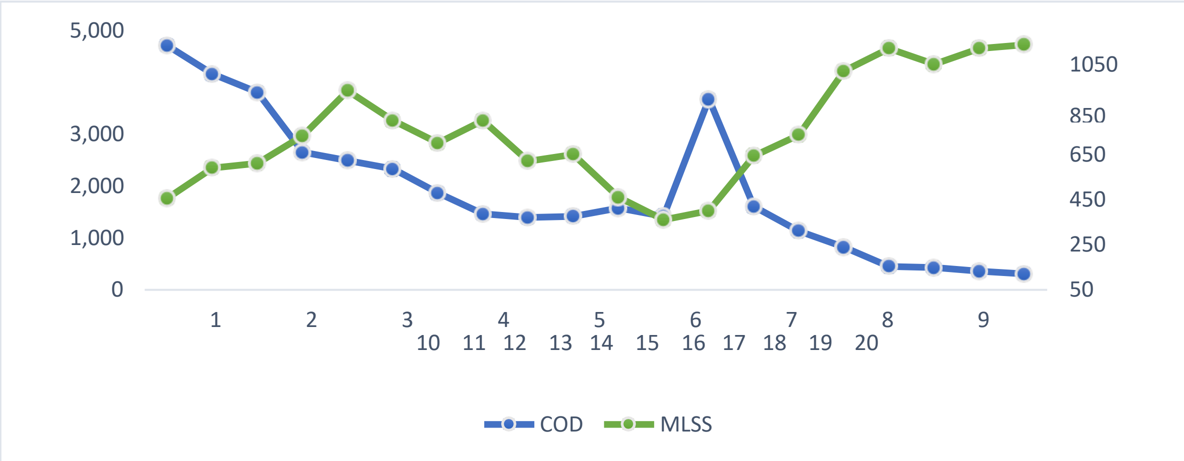

Figure 3. Seeding process conditions between MLSS and COD

Figure 3 shows the process of microorganism growth for 20 days. The MLSS value after 1 day of seeding has a value of 450 mg/L. The MLSS value gradually increased until the fifth day. After the sixth day, it gradually decreased this was due to the micro-organisms being able to slowly decompose the COD content (according to xxxx). In the same way, the MLSS value decreased, this was due to the reduced organic content so that there was no intake of microorganisms. On the 13th day, adding wastewater to determine the growth pattern of microorganisms and increase the MLSS value. On day 14, the MLSS value began to increase again along with the incoming organic matter. From day 17 to day 20 MLSS began to stabilize, ranging from 1120 to 1150 mg/L. The COD value from the 14th to the 20th day is also able to go down. The effect of MLSS on COD removal showed in Figure 2. The number on the graph was developed based on experimental data to describe the trend of COD and MLSS parameters. Figure 2 showed that the lower number of COD increased the MLSS number, this result shows the same pattern as Nanqi Ren., et.all's research (Ren et al., 2005).

Table 4. Results of the decrease in the acclimatization process

Day	**Parameter**					
	COD inlet (mg/L)	:OD outlet (mg/L)	nperatur (°C)	DO (mg/L)	pH	Percen Removal (%)
21	1258	490	29.7	2.5	8.7	61.05
22	2556	720	30.7	3.6	8.9	71.83
23	3792	960	28.8	3.7	8.8	74.68
24	5128	1298	28.4	4.2	8.7	74.69
25	6460	1330	29.8	4.1	8.9	79.41
26	6380	1252	29.7	3.9	8.9	80.38
27	6400	1260	26.6	3.5	9.0	80.31
28	6380	1309	27.8	3.7	8.8	79.48
29	6440	1085	28.9	3.8	8.8	83.15
30	6510	1308	29.2	3.6	8.9	79.91
31	6200	1194	30.2	3.8	8.8	80.74

The table above shows that the acclimatization process was carried out for 11 days but at 100% acclimatization on day 5 it ranged from 79% to 83%. This is considered to be at a steady-state following (Astuti et al., 2007) that if the COD decrease is stable above 80% and fluctuates by 5%.

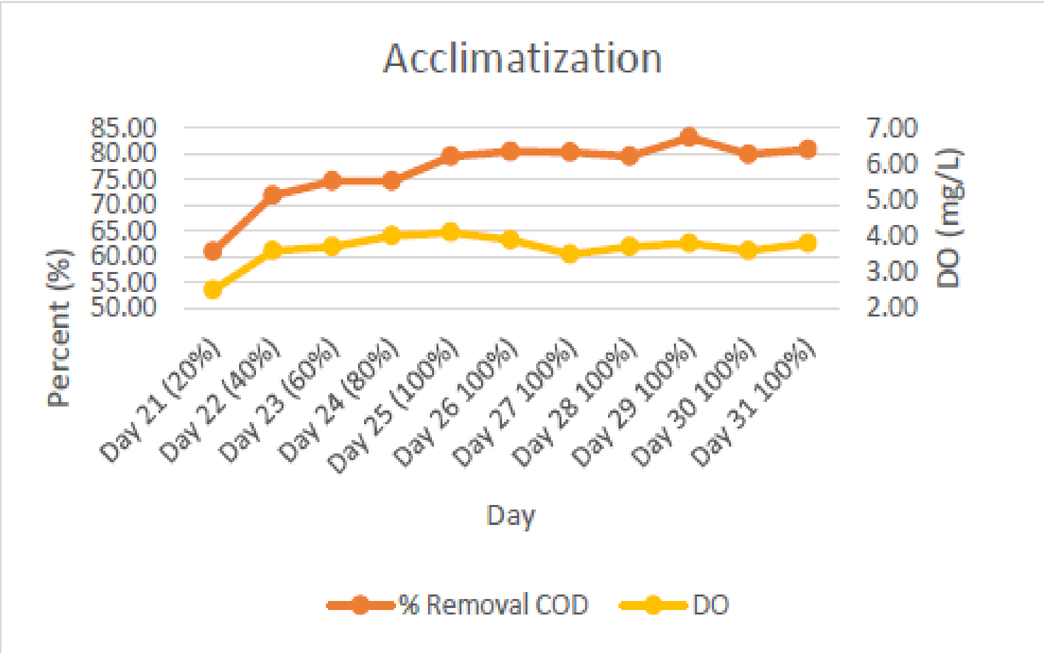

Figure 4. Gradual acclimatization process

The picture above shows that the DO value on day 22 ranges from 3.6 to 4.2. In addition, in acclimatization, the percentage of COD removal also increases gradually and starts to stabilize when the condition is 100% wastewater. This indicates that the microorganism is ready for the running process. The number of COD removal is increasing compared with increasing the number of DO on water, it can be seen in figure 4. The increasing number of DO in water is indicated that the number of oxygen in water increasing. The increasing of removal COD is due to the bacteria already acclimatizing oneself to the new environment.

Activated sludge process / Running process

One of the most frequent methods for secondary wastewater treatment is activated sludge. Ac-activated sludge uses a dense microbial culture in suspension as a suspended-growth biological treatment process to biodegrade organic waste under aerobic conditions and generate a biological floc for solid separation in the settling units (Stott, 2003). In this process, the MLSS was checked as an indicator of the presence of the activated sludge.

Organics, nutrients, and other micropollutants can all be treated at the same time in this bio-reactor. A variety of changes to the traditional activated sludge technique are also being used in the field. In this reactor, wastewater is combined with microbial culture under aerobic conditions, allowing the biomass to develop as contaminants are degraded.

Table 5. Sample analysis result

Air Flowrate	Parameter	After Aeration 18 hours and Detention Time in Sedimentation (hour)				
		1	2	3	4	5
4L/min	COD (mg/L)	2384.62	2124	1653.85	1601	1538.46
	TSS (mg/L)	880	860	720	704	700
	N-Total (mg/L)	188.44	175	167.28	160	158.7
	pH	8.6	8.7	8.8	8.8	8.9
	Temperature (^oC)	28.8	28.2	30	28.6	28.3
8L/min	COD (mg/L)	1307.69	1287	1230.77	1140	1115.38
	TSS (mg/L)	590	565	505	475	470
	N-Total (mg/L)	158.7	152	150.12	148	141.54
	pH	8.7	8.7	8.9	8.9	8.8
	Temperature (^oC)	28.4	28.3	28.4	29	28.9
12L/min	COD (mg/L)	923.08	885	750	702	656
	TSS (mg/L)	440	442	430	365	350
	N-Total (mg/L)	137.25	120	115.81	102	98.65
	pH	8.7	8.8	8.8	8.9	8.9
	Temperature (^oC)	27.3	27.9	28.2	27.8	28.4

Table 5 shows the various results of decreasing COD, TSS, and N-Total using various air velocities. These results show that the microorganisms work from pH 8.6 to pH 8.9. The table also shows that the use of air velocity in reducing organic content uses 12 L/min.

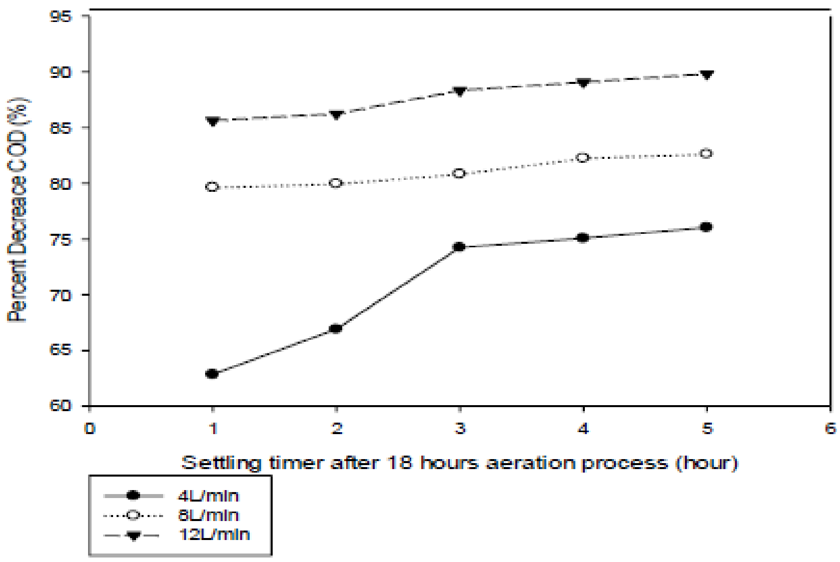

Figure 5. Percentage Removal COD in various air flowrate

Figure 5 shows the percentage decrease of COD value about the effect of flow rate. The COD value is measured per hour of settling time after 18 hours of aeration. With 12L/min of airflow, the COD removal was measured after 1 hour at 85,63 %, and after 5 hours it reach 89.79 %. The 8L/min of airflow, COD removal of 79.64% was obtained in the first hour and slowly raised to 82.63% in the 5th

hour. Meanwhile the 4L/min of airflow, during the first hour it was found the removal rate was only 62.87%. However, during the first 3 hours of settlement, the removal was raised to 76% and reached 75% during the 5th hour. It is assumed that a higher flow rate may cause turbulence that makes microbial activity more intensive.

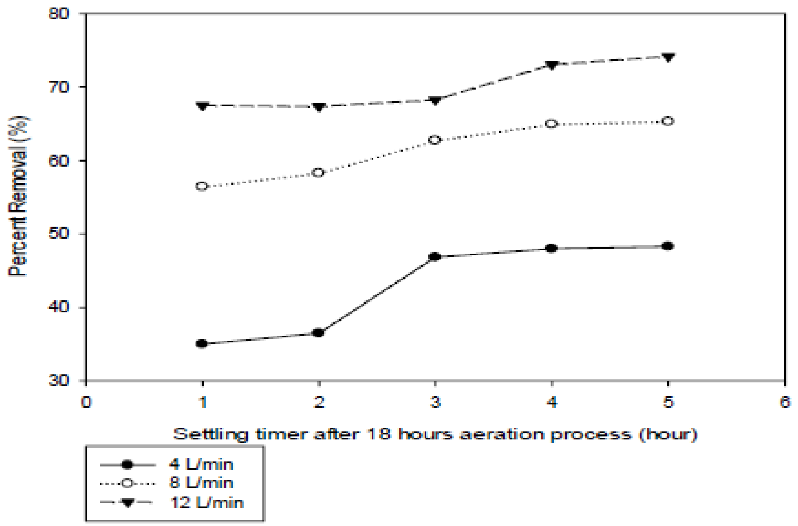

Figure 6. Percentage Removal TSS in various air flowrate

Figure 6 shows the percentage of TSS removal with the lowest capability using an air rate of 4 L/min and a setting time of 1 hour at 35.01%. The best ability using 12 L/min and settling time at 5 hours is 74.15%. For an air rate of 8 L/min, it has the ability of a settling time of 1 hour and 5 hours ranging from 56.43 - 65.29%. The pattern of a significant increase in ability generally occurs at the time of settling for 3 hours.

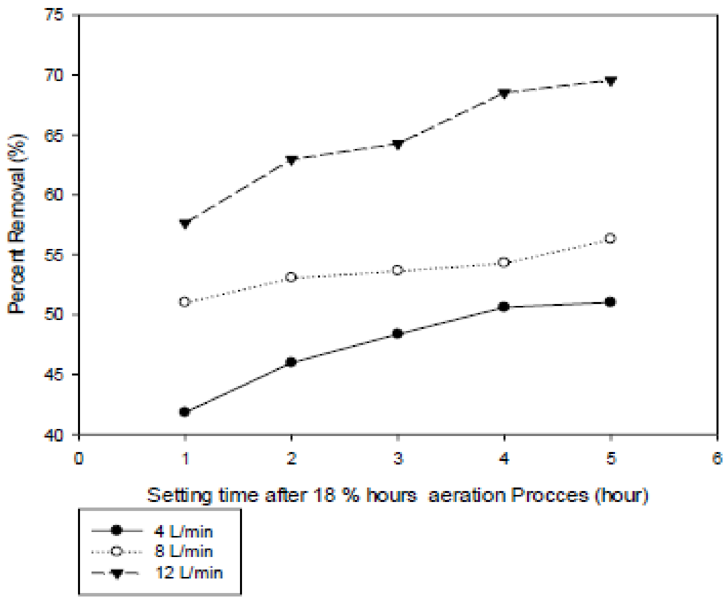

Figure 7. Percentage Removal N-Total in various air flowrate

Three kinds of airflow rates were used to analyze the effect of airflow rate on the degradation of N- Total. Various types of aeration devices are being used in biological reactors of municipal wastewater treatment plants to ensure that the microorganisms in the activated sludge have adequate access to oxygen (Drewnowski et al., 2019). Figure 7 shows the positive correlation between three kinds of airflow rate which means that a higher air flowrate can perform better resulting in the degradation of N-Total.

The higher airflow rate (12L/min) can remove about 69.55% of N-total on wastewater, this number is quite big compared to the 4L/min air flow rate. It can conclude that airflow rate plays sig- a significant role in degrading N-total in this process.

Conclusion

The invention of a water treatment technique that uses bacteria from wastewater as a medium appears to promise because it does not require the use of a bacterium stater or other media such as glucose. Another reason is that wastewater from food processing plants is better for microalgae production because it includes more useful nutrients and less poisonous and detrimental elements that interfere with microalgae growth. After 20 days of treatment under the same conditions (pH and temperature), the Acclimatization process can reach 83.15 percent. With 5 hours of re-circulation after the detention time (18 hours), the results of the COD number were also greatly reduced. The higher airflow rate (12L/min) can remove about 69.55% of N-total on wastewater.

Acknowledgment

The authors would like to thank the financial support from LPPM UPN "Veteran" Jawa Timur for this research project and Environmental Engineering Department UPNVJT who help during the analyzing the research samples.

References

Ahmad, H., & Adiningsih, R. (2019). *Efektivitas metode fitoremediasi menggunakan tanaman eceng gondok dan kangkung air dalam menurunkan kadar BOD dan TSS pada limbah cair industri tahu.*

Anwar, A. (2020). Pengolahan limbah cair industri tahu dengan menggunakan biofilter. *Tugas Akhir Universitas Islam Negeri Ar-Raniry Banda Aceh.*

Astuti D. A., Wahyudi, W., & Nurwini, A. R. (2007). pengolahan air limbah tahu menggunakan bioreaktor anaerob-aerob bermedia karbon aktif dengan variasi waktu tunggal. *Jurnal Teknologi Lingkungan Universitas Trisakti, 4*(2), 30-35.

Azhari. (2016). Pengolahan limbah tahu dan tempe dengan metode teknologi tepat guna saringan pasir sebagai kajian mata kuliah pengetahuan lingkungan. *Media Ilmiah Teknik Lingkungan, 1*(2). 1-8

Belén, F., et al. (2012). One option for the management of wastewater from tofu production: Freeze concentration in a falling-film system. *Journal of Food Engineering,* 110(3) 364-373. Doi: 10.1016/j.jfoodeng.2011.12.036

Damayanti, A., Hermana, J., & Masduqi, A. (2004). Analisis resiko lingkungan dari pengolahan limbah pabrik tahu dengan kayu apu. *jurnal Purifikasi, 5*(4),151-156.

Drewnowski, J., Remiszewska-Skwarek, A., Duda, S., & Łagód, G. (2019). Aeration Process in Bioreactors as the Main Energy Consumer in a Wastewater Treatment Plant. Review of Solutions and Methods of Process Optimization. *Processes,* 7(5), 311. https://doi.org/10.3390/pr7050311

Islam, M. M. M., Shafi, S., Bandh, S. A., & Shameem, N. (2019). Chapter 3 - impact of environmental changes and human activities on bacterial diversity of lakes. *In* S. A. Bandh, S. Shafi and N. Shameem eds. *Freshwater Microbiology*. Academic Press, 105-136. https://doi.org/10.1016/B978-0-12-817495-1.00003-7

Kahar, A. et al. (2017). The study of seeding and acclimatization from leachate treatment in anaerobic bioreactor. *ARPN Journal of Engineering and Applied Sciences, 12*(8), 2610-2614.

Nugroho, G. S. F., Sulistyaningrum, R., Melania, R. P., & Handayani, W. (2019). Environmental analysis of tofu production in the context of cleaner production: Case study of tofu household industries in Salatiga, Indonesia. *Journal of Environmental Science and Sustainable Development, 2(*2), 127-138. https://doi.org/10.7454/jessd.v2i2.1021

Nur, A., Komala, P. S., & Primasari, B. (2020). *Waste water treatment of tofu industry in Padang Panjang city using sequencing batch reactor capacity 0.34 m3/day*. 2235 020001. https://doi.org/10.1063/5.0006384

Ren, N., Chen, Z., Wang, A., & Hu, D. (2005). Removal of organic pollutants and analysis of MLSS– COD removal relationship at different HRTs in a submerged membrane bioreactor. *International Biodeterioration & Biodegradation,* 55(4), 279-284.

Stott, R. (2003). 31 - Fate and behaviour of parasites in wastewater treatment systems. *In* D. Mara and N. Horan eds. *Handbook of Water and Wastewater Microbiology*. London, Academic Press. pp. 491-521.