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The Effect of pH Values on Suspended Microorganisms Growth in Tofu Wastewater Treatment

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ABSTRACT

Tofu industry produces the waste that contains a lot of organic substances. The waste is discharged into the environment without any treatment process, it will cause the environmental pollution. In Indonesia, tofu industries (the small-scale industry) mostly do not treat their waste due to the problem of the high cost treatment process. The purpose of this research is to know the effective and economically reasonable that can be used by tofu producers to process tofu waste, especially liquid waste so not damage the environment. Water treatment process using bacterial from waste water as medium seems promising to develop since it does need any bacteria starter or other media like glucose. The other reason is wastewater from food processing is more suitable for microorganism cultivation because its effluent contains significant beneficial nutrient and less of toxic compounds and harmful substances that interface with the growth of microorganism in same condition (pH and Temperature) in Acclimatization process can reach 83.2% after 7 days of treatment. After the detention time (18 hours) the results of COD number also greatly decrease with 2.5 hours recirculation at 12 L/min air and pH 3.7 and 4.5 it can reach 85% and 86% of removal COD.

Keywords: Tofu wastewater, growth suspended microorganism, pH

Introduction

Tofu is one of the most commonly consumed side dishes in Indonesia. Tofu contains a lot of protein and vitamins needed by the body (Faisal et al., 2016). Soybean is food with high protein, tofu and tempeh is the example food that processed from soybean. Data from the Ministry of Agriculture in 2013 shows the tofu consumption in Indonesia per capita reach 7,039 kg/person for one year with the growth rate from 2012 to 2013 0,09% and with an average increase every year (Ministry of Agriculture, 2014; Agriculture, 2013). The data from table.1 shows that tofu more consumption than beef and chicken

Table 1 Per capita consumption of some foodstuffs in Indonesia (2012-2013)

No	Type of Food	2012 (%)	2013(%)	Growth Average
1	Tofu	6,987	7,039	0,09
2	Chicken	4,015	4,119	2,93
3	Chicken Eggs	6,518	6,153	1,61
4	Duck Eggs	2,190	1,825	-9,78
5	Tempe	7,091	7,091	0,23
6	Beef	0,365	0,261	-2,53

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The consumption of Tofu and Tempeh in Indonesian has an average of 84.000 tofu factories with a scale number of workers from 5 to eight people to large scale more than 100 workers, according to Bank Indonesia Tofu and Tempeh contribute to Gross Domestic Product (GDP) around 60 % and open opportunity for employment, and spending about 2,56 million tons of soybeans every year. But the Industries still use environmentally damaging production practices. The problems in the processed soy-based food industry are inefficiency, inadequate waste disposal, lack of hygiene, insufficient access to credit, and low awareness about new technologies (Faisal et al., 2016). Without business development services, support, or regulation, these enterprises suffer from avoidable inefficiencies that not only reduce profitability and productivity but also lead to environmental damage. Because we still make an average of 20 million m^3/year of liquid waste and 1,024 million tons of solid waste and with that much waste we can say as much as average emissions of 1 million tons of CO_2. In Indonesia, the efficiency of waste reduction is still high with 40% of the total capacity 100 kg soybean will turn into solid waste. Every 100 kg uses an average of 1,5-2 m^3 of water. The liquid waste from tofu is generated when the washing, pressing, and molding process, and it contains quite high organic substances that needed to be treated.

Table 2. Wastewater quality standard for tofu industry

Parameter	Concentration (mg/L)	Standard Concentration (mg/L)	Load Capacity (kg/ton)
COD	7.500-14.000	300	6
BOD	6.000-8.000	150	3
TSS		200	4
pH	5-6	6-9	

Resource: (Agriculture, 2013, Environmental, 2014) (Ministry of (Environmental, 2014)

The purpose of this research is to know the effective and economically reasonable that can be used by tofu producers to process tofu waste, especially liquid waste so as not to damage the environment. The tools to be used are simple and the process of the tools is also simple. This research uses bacteria to process COD, BOD, and TSS which are contained in liquid tofu waste. In addition, this research aims to determine the optimum pH for bacterial growth. In this research, bacterial growth in suspended growth culture and also does not require additional nutrients in the seeding process.

Research Method

Wastewater observed in this study is obtained from one of tofu industry in Sidoarjo. Two distinctive reactors were used, seeding and acclimatization. This research used the natural pH of tofu waste water (3.7) production and modified pH (4.5) using CaCO3 as comparison. The different Indonesia's standard method were used in this research to analyze the sample's parameters.

Table 3 Sample standard

Parameters	**Standard Method**
BOD	SNI 6989.72:2009
COD	SNI 6989.2:2019
TSS	SNI 06-6989.3-2004

The testing of parameter before running the experiment is needed to know the comparison results before and after treatment due to the effectiveness of this treatment. The vinegar in tofu home industries process affects the levels of COD and DO, so the result number of COD and DO at

different factories can be variate. The sampling process in this research spent 2.5 hours of sampling time with 18 hours of detention time.

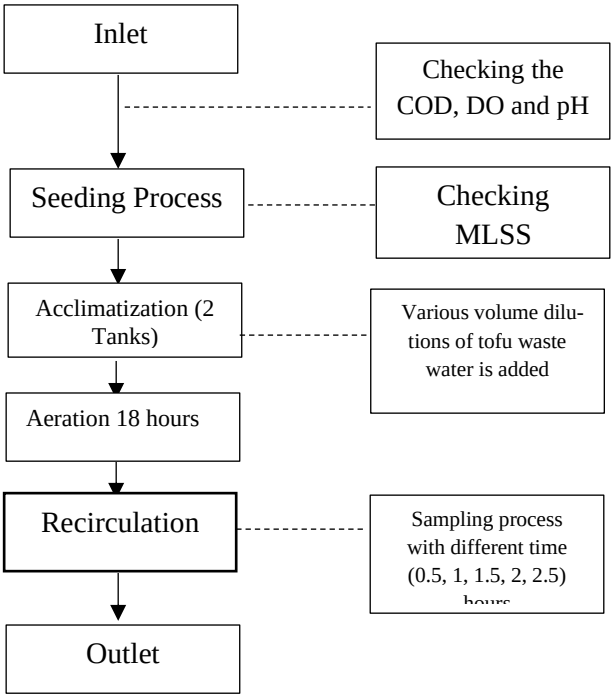


Figure 1. Flowchart of research method

Removal efficiency was calculated by the percentage of reduction in concentration for each pollutant as follows:

$$= (1-\frac{C\ eff}{C\ inf}) \times 100\%$$

Where, *Cinf* and *Ceff* is the influent and effluent concentrations in mg/L. The stages of conducting this research include seeding, acclimatization and operational with retention time variation.

Seeding Process

Seeding in this study is needed in order to obtain indigenous microorganisms which act as tofu wastewater decomposers by flowing seed sludge and tofu wastewater into a bioreactor (Astuti & Ayu, 2019). The seeding preparation on this research was run with a pump oxygen with 12 L/minutes capacity that connected to the reactor. On the primary day, one liter of tofu waste water has included to the reactor at that point include one liter each day until it comes to 10L on the fifth day. Within the seeding process, to avoid the formation of a lot of foam, the air conduit gaps are made bigger this strategy makes the air bubbles become huge, this affects the arrangement of foam. In case the air bubbles are getting smaller, the seeding process will create more bubbles. For this reason, the air bubbles are made bigger in order to create or minimize the foam produced.

Two kind of different pH number is used in this research, pH 3.7 (as initial pH) and pH 4.5 by adding $CaCO_3$ to adjust the pH. The reason why using $CaCO_3$ is it is cheaper than other materials

and easy to obtain, but the drawback of $CaCO_3$ is the processed-waste products become more odour and stickier but can still be overcome by the aeration process.

Acclimatization process

The acclimatization is a process which helps microorganisms to adapt to the changes in the new environment. The acclimation process is carried out in the reactor by gradually replacing wastewater with newly produced wastewater within 24 hours. During the acclimatization process, the biofilm layer will be thicker process runs after the seeding process, two tanks are needed into this process. The pH that used in this process is 3.7+0.1, with a recirculation that connects each other with a recirculation airflow rate of 100mL/min. The acclimatization stage begins from 20% of the natural substance presented into the reactor, separately 25%, 50%, 75%, and 100%. Within the 100% condition, it is carried out for several days until the outlet comes about ended up steady. At the acclimation process detention time of 24 hours is utilized.

Running process

To know the resistance of bacteria were given detention time in 18 hours. Sample was analyze every 30 minutes in 2.5 hours. Pump with air flowrate 12L/min is used for recirculation process, during this process the same water used more than once in a system. The water must leave the system and re-enter it or be used in a different system. Water recirculation reduces the need to take in new water.

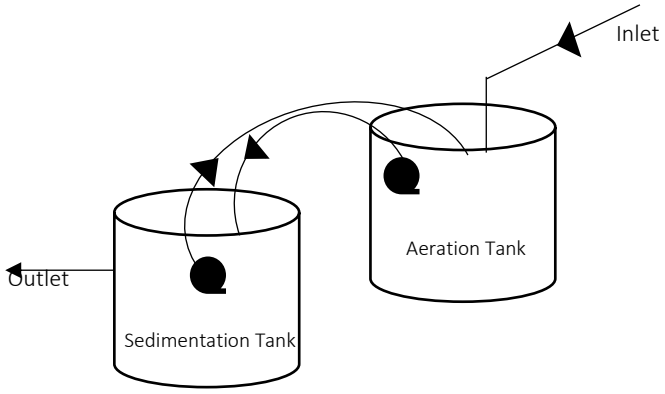


Figure 2. Design reactor process

Result and Discussion

The number of BOD, COD and TSS that produced by tofu home industry shows on table 3. Normally they directly discharge on water stream without any treatment. The high number of BOD, COD and TSS can contribute to water pollution. Table 3 present the characteristics of the tofu wastewater.

Table 4. Initial parameters number analysis for waste water

Parameters	Result
BOD	1360 (mg/L
COD	5230 (mg/L)
TSS	1206 (mg/L)

The Regulation of East Java Governor Regulation No.72 of 2013 about water quality standards soybean processed industrial waste mentioned the standard number for BOD, COD and TSS are 150, 300 and 200 mg/L. These number is quite small compare to the initial number of parameters

that tofu industry produced, in other words the number of parameters that tofu industry produced is exceed the standard.

Seeding

Attached growth bacteria is needed on wastewater treatment. Suspended growth bacteria needs oxygen during the process, but no need any media. In most cases attached growth bacteria used on seeding process.

Table 5. Results analysis for waste water parameters Day 1-13 on Seeding Process

Day	Parameter			
	MLSS	COD	pH	Temperature (^{0}C)
1	708	5200	7.0	29.2
2	952	5106	7.1	29.3
3	1200	4904	8.1	28.5
4	1680	4186	8.3	29.3
5	1740	4020	8.2	29.9
6	1870	3744	8.4	29.2
7	1944	3010	8.9	27.9
8	1880	2816	8.9	27.5
9	1522	2634	8.9	28.8
10	1430	2698	8.9	29.3
11	1546	2130	8.8	28.7
12	842	1862	8.8	31.6
13	952	1723	8.8	28.2

With the air flowrate that runs on water sample, on the day one the pH is increasing significantly compare to the initial sample with pH 3.7. The right air velocity must be have significant role on this process.

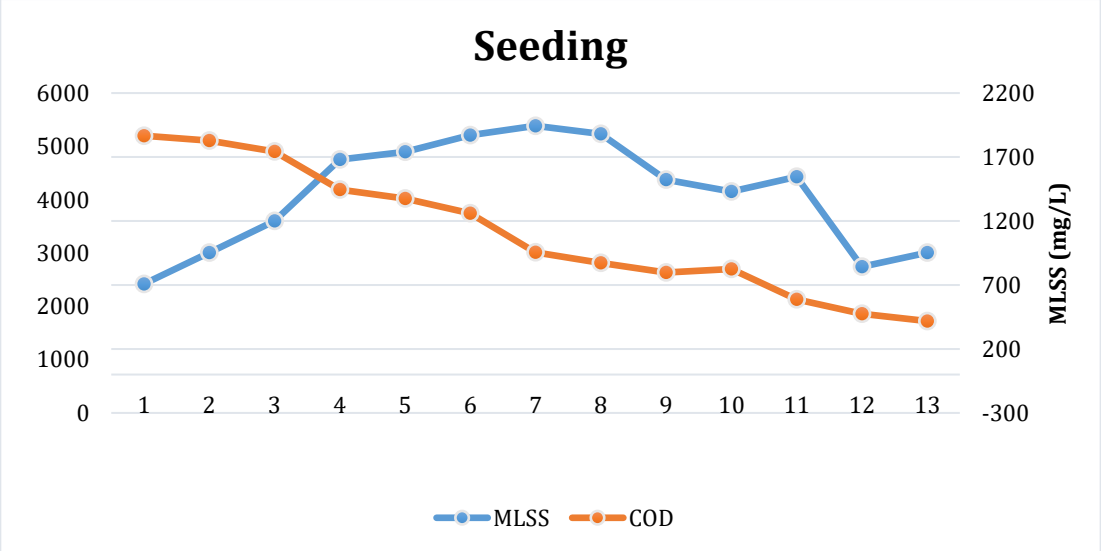


Figure 2. The effect of seeding process on MLSS and COD

The number of MLSS is represent the number of microorganism on water. Figure 2 shows the number of MLSS significantly increasing on the day one until six this pattern indicates that the organism capable to multiply used the organic materials on waste water. The number of MLSS decrease after the day 7 and get equilibrium after day 9. The peak number of MLSS on day sixth is 1.944 mg/L.

Due to decompositions of organics components microorganism the number of COD slightly decrease since the first day and get the equilibrium on day 9th. It is obvious that the higher MLSS worked the higher removal efficiencies of COD accomplished. The increase in COD removal efficiency might be attributed to a huge number of microorganisms within the higher sludge concentrations this results same, this shows the same result with research that Tian et al., delivered (Tian et al., 2018).

Acclimatization

The acclimatization process is the second step for this treatment. It needs seven day of treatment to analyze the parameters. The levels of biodegradation and time that substrate remains in the reactor were observed to see the relationship between the parameters.

Table 6 Degradation result trough the acclimatization process

Parameters						
Day	COD inlet (mg/L)	DO (mg/L)	pH	^{0}C	COD outlet (mg/L)	Removal of COD
14	1084.31	1.17	8.7	30	954.19	12.1%
15	1406.00	4.2	8.9	31	1012.32	28.2%
16	1397.00	4.45	8.8	30	894.08	36.1%
17	1376.00	4.54	8.8	28	660.48	52.2%
18	1388.00	5.24	8.8	31	527.44	72.3%
19	1402.00	5.22	8.8	31	308.44	78.1%
20	1358.00	5.36	9	27	230.86	83.2%

The COD parameter and the time was analyzed, the degradation of COD within 7 day is increasingly day by day. The high number of removal COD indicates that the aeration process on the stage is successfully applied. The number of DO on water also indicates that the aeration process is successfully applied, it is related with microorganism that the decomposing the wastewater. The temperature of treatment slightly different it may cause the room temperature that may change.

Running process

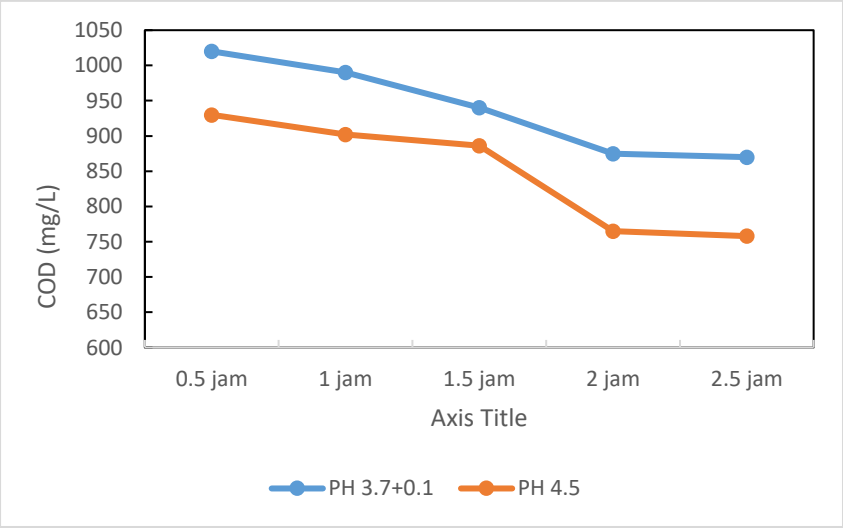
Two kind of different pH (3.7 and 4.5) were used in this process. The pH were adjusted using CaCO3. This step run after the water get stable on efficiency of organic matter and COD. The number of COD and TSS in inlet reactor during this process is 5230 mg/L and 1206 mg/L. The air flowrate that used on this reactor is 12 mg/L.

Table 7. Sample analysis result after detention time

	PARAMETER	0.5 hour	1 hour	1.5 hour	2 hour	2.5 hour
pH 3.7±0.1	COD (mg/L)	1020	990	940	875	870
	% Removal COD	80.50	81.07	82.03	83.27	83.37
	TSS	420	390	380	336	298
	%Removal of TSS	65.17	67.66	68.49	72.14	75.29
	pH	8.2	8.3	8.3	8.4	8.4
	Temperature(^{0}C)	28.4	29.4	30	30.5	29.6
pH 4.5	COD (mg/L)	930	902	886	765	758
	% Removal COD	80.50	81.07	82.03	83.27	83.37
	TSS	350	342	325	248	235
	%Removal of TSS	70.98	71.64	73.05	79.44	80.51
	pH	8.5	8.6	8.6	8.6	8.7
	Temperature(^{0}C)	28.7	29.9	30.7	31	30

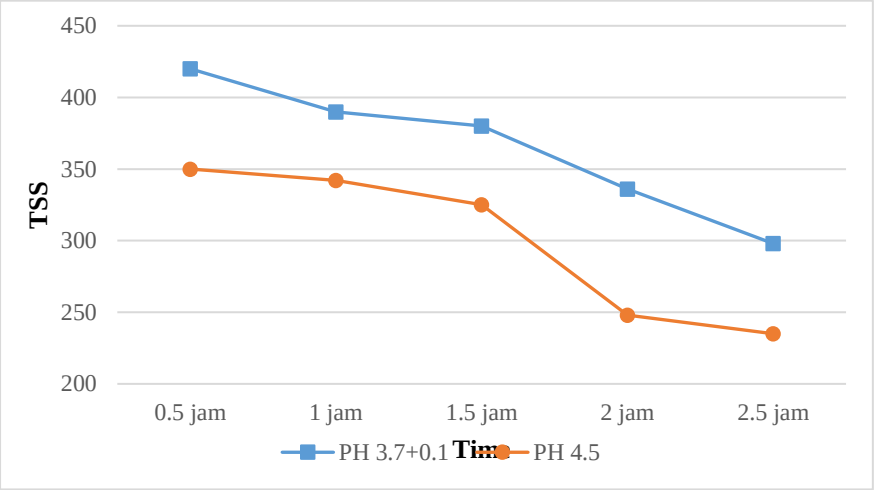
The pH value were analyzed on this process. The comparison of pH value before and after detention time on running process is greatly different. Air flowrate has the effect of raising the pH of this water from about 3.7 to 8.2 and 4.5 to 8.5, presumably as a result of removing the carbon dioxide from the water this result pattern same with P.W Kauter Results (Krauter et al., 1998) .

Waste solids control is one of the most critical processes that must be managed in recirculating systems(Isla Molleda, 2020). Solids decomposition can degrade water quality and thus directly and affect the physically water color. In this study, the TSS concentration in the inlet and outlet system showed almost the same performance, they decrease with the time from the beginning until the end of the experiment. The TSS result from pH 3.7 and 4.5 is not much different.



Picture 3. The COD concentration result on pH 3.7 and 4.5

COD number shows the significant decreasing, a very significant decrease was seen. This indicates that the recirculation on 2.5 hours give significant effect on this treatment.



Picture 4. Removal of TSS from the inlet on running process

Conclusion

Tofu industry produces the waste that contains a lot of organic substances. If the waste is discharged into the environment without any treatment process, it will cause the environmental pollution. In Indonesia, tofu industries (the small-scale industry) mostly do not treat their waste due to the problem of the high cost treatment process.

Water treatment process using bacterial from waste water as medium seems promising to develop since it does not need any bacteria starter or other media like glucose. The other reason is wastewater from food processing is more suitable for microorganism cultivation because its effluent contains significant beneficial nutrient and less of toxic compounds and harmful substances that interface with the growth of microorganism in same condition (pH and Temperature) in Acclimatization process can reach 83.2% after 7 days of treatment. After the detention time (18 hours) the results of COD number also greatly decrease with 2.5 hours recirculation at 12 L/min air and pH 3.7±0.1 and 4.5 it can reach 85% and 86% of removal COD. This research is running in laboratory scale this problem must be recalculate to bring in large scale applications, but this technology represents and effective, economically and environmentally friendly process for tofu waste water treatment.

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