Design of WWTP Anaerobic System at Tempe Factory

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Abstract. The tempe industry is a food industry that has the potential to pollute the environment from the liquid waste it produces. Liquid waste from the tempe processing process if it is immediately disposed of without going through the management process first will have an impact on environmental pollution. In Semarang City, precisely in Gunung Pati District, there is a medium-scale tempe processing factory. So far, the tempe factory's liquid waste is directly disposed of into a ditch behind the factory without processing the liquid waste first. This research is a quantitative research presented in the form of numbers and then explained in the form of descriptions. From the results of the wastewater quality test, the pollutant parameters BOD = 369 mg/L; COD = 28,000 mg/L; TSS = 0.991 mg/L; and pH = 4.3. According to the Regional Regulation of the Province of Central Java Number 5 of 2012 concerning Amendments to the Regional Regulation of the Province of Central Java Number 10 of 2004, this value still does not meet the requirements. The wastewater treatment plant that the researchers are planning is in the form of a holding tank; Equalization Tub; Anaerobic Digesters; Gas Holder; Initial Settling Tub; Anaerobic Biofilter using bioball filter media and steel nets as a barrier for bioballs where bacteria are grown; and Final Settling Tank. With an estimated effluent from the processing of BOD, COD, and TSS of 7.47225 mg/L; 189mg/L; and 0.00669 mg/L which means it meets the quality standard. From the planning results, it was obtained that the total budget plan for planning the tempe factory wastewater treatment plant was Rp. 111.280.021,49.

Keywords: WWTP, Anaerobic Digester, Anaerobic Biofilter

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1. Introduction

In Indonesia, waste disposal is a very serious environmental problem. Every city in Indonesia produces considerable waste, be it domestic waste, industrial waste, or medical waste. These wastes, if not managed properly, can have adverse impacts on the environment and human health. One of the main problems in waste management in Indonesia is the low public awareness of the importance of safe and sustainable waste disposal.

Tempeh industrial liquid waste can be treated by processing anaerobic digester methods and anaerobic biofilters. Liquid waste can be biodegraded with the role of microorganisms. In the final stage of the processing process, it produces liquid waste that is odorless and levels of organic pollutants are significantly reduced. This treated liquid waste can be directly disposed of into public channels or to water plants (Hidayati, 2017).

In Semarang City, precisely in Gunung Pati District, there is a medium-scale tempeh processing factory. Every day the tempeh factory produces 5 quintals of processed tempeh. In its treatment, the plant does not yet have a wastewater treatment plant. The tempeh factory's liquid waste has been directly discharged into the ditch behind the factory without processing the liquid waste first. This causes water pollution and causes unpleasant odors due to the absence of a good treatment process.

Therefore, based on the above background, researchers conducted a study entitled "Planning of a Tempeh Plant (Ipal) Wastewater Treatment Plant with Anaerobic Digester and Anaerobic Biofilter in the Semarang area (Case Study of Dampyak Gunung Pati Tempeh Factory Semarang City).

2. Research Methods

Research Methods

According to Tersiana, (2018). Research Method is an empirical, rational and systematic scientific way to obtain knowledge by conducting a study. For the method used in this study is a quantitative method, which is a method that produces a finding with a static procedure or quantitatively (Tersiana, 2018) quantitative research involves many numbers, from starting to collect data, interpretation of the data obtained, and exposure to data results, after that the results of the calculation data can be concluded.

Research Location

This research was carried out at the Dampyak Tempe Factory, Gunung Pati District, Semarang City, Central Java Province. Astronomically, the study location is located at coordinates 110°23'14.5 East Longitude and 7°06'44.0 South Latitude. The administrative boundaries of the research location include:

North : Magelang Regency and Salatiga City

South : Semarang City

West : Grobogan Regency and Demak Regency

East : Kendal Regency and Temanggung Regency

In this study carried out quality and quantity tests of processed tempeh waste that was disposed of every day.

Types of Research

The type of research used is to determine the characteristics of tempeh industry liquid waste. The characteristics of the parameters tested include BOD, COD, TSS, and pH. The results of this study will be used in determining the planning of the Wastewater Treatment Plant (WWTP). Planning wastewater treatment plants that will be planned for the treatment phase are Equalization Basins, Anaerobic Digesters, Initial Deposition Basins, Anaerobic Biofilters, and Final Deposition Basins.

Data Collection Techniques

In the process of preparing the thesis that will be carried out, there are data retrieval techniques and data sources that will be researched and obtained as below:

1) Primary Data

In the research conducted, conduct a direct survey at the research site in supporting planning. The following is the primary data taken, among others:

No	Primary Data	Data Sources
1	Production capacity per day	Data obtained from the Factory Manager
2	Sampling and analysis of wastewater characteristics	Data were obtained from tempeh wastewater sampling from the sewer of the Tempe Factory
3	Survey of Existing Conditions at the Research Site	Data is obtained from the Factory Manager to facilitate the implementation of the results of the planning that has been done.
4	Wastewater Disposal Conditions	Data obtained from the Factory Manager

2) Secondary Data

Data obtained indirectly at the research location and is supporting data taken from

existing data or has been collected and processed by other parties. In this study the secondary data taken are as follows:

No	Secondary Data	Data Sources
1	Water Quality Monitoring Data	Data obtained from Semarang District Health Lab
2	AHSP Data for 2022	Data obtained from the Public Works Office of Bina Marga and Cipta Karya of Central Java Province
3	HSPK Data (Unit Price of Activities) Semarang City in 2022	Data was obtained from Semarang Mayor Regulation Number 65 of 2022 concerning Changes in Unit Price Standards within the Semarang City Government T.A 2022

3. Results and Discussion

Location of Wastewater Treatment Plant Plan

The research location is located on the Dampyak tempeh factory land located in Semarang, Central Java. Dampyak tempeh factory is a tempeh production facility located in an urban area. The area of land available by estimating the wastewater produced. Site selection based on location adjacent to wastewater sources. This location was chosen because it has a large enough space, is land owned by the manager of the tempe dampyak factory and has obtained permission from the manager for the construction of WWTP. The land area available for WWTP placement is ± 78.59 m2

Quality and QuantityWastewater

1) Quality

Wastewater samples are taken at the final effluent of wastewater discharge. Wastewater quality testing was carried out at the Semarang District Health Laboratory Center, Central Java Province. Wastewater samples were taken as much as 5 liters for further testing. Samples were taken at 07.00 WIB and tested to the laboratory on the same day. The results of wastewater quality testing carried out can be seen in the table below:

No	Parameters	Result	Reciprocally Quality	Unit	Method
1	BOD	369	150	mg/L	SNI.06.6989.14-2004
2	COD	28000	275	mg/L	SNI.06.6989.15-2004
3	TSS	0,991	100	mg/L	SNI 06-6989.3-2004
4	Ph*	4,3	6-9	-	SNI 6989.11-2019

2) Quantity

Measurement of tempeh treatment liquid waste discharge is carried out by calculating the volume of water needs in each tempeh manufacturing process. Every day the Dampyak Tempeh Factory processes soybeans weighing 5-6 quintals. The estimated results of liquid waste discharge can be seen from the following table:

No	Process	Volume of Wastewater (liters) per day
1	Soaking	725
2	Laundering	3125
3	Boiling	620
Total		4470

Here is the calculation of wastewater plan discharge:

1. Daily debit (Qab) : 4.47 m3/day or 0.003104167 m3/min
2. Infiltration discharge

   The amount of infiltration discharge is 10-20% of the amount of wastewater discharge (Moduto, 2000)

   Qinf = 10% x Qab

   = 10% x 4.47

   = 0.447 m^3/day or 0.00031041667 m^3/min
3. Maximum daily discharge (Qmd)

   The maximum daily discharge is the maximum limit of the amount of wastewater that is allowed to be discharged into the piping system or environment on a daily basis. The peak factor (fp) based on the Planning Criteria

of the Directorate General of Copyright of the Public Works Office of 1996 for the urban category is 1.75 – 2.0, then, the maximum daily discharge (Qmd) is as follows:

Qmd = fp x Qab

= 1.75 x 4.47

= 7.8225 m^3/day or 0.00543229167 m3/min

4. Peak discharge

Peak discharge is the discharge of wastewater produced in a certain period of time to calculate the dimensions of the channel. The peak discharge is the sum of the maximum discharge and infiltration/inflow discharge.

Qpeak = Qmd + Qinf

= 7.8225+ 0.447

= 8.27 m3/day or 0.005743056 m3/min

Wastewater Treatment Plant Planning

1. Sump

The reservoir (also called equalization tank) is one of the main components in wastewater treatment plants. The dimensions of the sump are calculated as follows.

Waste Discharge = 7.8225 m^3/day, with8 working hours

$$= \frac{7{,}8225\ m^3/hari}{8\ jam}$$

= 0.978 m^3/h

= 16.30 L/min

Dimension Calculation

Required body volume:

Volume= 0.978 m^3

Required dimensions:

The width and depth are set by the researcher

Width = 1 m

Depth = 0.5 m

$$\text{Length} = \frac{\text{volume}}{\text{lebar x kedalaman}}$$

$$= \frac{0{,}978}{1 \text{ x } 0.5}$$

= 1.956m ~ 2m

Then the dimensions are set:

Dimension = Length x width x depth

= 2m x 1m x 0.5m

= 1 m3 > 0.978m^3(required volume)

2. Equalization Body

Equalization basins are designed to cope with changes in the quality and quantity of wastewater entering the treatment plant. The following calculation of equalization can be seen below:

a. Influent

The waste discharge used is the maximum daily waste discharge

Waste discharge (Q) = 7.82 m3/day, with 8 hours of work

= 0.978 m3/h

= 16.30 L/min

Based on subchapter 4.1.1 on wastewater quality, the levels of organic compounds entering the bath with parameters:

BOD*influent* = 369 mg/L

COD*influent* = 28000 mg/L

TSS*influent* = 0.991 mg/L

b. Dimension Calculation

Time to stay in the tub is:Time of stay (td) = 4 hours (Ministry of Health, 2011)

Required body volume:

Volume = Q x td

= 0.978 x 4

= 3.91 m^3

Required dimensions:

The width and depth are set by the researcher

Width = 2 m

Depth = 1 m

Length $= \frac{\text{volume}}{\text{lebar x kedalaman}}$

$= \frac{3,91}{2 \text{ x } 1}$

= 1,955 m ~ 2 m

Then the dimensions are set:

Dimension = Length x width x depth

= 2 x 2 x 1

= 4 m3 > 3.91 m^3 (required volume)

The height of the guard is planned to be 0.1 m, bringing the total depth of the body to 1.1 m

c. Pump Specifications

With a liquid waste discharge of 16.30 liters / minute, the following pump specifications are needed:

Type = Submersible pump

Capacity = 120 ltr/min

Thrust = 16 meters

Material = Stainless Steel

Recommendation= Leo automatic QDX

d. Effluent

In the equalization basin, there is no significant allowance for BOD, COD, and TSS, so that the concentration of effluent equalization is considered the same as the influent concentration.

3. Anaerobic Digester

Anaerobic digester serves to decompose organic matter contained in wastewater by using anaerobic microorganisms. The following calculation of the dimensions of the anaerobic digester can be seen below:

The waste discharge used is a daily discharge of 4.47 m^3 / day.

TSS content = digester efficiency x TSS entry

= 40% x 0.991

= 0.3964 $g/^{m3}$

= 0.0003964 kg/m^3

$$\text{Qwaste} = \frac{\text{TSS x Q}}{pw \; x \; Sd \; x \; Ps}$$

$$= \frac{0{,}0003964 \text{ x } 4{,}47}{100 \; x \; 1{,}02 \; x \; 0{,}05}$$

$= 0.0000348^{m3}$/day

Vreaktor = Qwaste x td

= 0.0000348 m3/day x 10 days

= 0.000348 m^3

$$Vdome = \frac{Vreaktor}{4}$$

$$= \frac{0,000348}{4}$$

= 0.000087 m^3

Vtotal = Vreaktor + Vdome

= 0.000435 m^3

The dimensions of the anaerobic digester set by the researcher, Dimeter = 0.15 m; Cylinder height = 0.1 m; Dome height = 0.075 m.

The dimensional size of the holding gas is determined: Length = 0.12 m; Width = 0.12 m; Depth = 0.12 m.

4. Initial Settling Body

At this stage, wastewater is drained into the initial settling basin and left for some time to precipitate the solid materials contained in it.

a. Influent

Waste Discharge = 4.47 m^3/day with 8 working hours

= 0.560m^3/h

Levels of compounds that enter the tub:

BOD*influent* = 55.35 mg/L

COD*influent* = 4,200 mg/L

TSS*influent* =0.446 mg/L

b. Dimension Calculation

Volume = Q x td

= 0.560 x 2

= 1.12 m^3

The dimensions set by the researcher, Length = 3 m; Width = 0.7 m; Depth = 0.6 m.

c. Effluent

TSSeffluent = 20% x TSSinfluent

= 20% x 0.446

= 0.3568 mg/L

5. Anaerobic Biofilter

Wastewater treatment aims to reduce organic matter content and reduce BOD and COD in wastewater.

Levels of compounds that enter the tub:

BOD*influent* = 55.35 mg/L

COD*influent* = 4,200 mg/L

TSS*influent* = 0.0892 mg/L

Dimension Calculation:

1. BOD load = Q x BOD content

= 4.47 x 55.35

= 247.4145 g/day

= 0.247 kg/day

2. COD load = Q x COD content

= 4.47 x 4200

= 18774 g/day

= 18.774 kg/day

Vmedia biofilter $= \frac{\text{Beban BOD}}{Standar\ beban\ BOD}$

$= \frac{0{,}247\ \text{kg/hari}}{2\ kg\ BOD/m3hari}$

= 0.1235 m^3

Vreactor required $= \frac{100 \text{ x Vmedia biofilter}}{60}$

$= \frac{100 \text{ x } 0{,}1235}{60}$

= 0.2 m^3

Defined dimensions:

Width = 0.4 m; Depth = 1 m; Depth = 1 m plus a planned guard height of 0.1 m.

6. Final Settling Body

The final settling basin serves to precipitate solid particles andremove

organic substances that still remain in wastewater.

Levels of compounds that enter the tub:

BOD*influent* = 8.3025 mg/L

COD*influent* = 210 mg/L

TSS*influent* = 0.0669 mg/L

Dimension Calculation:

Volume = Q x ts

= 0.560^{m3}/h x 2.5 hours

= 1.4 m^3

Defined dimensions:

Width = 1.1 m; Depth 1 m; Length = 1.3 m plus planned guard height of 0.1 m.

Pump Specifications needed:

a. Type = Submersible pump

b. Capacity = 120 L/min

c. Thrust = 16 meters

d. Material = Stainless Steel

e. Recommendation = Leo automatic QDX

Here is the estimated decrease in the quality of effluent liquid waste:

EFFLUENT QUALITY FORECAST			
Stages	**Parameters**		
	BOD	**COD**	**TSS**
	mg/L		
Influent	369	28000	0,991
Equalization Body	0%	0%	0%
	369	28000	0,991
Anaerobic Digester	85%	85%	40%
	55,35	4200	0,446
Initial Settling Body	0%	0%	80%
	55,35	4200	0,0892
Anaerobic Biofilter	85%	9.5%	70%
	8,3025	210	0,0669
Final Settling Body	10%	10%	90%
	7,47225	189	0,00669
Effluent	7,47225	189	0,00669

Wastewater Treatment Construction Cost Budget

The unit price of each job obtained is then multiplied by the volume of work so that the total cost can be determined in the planning of the Tempeh Plant WWTP. Total Budget Plan (RAB) amounted to Rp. 111,280,021.49 (one hundred eleven million two hundred eighty thousand twenty one rupiah forty-nine cents).

4. Conclusion

1. The results of the analysis of the planned Wastewater Treatment Plant (WWTP) are able to produce a reduction in effluent levels that are below the quality standard requirements in the Regional Regulation of Central Java Province Number 5 of 2012 concerning Amendments to the Regional Regulation of Central Java Province Number 10 of 2004 for parameters BOD, COD, TSS. among others: BOD = 7.47225 mg/L(Meet); COD = 189 mg/L(Meets); and TSS = 0.00669 mg/L(Meet). Meanwhile, in terms of the quantity of wastewater produced, the amount of daily discharge is 4.47 m 3 / day, infiltration discharge is 0.447 m 3 / day, maximum daily discharge is 7.8225 m 3 / day, and peak discharge is 8.27 m 3 / day.

2. WWTP design for tempeh wastewater treatment produced with a maximum daily discharge of 7.8225 m^3 / day, using steel plate material types . The following are the dimensions of the processing building: Reservoir with dimensions of 2 m x 1 m x 0.3 m; Equalization Body (with submersible pump capacity of 16 ltr/min) with dimensions of 2 m x 2 m x 1.1 m;Anaerobic digester 0.15 m in diameter and 3.25 m in height; gas reservoir dimensions of 0.12 m x 0.12 m; Initial Settling Body with dimensions of 3 m x 0.7 m x 0.7 m; Anaerobic Biofilter (contains 1052 Bioballs/bacterial culture media) fruits with a diameter of 6 cm with dimensions of 0.5 m x 0.4 m x 1.1 m ; and Final Deposition Basin with dimensions of 1.3 m x 1.1 m x 1.1 m (submersible pump capacity 16 ltr/min).

3. The Budget Plan (RAB) for the main structure of WWTP is Rp. 66,610,974.10 and the supporting buildings are Rp. 44,669,047.39. So the total Budget Plan (RAB) in this plan is Rp. 111,280,021.49 (one hundred eleven million two hundred eighty thousand twenty-one rupiah forty-nine cents)

5. Conclusion

1. T It is necessary to carry out a study of tempeh / tofu plants that already have wastewater treatment plants (WWTP) as a reference in designing suitable wastewater plants (WWTP).
2. It is necessary to carry out testing of the quality and quantity of wastewater again by

observing the discharge per hour or per minute for one full day, and is expected to carry out wastewater quality testing directly to the wastewater disposal body in order to find out the contents in it whether it affects the quality of the water body or not.

3. Factory managers are expected to be able to carry out wastewater treatment generated from tempeh factories by learning the correct treatment procedures, so that the effluent produced can meet the quality standards that have been set.
4. In planning a wastewater treatment plant (WWTP), a more economical alternative can be chosen to reduce the cost budget plan that has been analyzed by researchers, for example in the selection of materials in the main building.

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