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MORALITY BEFORE KNOWLEDGE

Mitigating environmental pollution from tofu industry wastewater: Case of Suyanto Tofu Factory, Mojokerto

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ABSTRACT

Background: This research investigates the impact of tofu industry wastewater on the aquatic environment at the Suyanto Tofu Factory, Mojokerto. The tofu industry produces liquid waste that contains high pH, Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD), so it has the potential to pollute local rivers. Although the Suyanto Tofu Factory has wastewater treatment facilities, these facilities are currently not functioning, indicating an urgent need to design a new wastewater treatment plant. In this context, the research aims to determine the volume of wastewater produced, analyze BOD, COD, TSS and pH levels in wastewater, and design sustainable wastewater treatment facilities for the tofu industry. **Methods:** The method used is planning the design Constructed Wetland system with water hyacinth plants . This method is expected to minimize the environmental impact of tofu wastewater, protect the surrounding aquatic ecosystem, and comply with environmental regulations. **Findings:** This research found a wastewater treatment plant model using a pond system Sanita *(Constructed Wetland)* which can reduce tofu waste effectively and sustainably is very important to maintain water quality and river ecosystems around the Suyanto Tofu Factory. **Conclusion:** The liquid waste at the Suyanto tofu factory has high levels of acidity and organic pollutants, with a pH of 3.91, TSS of 1050 mg/L, BOD of 2063 mg/L, and COD of 5135 mg/L. The factory uses a wastewater management design involving Sanita Pond processing with Eichhornia crassipes plants, effectively reducing the organic content in the waste. **Novelty/Originality of this Study:** By proposing a Constructed Wetland system for tofu industry wastewater treatment, this research introduces an innovative, sustainable solution tailored to local conditions, potentially revolutionizing waste management practices in small-scale food industries.

KEYWORDS : tofu industrial wastewater; environmental impact; *constructed wetland*.

1. Introduction

Currently, water pollution has become commonplace in rural to urban areas as industry continues to develop in both areas (Cosgrove & Loucks, 2015; Cohen, 2006; Schwarzenbach et al., 2010). However, industrial growth has not been accompanied by effective and quality water pollution management. Water can be a medium for destroying the surrounding environment and disrupting aquatic ecosystems. The tofu industry produces liquid waste (Widayat et al., 2019; de Souza Moraes et al., 2022), if it is not processed and discharged into water bodies, it can affect the physical and chemical properties of water, thereby impacting the survival of aquatic organisms. Business actors often lack awareness and knowledge about tofu wastewater management, which can have an impact on the environment (Nasir et al., 2015). With advances in technology, sanitation systems have proven to be very efficient for treating wastewater from tofu production (Karamah et al., 2019). This process ensures that waste water is safe before being discharged into

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surrounding waters and can benefit surrounding plants, such as Mr Suyanto's. Aquatic plants play an important role in absorbing oxygen through their leaves, stems and roots.

Wastewater pollution refers to direct or indirect physical changes to water that can endanger health, cause disease, or disrupt the survival of living organisms (Akpor & Muchie, 2011; Smarzewska & Morawska, 2021). These changes can be proven through physical, chemical, biological, or radioactive changes. On the other hand, water quality is an important factor that determines human welfare (Rahmawati, 2020). Constructed wetlands are nature-based solutions able to remove different pollutants from water, including arsenic. Arsenic is a pollutant of concern given its toxicity and its presence in water sources worldwide. Despite the increased interest in investigating the performance of constructed wetlands in the treatment of arsenic-contaminated water at the laboratory scale, the application of these solutions at the pilot and full scale is still limited (Bravo-Riquelme and Lizama-Allende, 2024). Putri stated that the Wastewater Treatment Plant (WWTP) in one of the tofu industries in Probolinggo City consists of an anaerobic digester and anaerobic biofilter (ABF) where the ABF has not been operating for a long time. The anaerobic digester is the main unit in this installation, so the output quality of the processing unit is still far from the standard of Governor Regulation number 72/2013. To optimize the processing system, performance evaluation and redesign of the WWTP are needed. The evaluation and redesign include wastewater quality analysis, evaluation of existing wastewater treatment, determination of treatment alternatives, and detailed engineering design. The results of this study indicate that the performance of the WWTP can be optimized by redesigning the unit including the ABF and artificial wetlands (Putri et al., 2019).

The treatment in constructed wetland systems was found to be economical, as the cost of construction was only involved, and operational and maintenance costs were very minimal. Even this research was conducted for the sole purpose of commuting the efficiency of pollutant removal in a short span of time (Ali et al., 2024). Significant operational and maintenance issues affecting the sustainable development and application of subsurface flow (SSF) wetlands in wastewater treatment require a method. According to Mishra et al., 2024 claiming that there is a detrimental effect on the wetland system's lifespan. The study's conclusions highlight the remediation techniques required to remove the obstruction in CW and inform productive researchers of all pertinent details regarding SSF wetland obstruction in order to lessen system obstruction and establish CW technology as a workable and sustainable wastewater treatment alternative in the near future.

Mojokerto Regency borders Lamongan Regency and is famous for its extensive rice fields. However, in Kemlagi District, Mojokerto, rice fields are decreasing due to the establishment of industrial factories. Industrial development will affect the amount of wastewater in rural drainage channels. The Suyanto Tofu Factory is an industry located in Mojokerto Regency, precisely in Rembu Kidul Hamlet, Kemlagi District. This tofu factory processes approximately 500 kg of soybeans every day and requires approximately 800 liters of water per day for production, resulting in quite a lot of liquid waste. Founded in 2002, the Suyanto Tofu Factory initially implemented waste water treatment facilities. However, over the years, these facilities fell into disrepair, were buried underground, and no longer functioned. Therefore, there is an urgent need to design new wastewater treatment facilities.

Based on the background above, the problems identified are as follows: The waste water treatment facility (IPAL) at the Suyanto Tofu Factory is not functioning, causing river water pollution near the tofu factory, so it is necessary to design an environmentally friendly waste water disposal system. Tofu liquid waste has the potential to pollute the aquatic environment affected by waste water discharge. The Suyanto Tofu Factory requires waste water treatment facilities to prevent damage to the surrounding aquatic ecosystem. Liquid waste produced by the Suyanto Tofu Factory contains high levels of pH, TSS (Total Suspended Solids), BOD (Biochemical Oxygen Demand), and COD (Chemical Oxygen Demand). The waste produced by the Suyanto Tofu Factory emits an unpleasant odor and pollutes the river.

Research aims to achieve the following: determine the volume of waste water discharge from the tofu production process at the Suyanto Tofu Factory. analyzing BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), TSS (Total Suspended Solids), and pH levels in liquid waste from the Suyanto Tofu Factory , preparing a design for waste water treatment facilities (IPAL) at the Suyanto Tofu Factory. Plan and calculate the construction of waste water treatment facilities (IPAL) with an Artificial Wetland system (Zidan & Hady, 2018; Campbell & Ogden, 1999) because according to the results of field surveys around the factory, the land is large enough to be built and water hyacinth plants are easy to find in the area around the factory. Therefore, researchers propose sustainable solutions through appropriate wastewater treatment technology, and ensuring compliance with environmental regulations to protect the surrounding water ecosystem.

2. Methods

2.1 Research location

Mojokerto Regency is one of the districts located in East Java Province. The research location is the Suyanto Tofu Factory in Rembu Kidul Hamlet, Japanan Village, Kemlagi District, Mojokerto Regency, East Java 61353. This tofu factory was founded in 2002 and is owned by Mr Suyanto. Based on the results of the interview survey, the Suyanto tofu factory, which was founded in 2002, initially had a waste water treatment plant. However, until now the installation has not worked. Figure 2 shows that currently processing wastewater from tofu factories using small wells to settle the remaining tofu, which is then directly discharged into the nearest river without prior processing.

Fig. 1. Tofu factory IPAL 2023

2.2 Kadlec and Knight method

The planned design uses the Kadlec and Knight method because the waste produced by the Suyanto tofu factory contains levels of pH, BOD, TSS, and COD. Therefore, the formula for calculating the dimensions of the sanitary pond uses the Kadlec and Knight method which assumes that all pollutants use plug flow (Kadlec et al., 2000). The formula equation for determining the area of the wetland is as follows:

$$C^* = 3{,}5 + 0{,}053\ C_I$$

$$A_s = \frac{365.Q}{k} \ln \frac{C_e - C^*}{C_i - C^*} \quad \text{(Eq.1)}$$

A_s = Area
C_e = Target concentration of pollutants in effluent (mg/L)
C_i = Reference concentration of pollutants in influent (mg/L)
C^* = Reference concentration of pollutants BOD
k = Rate constant at first stage (m/yr)
Q = Average discharge of wastewater passing through wetland

Table 1. Table of parameter values for subsurface constructed wetland planning using the Kadlec and Knight formula

Parameter	BOD
K_{20} (m/yr)	180
Q	1,00
C^* (mg/l)	3,5 + 0,053 Ci

2.3 Sanita pond plants (Constructed wetland)

Water Hyacinth (Eichhornia crassipes) is a type of floating aquatic plant and is usually used as an aquatic plant to absorb pollutants. Water hyacinth has a high growth rate so that this plant is considered a weed that can damage the aquatic environment. Water hyacinth easily spreads through water channels to other water bodies. Water hyacinth lives floating in water and sometimes takes root in the soil. Its height is around 0.4 - 0.8 meters and has no stem (Rahmawati, 2020).

Although Water Hyacinth (Eichhornia crassipes) is considered a weed in waters, it actually plays a role in capturing heavy metal pollutants. A series of studies on the ability of water hyacinth by Indonesian researchers, including by Widyanto and Susilo (Widyanto & Susilo 1977). Reported that within 24 hours water hyacinth can absorb cadmium (Cd), mercury (Hg), and nickel (Ni), each at 1.35 mg/g, 1.77 mg/g, and 1.16 mg/g if the metals are not mixed. Water hyacinth also absorbs Cd 1.2 mg/g, Hg 1.88 mg/g and Ni 0.3 mg/g dry weight if the metals are mixed with other metals. Another study concluded that chromium (Cr) metal can be absorbed by water hyacinth maximally at pH = 7. In their research, the Cr metal which was originally at 15 ppm decreased by 51.85 percent. In addition to being able to absorb heavy metals, water hyacinth is also reported to be able to absorb pesticide residues.

2.4 Sample collection

The Suyanto tofu industry operates from 08.00 to 16.00 for tofu production. On average, this industry processes 500 kg of soybeans per day and requires 800 L of water every day. In this planning, the waste w ater flow rate is determined based on literature referred to by (Potter & Pawliszyn, 1994) as quoted in (Pamungkas & Slamet, 2017), showing that 1 kg of soybean raw materials produces 15-20 L of waste water.

Wastewater samples are collected at certain locations that represent overall conditions, usually from separate channels where wastewater is not mixed or influenced by other conditions. Table 1 below describes the flow rate of wastewater produced by the Suyanto tofu industry using a questionnaire for tofu factory employees. The pH, TSS, COD and BOD parameter values were obtained from sample testing at the UPTD Environmental Laboratory of the Environmental Agency (DLH) Mojokerto Regency.

Table 2. Wastewater production levels

Working hours	Soybean usage (kg/day)	Wastewater production rate (L/day)
08.00 – 16.00	500	7500

2.5 Wastewater treatment design

Constructed Wetland or artificial wetland is a planned processing system or controlled which designed use process experience (Campbell & Ogden, 1999; Vymazal & Kröpfelová, 2008; Kadlec et al., 2000). Process This involve vegetation, media And microorganisms for process water waste (Risnawati & Damanhuri, 2009).

2.6 Wastewater treatment system performance

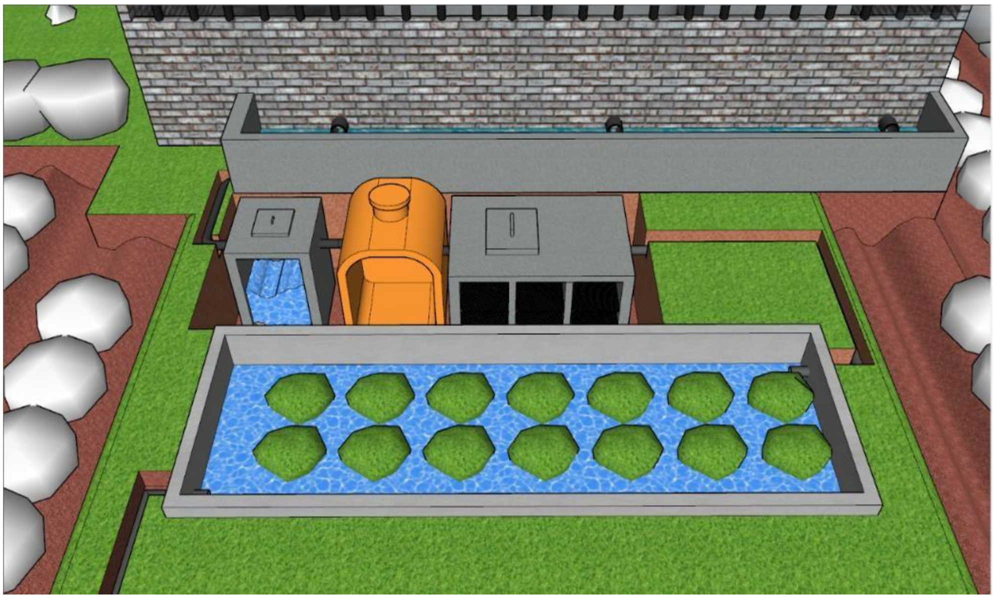

Fig. 2. Built wetland waste processing design

The waste water treatment process begins by directing the waste water into the initial equalization tank. This process aims to settle some suspended particles such as sand, mud and organic solids, while neutralizing the pH level with the addition of lime. The effluent from the initial equalization tank is then flowed from top to bottom to the biodigester tank, where the tofu waste water is managed to produce a by-product in the form of methane gas (CH_4).

The water from the biodigester tank is then channeled to the biofilter. In the anaerobic biofilter tank, gravel, sand and coral media are used and aerated with air. Organic substances in waste water that stick and grow on the surface of the media will be broken down by organic substances. So waste water will come into contact with microorganisms suspended in the water or attached to the surface of the media. This process increases the efficiency of decomposing detergents, organic substances, and accelerates nitrification for more efficient ammonia removal. This process is often called Contact Aeration (Haruta et al., 1991). The water from the biofilter tank will then be channeled to the sanitation pond. In its planning, this sanitation pond uses gravel as a medium planted with plants such as water hyacinth. Next, the waste water is channeled into the pond and the water level must be kept below the surface of the coral to prevent odors and the presence of other insects. To prevent clogging of the coral, wastewater must pass through a separate particle settling unit before entering the wetland unit (sanitary pond).

3. Results and Discussion

3.1 Wastewater quality analysis

The results of the Suyanto Tofu Factory Wastewater Quality Analysis are important data obtained from sample testing at the UPTD Environmental Laboratory of the Environmental Agency (DLH) Mojokerto Regency. One liquid wastewater sample was taken from the tofu factory for testing. The results of laboratory testing of liquid waste water are shown in table 3.

Table 3. Characteristics existing waste factory know Suyanto

Parameter	Results analysis	Quality standards Permanent LHK	Unit	Information
Ph	3.91	6 – 9	-	No fulfil quality standards
TSS	1050	200	mg/L	No fulfil quality standards
COD	5135	300	mg/L	No fulfil quality standards
BOD	2063	150	mg/L	No fulfil quality standards

The test results for pH, TSS, COD and BOD parameters exceed the maximum waste water limits in accordance with Minister of Environment and Forestry Regulation Number 5 of 2014 concerning Waste Water Quality Standards. Therefore, wastewater treatment using a Sanitation Pond (CW) is necessary to reduce these parameters to below the maximum standard, so that it is safe to discharge into the surrounding ecosystem.

3.2 Current location conditions

From the industrial spatial layout map below, it can be seen that the land available for planning the Sanitation Pond Waste Water Treatment Plant (IPAL) is located behind the Suyanto Tofu Factory. The land area is 14.56 meters by 13.30 meters, so the total area is 193.6 square meters.

3.3 Wastewater inlet piping planning

The first step in planning a pipeline network is to calculate the flow rate of liquid waste water.

3.4 Pipe dimension planning

After calculating the wastewater flow rate, the next step is to analyze the slope of the terrain. The land elevation data and planned channel length are known as follows:

Initial ground height = 24.8 m
Final ground height = 24.775 m
Channel length = 2m
Land slope (S) $=\frac{24{,}8\ \text{m}-24{,}775\ \text{m}}{2\ \text{m}}$
= 0.012 ~ 1.3% ground slope

From the land slope analysis above, the resulting slope is too steep. Therefore, it needs to be re-planned to achieve the minimum slope requirement of 2%. For the inlet pipe, the planned elevation and length of the channel are as follows:

Initial ground height = 24.85 m
Final height of land = 24,760 m
Channel length = 2m
Land slope (S) $=\frac{24{,}85\ \text{m}-24{,}760\ \text{m}}{2\ \text{m}}$
= 0.04 ~ 4% ground slope

The minimum pipe diameter can be calculated based on the planned flow rate. By using PVC pipes, the minimum diameter of the waste water pipe is 110 mm (approximately 4 inches), with the planned speed adjusted to the pipe dimensions.

Planned flow rate (Qp) = 0.00052 m3/sec
Channel slope (S) = 0.04
Manning coefficient (n) = 0.012
Planned pipe diameter = 110 ~ 0.11 m
Full $=\frac{D/4^{0,67}S^{0,5}}{n}$

$= \frac{(0,11/4)^{0,67} 0,04^{0,5}}{0,012}$

= 1.5 m/sec

Based on the speed calculation (v) above, the Qf value for full channel flow is as follows:

Qfull = Vfull × A

= 1.5 m/sec × (0.25 × Л × (0.11 m)2)

= 0.0143 m3/sec

Qp/Qf = 0.00052 m3/sec / 0.0143 m3/sec

= 0.036 m3/sec

Vpeak = $\frac{\text{Vpeak}}{\text{Vfull}} \times Vfull$

= 0.47 m/sec × 1.5 m/sec

= 0.705 m/sec

The speed calculation results above meet the speed requirements of 0.6 – 3 m/sec.

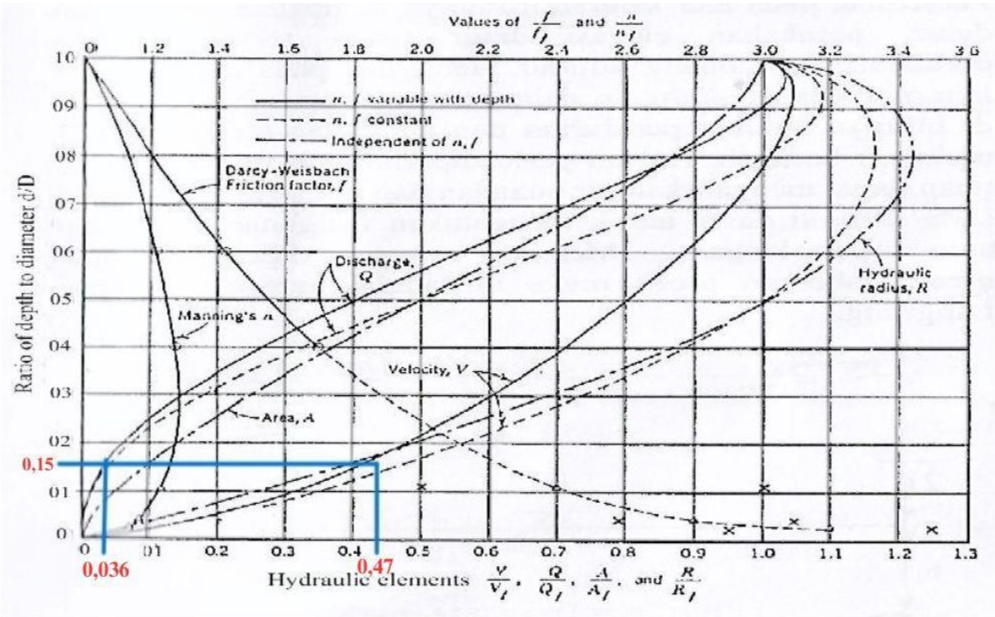

Fig. 3. Hydraulic element graphics

3.4.1 Pipeline planting plan

The following is the pipe planting plan for influent:

Data

Initial ground height = 24.8 m

Final height of land = 24.775 m

Planning

Initial planned height = 24.85 m

Pipe length = 2 m

Pipe slope = 0.04

Headloss = Pipe slope × Pipe length

= 0.04 × 2 m

= 0.08 m

Planned downstream height = Initial planned height - headloss

= 24.85 m - 0.08 m

= 24.77 m

Therefore, the depth of soil excavation is as follows:

Initial excavation depth at the top

= Initial planned height - Initial height of land

= 24.85 m - 24.8 m

= 0.05 m

Initial excavation depth at the bottom
= Top initial excavation depth + Outer pipe diameter
= 0.05 m + 0.114 m
= 0.164 m
Final excavation depth at top
= Final height of land - Final planned height
= 24.775 m - 24.77 m
= 0.005 m
Final excavation depth at the bottom
= Top final excavation depth + Outer pipe diameter
= 0.005 m + 0.114 m
= 0.119 m

3.5 Sanitation pond wastewater treatment plant design planning (Artificial wetland)

The planned wastewater treatment plant design considers the design criteria for each treatment pond unit to achieve effective performance.

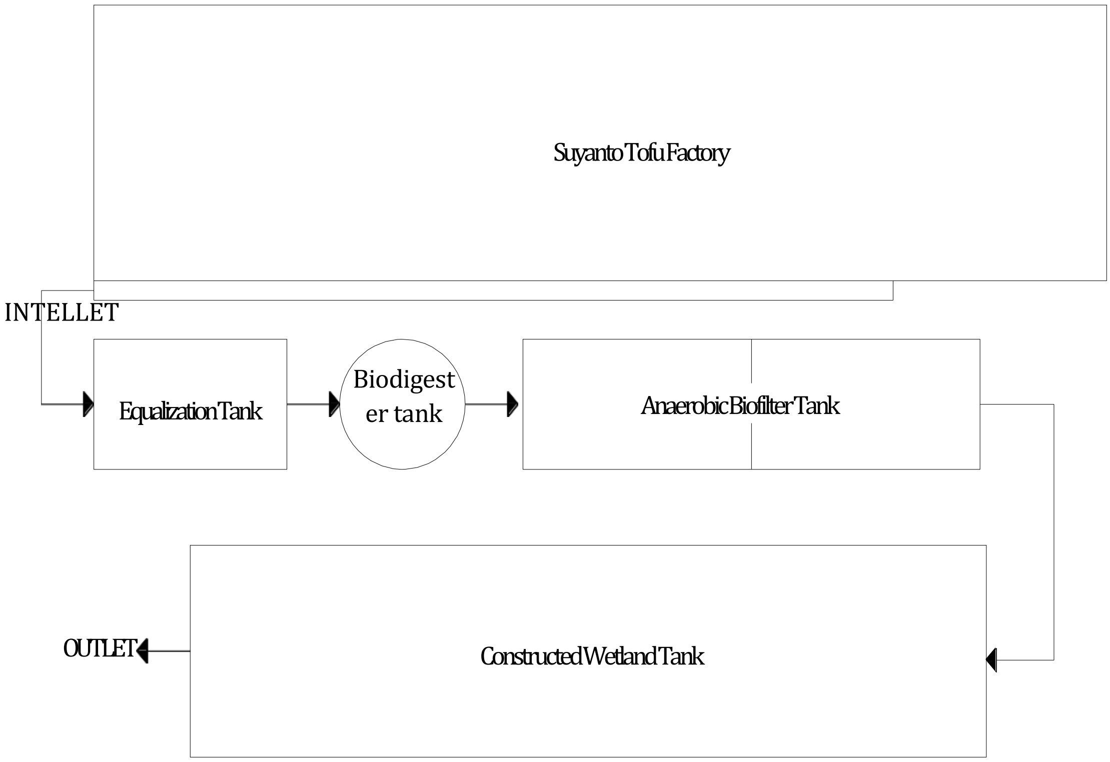

Fig. 4. Scheme of the Suyanto tofu factory wastewater treatment plant

3.5.1 Equalization tank

Equalization tanks are used to overcome operational problems such as flow rate variations and improving the decomposition of organic materials (Gantz et al., 2020; Fotso, 2021). It also improves downstream process performance and reduces the size and cost of downstream processing facilities. Flow equalization aims to achieve a constant flow rate and can be applied to different conditions depending on the characteristics of the collection system (Mikola, 2013).

3.5.1.1 Waste

The equalization tank is planned as a place to neutralize pH levels by adding lime according to daily wastewater flow requirements. Therefore, by adding lime according to calculations, the pH level required by the applicable quality standards will be achieved.

Given:

pH = 3.91

Q = 7500 L

= 7500kg

= 7,500,000 grams

$[H^+]$ = $10^{-4.28}$

Mr CaO = 56.0774 g/mol

Moles [H+] = $[H^+]$ x Q

= $10^{-4.28}$ x 7,500,000 grams

= 393.60 mol

To reach pH = 7: $CaO + 2H^+ \rightarrow Ca^2 + H_2O$

Mole CaO = 1/2 Mole $[H^+]$

= 196.8 moles

Grams of CaO = Moles of CaO x Mr. CaO

= 196.8 x 56.0774 g/mol

= 11,036.03 grams

= 11.03kg

Therefore, 11.03 kg of lime is needed per day to reach a pH of 7.

In the equalization tank unit, there is no significant removal of BOD, TSS, and TDS, so the effluent concentration from the equalization tank is considered to be the same as the influent concentration.

3.5.2 Biodegester

A system that accelerates the decomposition of organic materials. From this process, biogas and other compounds are formed through biofiltration (de Souza Moraes et al., 2022; Meghvansi et al., 2022). This biogas can be used for cooking fuel, heating, generating electricity, running machines, and other applications.

Levels of organic compounds entering the biodegester with parameters:

$TSS_{influent}$ = 1050 mg/L = 1050 g/m^3

$BOD_{influent}$ = 2063 mg/L = 2063 g/m^3

$COD_{influent}$ = 5135 mg/L = 5135 g/m^3

3.5.2.1 Waste

TSS_{waste} = 60% x TSS_{effect}

= 60% x 1050mg/L

= 630mg/L

BOD_{waste} = 15% x BOD_{effect}

= 15% x 2063mg/L

= 309.5mg/L

COD_{waste} = 15% x COD_{influx}

= 15% x 5135mg/L

= 770.25mg/L

Therefore, the levels of compounds removed can be calculated as follows:

$TSS_{removed}$ = $TSS_{influent}$ - $TSS_{effluent}$

= 1050 mg/L - 630 mg/L

= 420mg/L

$BOD_{removed}$ = $BOD_{influent}$ - $BOD_{effluent}$

= 2063 mg/L - 309.5 mg/L

= 1753.5mg/L

$COD_{removed}$ = $COD_{influent}$ - $COD_{effluent}$

= 5135 mg/L - 770.3 mg/L
= 4382.8mg/L

3.5.2.2 Biogas production

By knowing the decrease in COD values in the biodigester, theoretically biogas production can be estimated (Tang et al., 2010; Moreda, 2016). Based on research by Metcalf & Eddy (2003), the yield coefficient (Y) is 0.05 – 0.10, and the decay coefficient (kd) is 0.02 – 0.04. Commonly used values are Y = 0.08 g VSS/g COD and kd = 0.03 g/gd.

- COD Value:
- $COD_{removed}$ = 4382.8 mg/L ~ 4.3828 kg/m^3
- COD_{waste} = 770.3 mg/L ~ 0.7703 kg/m^3
- COD load:
- COD $load_{removed}$ = 4.3828 kg/m^3 x 7.5 m^3/day
= 32.87kg/day

waste COD $load_{liquid}$ = 0.7703 kg/m^3 x 7.5 m^3/day
= 5.76kg/day

- Px Calculation:

$$=\frac{\text{Y (COD load removed} - \text{COD load effluent)}}{1 + \text{kd x Hydraulic retention time}}$$

$$=\frac{0.08\text{ g Vss/g (3,287 kg/day} - \text{5,76 kg/day)}}{1 + 0.03 \text{ x } 10\text{ day}}$$

= 11.7kg/day

- Calculate the volume of methane per day at 35°C:

V_{CH4} = (0.40) x((S $_0$ - S) - 1.42 pixels)
= (0.40) x ((32.87 kg/day - 5.76 kg/day) - 1.42 (11.7 kg/day)
= 4.19 m^3/day

- Calculate biogas per day (assuming methane is 65% of biogas):

Biogas production $=\frac{4.19m^3 CH_{4/day}}{0.65m^3 CH_{4/day}}$
= 6.45 m^3/day

3.5.3 Anaerobic biofilter

Anaerobic biofilters are treatment systems designed to enhance the decomposition of organic materials in the absence of oxygen . This system uses microorganisms that thrive in anaerobic conditions to break down organic pollutants (Rene et al., 2013; Hendriarianti & Karnaningroem, 2016) resulting in biogas production and reducing contaminant concentrations in wastewater.

3.5.3.1 Waste

TSS_{waste} = 30% x TSS_{effect}
= 30% x 630mg/L
= 189mg/L

BOD_{waste} = 15% x $BOD_{influent}$
= 15% x 309.5 mg/L
= 46.41mg/L

COD_{waste} = 15% x $COD_{incoming}$
= 15% x 770.3mg/L
= 115.6mg/L

Therefore, the levels of compounds removed can be calculated as follows:

$TSS_{removed}$ = $TSS_{influent}$ - TSS_{waste}
= 630 mg/L - 189 mg/L
= 441mg/L

$BOD_{removed}$ = $BOD_{influent}$ - $BOD_{effluent}$
= 309.5 mg/L - 46.41 mg/L
= 263.09mg/L

$COD_{removed}$ = $COD_{influent}$ - $COD_{effluent}$
= 770.3 mg/L - 115.6 mg/L
= 654.7mg/L

3.5.4 Artificial wetlands

Constructed wetlands (CW) are a complex alternative for domestic wastewater treatment involving processes such as filtration, sedimentation, and biological treatment (Rosendo et al., 2022; Mthembu et al., 2013). The CW planned in this design is of the Subsurface Flow (SSF) type (Mena et al., 2008; Langergraber, 2008), where the flow direction is horizontal and occurs below the surface of the media consisting of soil, fine gravel and coarse gravel.

Table 4. Characteristics of Suyanto tofu factory wastewater

Parameter	Analysis results	Standard (Permanent LHK)	Unit	Notes
pH	3.91	6 – 9	-	Does not meet standards
Total Suspended Solids (TSS)	1050	200	mg/L	Does not meet standards
Chemical Oxygen Demand (COD)	5135	300	mg/L	Does not meet standards
Biochemical Oxygen Demand (BOD)	2063	150	mg/L	Does not meet standards

Suyanto Tofu Factory wastewater does not meet the pH, TSS, COD and BOD quality standards required according to the LHK Perman regulations. This shows the need for appropriate wastewater treatment measures so that waste quality is within acceptable limits. From the estimated quality of waste water produced from the Waste Water Treatment Plant (IPAL), it will then be compared with the waste water quality standards set by East Java Governor Regulation No. 72 of 2013. This comparison aims to find out whether all parameters meet government standards. set standards. Comparison of liquid waste with quality standards is presented in the following table.

Table 5. Comparison of WWTP effluent with waste water quality standards

Parameter	Copy	Quality standards	Information
TSS (mg/L)	30	200	Meets quality standards
BOD (mg/L)	13.41	150	Meets quality standards
KOD (mg/L)	5.78	300	Meets quality standards
pH	7	6-9	Meets quality standards

3.6 Hydraulic profile

3.6.1 Biodegester tank

Headloss Speed
Diameter (b) = 1.16 m
Height (y) = 1.5 m
Speed (v) = 0.3 m/sec
Gravitational acceleration (g) = 9.81 m/sec
Hydraulic radius (R) $= \frac{b \times y}{b+2y}$

$= \frac{1,16 \, x \, 1.5}{1.16+2(1.5)}$

= 0.418m

Friction coefficient (f) $= 1.5 \times (0.01989 + \frac{0.0005078}{4R})$

$= 1.5 \times (0.01989 + \frac{0.0005078}{4 \text{ x } 0.418})$

$= 0.03$ m

Flow length (P) = 1 m

Head loss (hf) $= \text{fx}\frac{r}{4R} \; x \; \frac{V^2}{2g}$

$= 0.03\text{x}\frac{1}{4 \text{ x } 0.418} \; x \; \frac{0.3^2}{2 \text{ x } 9.81}$

$= 0.00082$ m

3.6.2 Anaerobic biofilter

Head Drop

Fall length = 1 meter

H_L $= (\frac{V \, x \, n}{1 \, x \, R^{2/3}}) \; 2 \text{ x L}$

$= (\frac{0.3 \, x \, 0.013}{1 \, x \, 0.4444^{2/3}}) \; 2 \text{ x } 1$

$= 0.00004$ m

Headloss Bend

Bend length = 2 meters

H_L $= (\frac{V \, x \, n}{1 \, x \, R^{2/3}}) \; 2 \text{ x L}$

$= (\frac{0.3 \, x \, 0.013}{1 \, x \, 0.4444^{2/3}}) \; 2 \text{ x } 2$

$= 0.00008$ m

Losing your head Media

H_L $= 8.9 \times 10^{-5} \times v \times D^{-2}$

$= 8.9 \times 10^{-5} \times 0.3 \text{ m/sec} \times 0.05^{-2}$

$= 0.01068$ m

Headloss Speed

Length (b) = 2 m

Width (y) = 0.8 m

Speed (v) = 0.3 m/sec

Gravitational acceleration (g) = 9.81 m/sec

Hydraulic radius (R) $= \frac{b \text{ x } y}{b+2y}$

$= \frac{2m \, x \, 0.8m}{2m+2(0.8m)}$

$= 0.4444$ m

Friction coefficient (f) $= 1.5 \times (0.01989 + \frac{0.0005078}{4R})$

$= 1.5 \times (0.01989 + \frac{0.0005078}{4 \text{ x } 0.4444})$

$= 0.03026$ m

Flow length (P) = 2 m

Head loss (hf) $= \text{fx}\frac{r}{4R} \; x \; \frac{V^2}{2g}$

$= 0.03\text{x}\frac{1}{4 \text{ x } 0.4444} \; x \; \frac{0.3^2}{2 \text{ x } 9.81}$

$= 0.00015$ m

3.6.3 Artificial wetlands

Headloss Speed

Given:

Length (b) = 12 m

Width (y) = 3 m

Speed (v) = 0.3 m/sec
Gravitational acceleration (g) = 9.81 m/sec^2
Hydraulic radius (R) $= \frac{b \times y}{b+2y}$
$= \frac{12m \; x \; 3m}{12 \; m + (2 \; x \; 3m)}$
= 2 m
Friction coefficient (f) $= 1.5 \times (0.01989 + \frac{0.0005078}{4R})$
$= 1.5 \times (0.01989 + \frac{0.0005078}{4 \times 2})$
= 0.02 m
Stream length (P) = 12 m
Head loss (hf) $= f x \frac{r}{4R} \; x \; \frac{V^2}{2g}$
$= 0.02 x \frac{12 \; m}{4 \times 2} \; x \; \frac{0.3^2}{2 \times 9.81}$
= 0.00013 m

3.7 Planning pipe outlet dimensions

The land elevation data and planned channel length are known as follows:
Initial ground height = 24.8 m
Final height of land = 24.8 m
Channel length = 15 m
Land slope (S) $= \frac{24.8 \; m - 24.8 \; m}{15 \; m}$
= 0 ~ land slope of 0% s

From the land slope analysis above, the resulting slope does not meet the minimum requirements. Therefore, it is necessary to re-plan to achieve the required land slope elevation of at least 2%.

For outlet pipes, the elevation plan and channel length are as follows:
Initial ground height = 24.8 m
Final ground height = 24.2 m
Channel length = 15 m
Land slope (S) $= \frac{24.8 \; m - 24.2m}{15}$
= 0.04 ~ land slope of 4% s

The minimum pipe diameter can be calculated based on the planned flow rate. The minimum diameter of the waste water pipe is 110 mm, which is approximately 4 inches, with the planned speed adjusted to the dimensions of the pipe.
Planned flow rate = 0.00052 m^3/sec
Channel slope (S) = 0.04
Manning roughness coefficient (n) = 0.012
Planned pipe diameter = 110 mm = 0.11 m
Full $= \frac{D/4^{0,67} S^{0,5}}{n}$
$= \frac{(0,11/4)^{0,67} 0,04^{0,5}}{0,012}$
= 1.5 m/sec

Based on the speed calculation above, the Qf value for full channel flow is as follows:
Q full = Full × A
= 1.5 m/sec × (0.25 × Л × (0.11 m)^2)
= 0.0143 m^3/sec
Q p /Q f = 0.00052 m^3/sec/ 0.0143 m^3/sec
= 0.036 m^3/ sec

V peak $= \frac{Vpeak}{} \times Vfull$

 https://doi.org/10.61511/aes.v2i1.2024.819

$$Vfull$$
$$= 0.47 \text{ m/ sec} \times 1.5 \text{ m/sec}$$
$$= 0.705 \text{ m/sec}$$

The speed calculation results above meet the speed requirements of 0.6 – 3 m/sec.

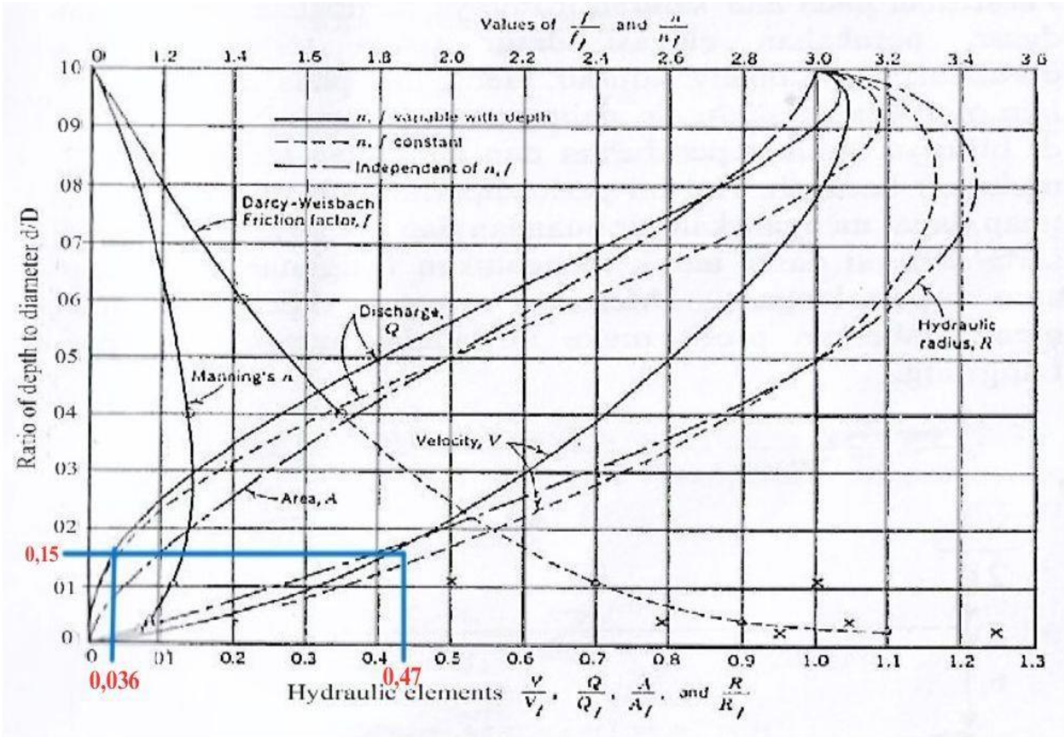

Fig. 5. Hydraulic element graphics

3.7.1 Planning for pipe outlet installation

The following is the plan for installing influent pipes:

Data
Initial ground height = 24.8 m
Final height of land = 24.8 m
Planning
Initial planned height = 24.8 m
Pipe length = 15 m
Pipe slope = 0.04
Headloss = Pipe slope × Pipe length
= 0.04 × 15 m
= 0.6 m
Planned downstream height = Planned initial height - headloss
= 24.8 m - 0.6 m
= 24.2 m

So, the depth of soil excavation is as follows: Initial subsoil excavation depth 0.114 m. Final excavation depth of top soil 0.6m. The final excavation depth of the subsoil 0.486 m.

This outcome is consistent with Raivaldi et al., 2021 research which indicated that industrial house stairways dominate the tofu preparation sector, which is mostly carried out by small firms and is present in practically every Indonesian city. The biggest industry lacks wastewater processing equipment. The wastewater focus has messed up contamination because it is still above the edge quality norm. By using plants, constructed wetlands are a cost-effective and dependable green technology to reduce water contamination. Utilizing Typha latifolia plants, artificial wetlands of the horizontal flow type Sub-Surface Flow are performed. With Typha latifolia plants, soil, sand, and gravel are the media employed. Every seven days, samples are obtained at the inlet and outflow of the artificial wetlands to test the quality of the tofu wastewater.

4. Conclusion

The existing condition of liquid waste at the Suyanto tofu factory contains a pH of 3.91 mg/L; TSS of 1050 mg/L; BOD of 2063 mg/L; and COD of5135 mg/L. The waste management design at the Suyanto tofu factory uses processing Sanita Pond (CW) wastewater with Eichhornia plants crassipes. For Equalization Tubs with dimensions 2.5m long, 1.5m wide, height 1.2m, Biodegester tub with dimensions 2.05m high, diameter 1.16m, Anaerobic biofilter tank with dimensions 1m long, 0.8m wide, 1.2m high, and Sanita Pool with dimensions 12m long, 3m wide, 1.1m high. This method is able to reduce the levels of organic content in tofu factory waste.

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Author Contributions

Conceptualization, M.Z., E.N., A.R.; Methodology, M.Z., E.N.; Software, M.Z., E.N., A.R.; Validation, M.Z., E.N., A.R.; Formal Analysis, M.Z., E.N.; Investigation, E.N., A.R.; Resources, M.Z., E.N.; Data Curation, M.Z., E.N., A.R.; Writing – Preparation of Original Draft, M.Z., E.N.; Writing – Review & Editing, M.Z., E.N.; Visualization, E.N., A.R.; Supervision, E.N., A.R.; Project Administration, E.N., A.R.; and Funding Acquisition, E.N., A.R.

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