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# Trickling Filter with River Stone and Hose Piece Media Variations for Treating Poultry Slaughterhouse Wastewater

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**Abstract**. The Poultry Slaughterhouse (RPU) operations generate wastewater with characteristics of high organic matter, expressed in parameters such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and oils and fats, requiring treatment to meet effluent standards and prevent water pollution. This research aims to determine whether a trickling filter can be used to treat poultry slaughterhouse wastewater. The wastewater was taken from the Wonokromo poultry slaughterhouse in Surabaya. The study was conducted using two wastewater tanks, with Tank 1 (P1) for collecting slaughter wastewater, and Tank 2 (P2) to maintain water pressure and distribute water to two trickling filter reactors. The trickling filter in this study used different media: the first trickling filter (R1) used stone media, and the second trickling filter (R2) used plastic hose pieces as media, with a flow rate of 10 milliliters per minute. The effluent from the trickling filter was collected and examined at 24, 96, and 186 hours, measuring TSS, BOD, and remaining oils and fats. The poultry slaughterhouse wastewater was distributed over the trickling filter, allowing the wastewater to trickle down to the surface of the filter media. The experiment concluded that the trickling filter with stone media and plastic hose pieces can treat poultry slaughterhouse wastewater with BOD removal above 80% and COD removal above 85%, but had low TSS removal, around 20%, after 186 hours of operation.

***Keywords:*** BOD, oils and fats, Poultry Slaughterhouse (RPU), trickling filter, TSS, wastewater

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## 1. Introduction

Chicken meat is a widely favored source of protein among Indonesians due to its affordability and easy availability. Over the past decade (2014–2023), chicken meat consumption in Indonesia has shown a consistent annual growth rate of 7.44%. In 2014, the average consumption was 3.96 kg per capita per year, which rose to 7.4 kg per capita per year by 2023 [1]. The slaughtering process in poultry slaughterhouses generates approximately 0.1 m³ of wastewater per bird per day [2]. As the population continues to grow, the demand for chicken meat is expected to rise, increasing the volume of waste produced by poultry processing activities. Therefore, developing effective management and wastewater treatment systems for poultry slaughterhouses is essential to ensure compliance with established effluent standards [3].

Poultry slaughterhouse. A building or several buildings used for slaughtering and processing poultry for consumption is the definition of a poultry slaughterhouse (PPU). Poultry slaughterhouses can be categorized into several types based on the number of birds slaughtered per day, with poultry slaughterhouse areas ranging from 200 m² for less than 500 birds/day and up to 15,000 m² for more than 10,000 birds/day. In brief, a poultry slaughterhouse has several areas of live birds, slaughtering area, de-feathering area, removing the meat, cooling area, sorting and packaging area, and cold storage area. Various activities in the slaughterhouse will generate liquid waste and solid waste. Liquid waste, generally a mixture of blood, production water, sanitation water, domestic liquid waste, while solid waste is in the form of poultry carcasses, feathers, meat flakes, bones, offal, poultry manure, and domestic solid waste [4]. Wastewater quality standards include the parameters BOD, COD, TSS, oil and fat, NH3-N, and pH [3].

**Trickling Filter.** A trickling filter is used for the aerobic biological treatment of wastewater. Biological wastewater treatment relies on microorganisms to biodegrade pollutants present in the wastewater. In the trickling filter method, a solid medium is required. Microorganisms grow and attach to the surface of this medium, forming what is known as a biofilm. The amount of biofilm that develops is influenced by the surface area of the trickling filter medium — the greater the surface area, the more biofilm can grow. The biofilm consists of various microorganisms, including bacteria, protozoa, and fungi. As wastewater flows over the biofilm, these microorganisms feed on the organic substances present in the water. Over time, the biofilm thickens, but portions of it will eventually slough off and become sludge [5],[6].

In domestic wastewater treatment using a trickling filter with bamboo chip media, several types of microorganisms involved in the treatment process have been identified. In the suspended phase, aerobic bacteria such as Aeromonas hydrophila and Aerobacter aerogenes were found. On the attached bamboo media, aerobic bacteria such as Aeromonas hydrophila, Escherichia coli, and Pseudomonas aeruginosa were identified [7].

Trickling filters perform effectively in wastewater treatment. They are used for treating domestic wastewater at the Bojongsoang Wastewater Treatment Plant (WWTP) in Bandung, which serves Central, South, and East Bandung. Research has shown that using a trickling filter with 5 cm bamboo chip media achieved a COD removal efficiency of 75.69% and BOD removal of 72.00% [7]. A trickling filter with coconut fiber media operating at a flow rate of 0.256 L/minute achieved removal efficiencies of 91.3% for BOD, 50.25% for nitrate, and 37.5% for ammonia [8]. Wastewater from tofu industry with initial characteristics of BOD 132 mg/L, COD 278.7 mg/L, and TSS 1804 mg/L was reduced by 91%, 88%, and 86%, respectively, using a trickling filter. Trickling filters with gravel media outperformed those using bioball media [6]. A trickling filter using bamboo media (3–6 cm in size, 50 cm thick) was also applied for treating tofu industry wastewater. This setup achieved COD removal of 40.46% and BOD removal

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of 66.67%, for wastewater with initial COD of 9,888 mg/L and BOD of 8,899 mg/L [9]. In another study, catering business wastewater with initial BOD of 434.5 mg/L and COD of 1,904.4 mg/L was treated using a rotating perforated distribution pipe at 50 rpm. Trickling filters using bioball and pumice stone media were tested. The results showed that pumice media had higher removal efficiency, with 82.1% for $BOD_5$ and 89.8% for COD, compared to bioball media [6].

This study aims to determine the effectiveness of a trickling filter in treating poultry slaughterhouse wastewater, in terms of the removal of BOD, COD, and TSS, using wastewater samples from the poultry slaughterhouse at Wonokromo Market, Surabaya.

## 2. Materials and Methods

A laboratory-scale study was conducted using two wastewater holding tanks and two trickling filter reactors. The wastewater used in the study was sourced from the Poultry Slaughterhouse at Wonokromo Market, Surabaya.

Holding tank 1 (P1), with a capacity of 80 liters, was used to store the wastewater. Every three days, the wastewater in P1 was refreshed by adding new wastewater from the Wonokromo Market Poultry Slaughterhouse. Wastewater from P1 was then channeled into holding tank 2 (P2). Holding tank 2 (P2), with a capacity of 40 liters, was equipped with an overflow system to maintain a constant water level. P2 functioned as a flow distributor to trickling filter reactor 1 (R1) and trickling filter reactor 2 (R2), as well as to maintain a constant head pressure toward the trickling filter reactors.

The trickling filter reactors measured 40 cm × 40 cm × 40 cm and were made of 0.5 cm-thick glass. Each trickling filter reactor had an underdrain space with a height of 5 cm, followed by a 10 cm thick filter media layer. Trickling filter reactor 1 (R1) was filled with natural stone media sized 1–2 cm, while trickling filter reactor 2 (R2) contained media made from cut rubber hose pieces, also sized 1–2 cm.

Wastewater from holding tank 2 (P2) was directed into the trickling filter reactors through an inlet distribution system, located at the top of each trickling filter reactor. As the wastewater flowed through the inlet distribution system, it created droplets that fell onto the surface of the trickling filter media. The inlet distribution system had a diameter of 35 cm and was constructed from 0.5 cm diameter pipes arranged in a circular pattern. Along the circular path, there were orifices with a diameter of 0.1 cm, spaced 5 cm apart. Wastewater exited through the orifices and dripped onto the surface of the trickling filter media.

Seeding and Acclimatization were carried out for three weeks. The microbial inoculum was sourced from the SIER Wastewater Treatment Plant (IPAL SIER) in Surabaya. Seeding was conducted in batch mode for three days. The microbial culture was mixed with poultry slaughterhouse wastewater and introduced into the trickling filter reactors to promote the growth of microorganisms (biofilm) on the surface of the trickling filter media. Following this, continuous acclimatization was performed by flowing poultry slaughterhouse wastewater through the reactors, allowing the microorganisms to adapt to the characteristics of the wastewater.

The treatment of poultry slaughterhouse wastewater using a trickling filter was conducted with an inlet distributor flow rate of 10 milliliters/minute. The trickling filter effluent was examined at hours 24, 96, and 186. The parameters for measuring the effluent include pH, temperature, BOD, and TS.

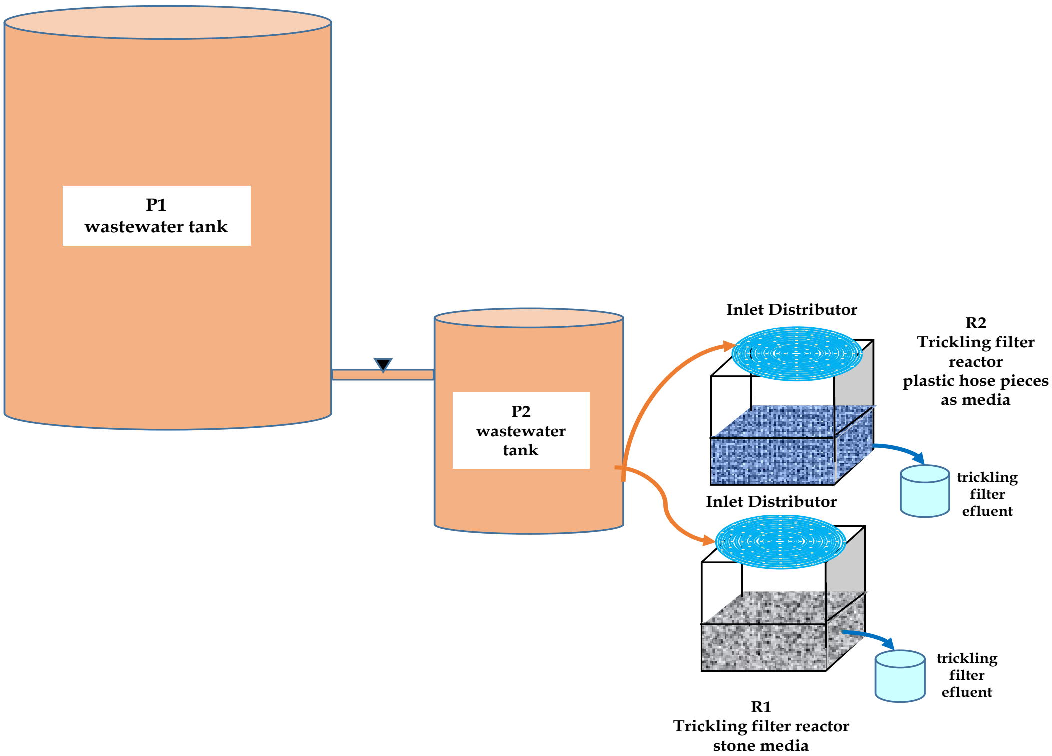

**Figure 1.** Experimental reactor setup

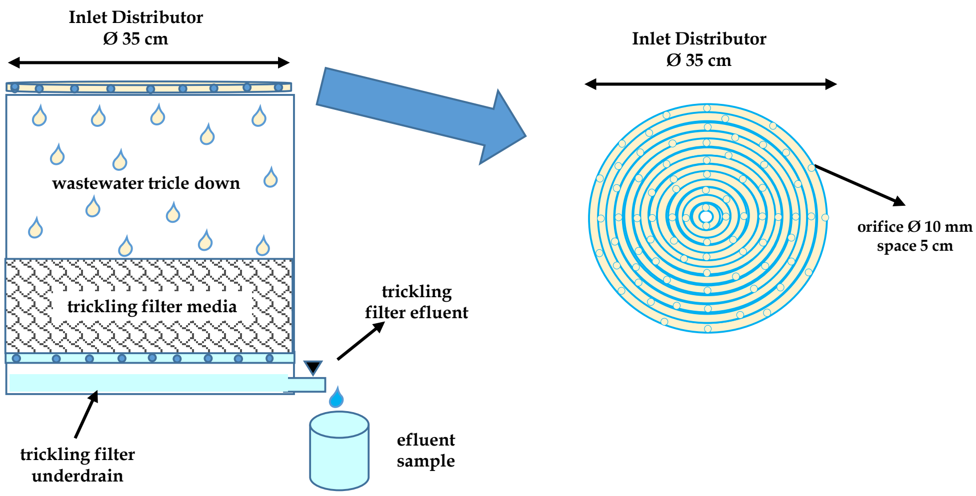


**Figure 2.** Detailed Trickling Filter Reactor Experiment

### 3. Results and Discussions

Poultry slaughterhouse wastewater has been previously studied with various treatment methods. Table 1 below presents the quality of poultry slaughterhouse wastewater from different areas.

**Table 1.** Poultry Slaughterhouse Wastewater Quality

| N | Source of wastewater | BOD (mg/L) | COD (mg/L) | TSS (mg/L) | Oils and fats (mg/L) | NH3-N (mg/L) | pH | Data source |
|---|---|---|---|---|---|---|---|---|
| 1 | Effluent quality standards | 100,0 | 200,0 | 100,0 | 15,0 | 25,0 | 6 - 9 | PerMenLH 5/2014 [3] |
| 2 | Poultry Slaughterhouse is located in Jombang | 1.648,0 | 2.603,0 | .212,0 | 180,0 | 141,0 | - | Nurilita Amalia Cahyani, et.al. [10] |
| 3 | Poultry Slaughterhouse is located in Kota Lama, Kedung Kandang, Malang | -- | 1.448,5 | 1.500,0 | -- | -- | -- | Yohana Febrianti Damuk, et.al. [11] |
| 4 | UD Giri Sari Poultry Slaughterhouse is located in , Penatih, Denpasar Timur | 814,8 | -- | -- | -- | -- | -- | Ni Luh Tisya Daniswari, et.al. [12] |
| 5 | Poultry Slaughterhouse is located in Makasar | 3.204,7 | 5.969,6 | -- | -- | -- | -- | Eka Apriyanti [13] |
| 6 | Poultry Slaughterhouse is located in Pulogadung Jakarta | 3.215,3 | 6.406,4 | 126,0 | 15,0 | 13,8 | 7,1 | B. Oktafani, et.al. [14] |
| 7 | Poultry Slaughterhouse is located in Sidoarjo | 336,0 | 848,0 | 222,0 | ---- | 280,0 | -- | Sekar Huwaidah Qatrunada, et.al. [15] |
| 8 | Poultry Slaughterhouse is located on Sumatra street, Jember | 3.360,0 | 5.600,0 | 548,0 | -- | -- | 7,1 | Elida Novita, et.al. [16] |
| 9 | Guci Randy Jaya Poultry Slaughterhouse is located in Jatiwarna, Bekasi | 731,8 | 1.023,4 | 159,2 | 9,0 | -- | 7,1 | P. Audella, et.al. [17] |
| 10 | Poultry Slaughterhouse is located in Kalitirto, Berbah, Sleman | 236,0 | 725,0 | 650,0 | 6.700,0 | -- | 6,2 | Oddy Satria Bhaskara, et.al. [18] |
| 11 | Poultry Slaughterhouse is located in Penggaron, Semarang | 401,3 | 829,6 | 502,0 | -- | 2,0 | 6,9 | Santya Nareswari, et.al. [19] |
| 12 | Poultry Slaughterhouse is located in West Pontianak, Pontianak | 317,0 | 873,0 | 160,0 | 6,9 | -- | 6,2 | Indah Suciana, et.al. [2] |
| 13 | Poultry Slaughterhouse is located in Wonokromo, Surabaya | 980,0 | -- | 40,0 | 74,0 | -- | -- | Research results, 2025 |

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The Biochemical Oxygen Demand (BOD) value is essential in biological wastewater treatment, as it reflects the concentration of organic materials that can be degraded by microorganisms. Based on Table 1 and Figure 3, the BOD value of poultry slaughterhouse wastewater is notably high, exceeding 3000 mg/L. The method of sample collection and the location where the wastewater samples are taken can influence the BOD values obtained. Grab sampling, for instance, may lower the BOD value, as it may result in a mixture of samples from different locations and times. The most representative sample of poultry slaughterhouse wastewater should be taken from the wastewater collection point, where the effluent from various activities has already been mixed. The BOD of all poultry slaughterhouse wastewater exceeded the permissible limit, indicating that treatment is necessary before discharge into natural water bodies to prevent water pollution.

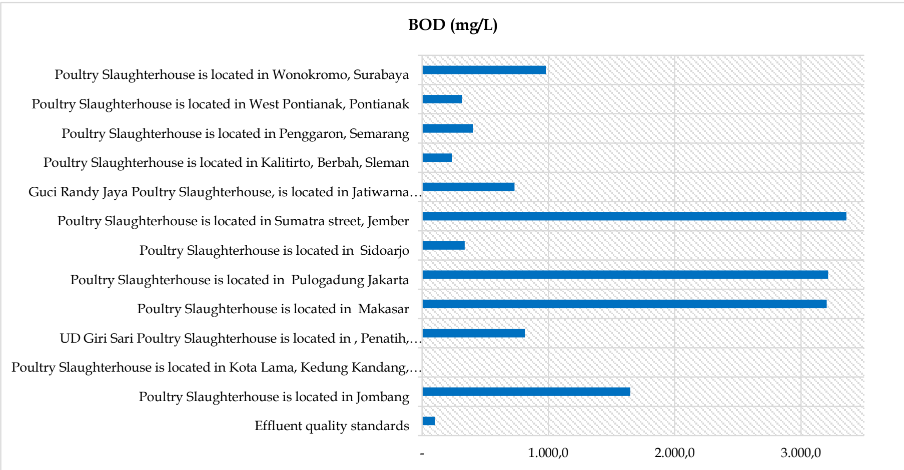


**Figure 3.** Biochemical Oxygen Demand (BOD) of Poultry Slaughterhouse Wastewater

The Chemical Oxygen Demand (COD) value reflects the concentration of organic materials in wastewater, including those easily biodegradable by microorganisms and those more resistant to degradation. As shown in Table 2 and Figure 4, the COD value of poultry slaughterhouse wastewater can exceed 6,000 mg/L. When the BOD to COD ratio is calculated, it yields a range of approximately 0.5. This ratio suggests that the organic matter in poultry slaughterhouse wastewater is not easily degradable by microorganisms. Given this BOD/COD ratio, it is recommended to first apply anaerobic biological treatment, followed by aerobic biological treatment. The high COD in poultry slaughterhouse wastewater is primarily due to the presence of organic matter such as blood, fat, and tissue residues.

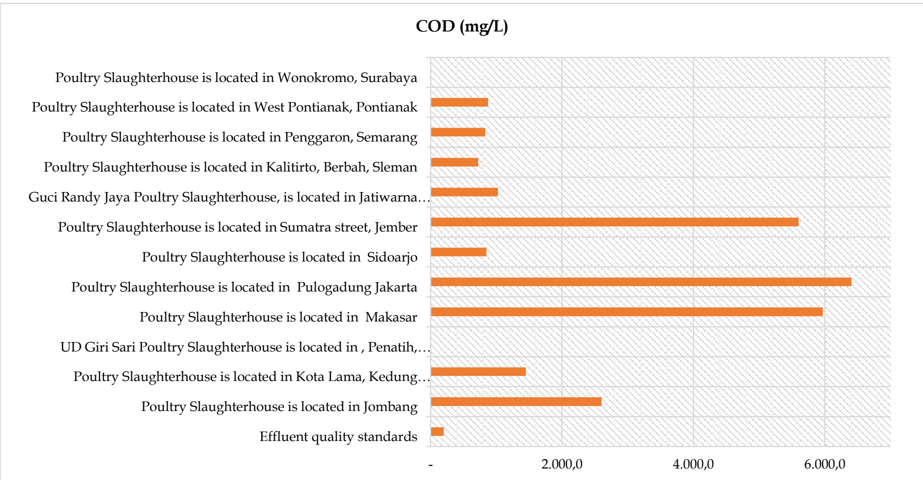


**Figure 4**. Chemical Oxygen Demand (COD) of Poultry Slaughterhouse Wastewater

The Total Suspended Solids (TSS) in poultry slaughterhouse wastewater were found to exceed regulatory limits, indicating a high concentration of both organic and inorganic particulate matter. The TSS levels reached approximately 1500 mg/L. Treatment of poultry slaughterhouse wastewater requires multiple stages, beginning with physical treatment processes aimed at removing TSS, feathers, oils, and fats. This is followed by biological treatment, in which microorganisms are used to degrade the remaining organic matter.

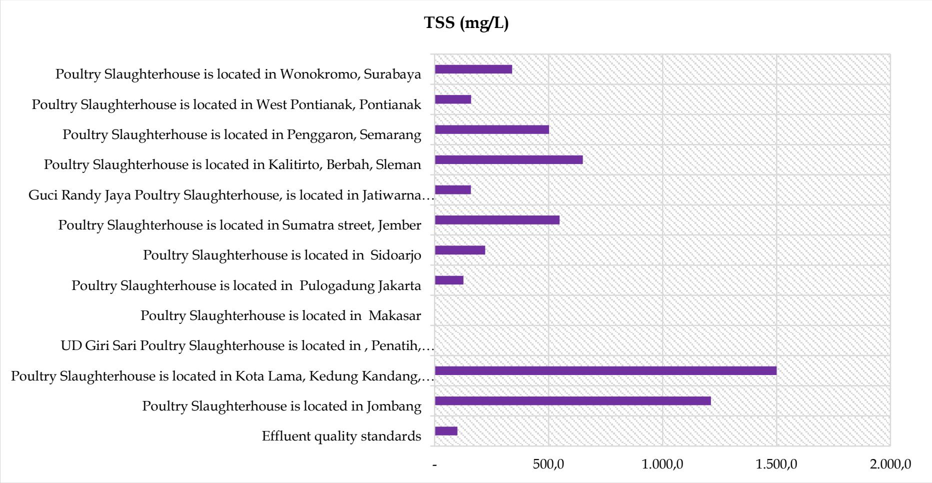


Figure 5. Total Suspended Solids (TSS) of Poultry Slaughterhouse Wastewater

A trickling filter with two types of media was used to treat poultry slaughterhouse wastewater at the laboratory scale. The filter operated at a flow rate of 10 milliliters per minute, and effluent samples were collected and analyzed at durations of 24, 96, and 186 hours. The measured effluent parameters included pH, temperature, biochemical oxygen demand (BOD), and total solids (TS). The experimental results are presented in Table 2 below.

**Table 2**
TSS, BOD, Oils and fats Concentration in Poultry Slaughterhouse Wastewater Treated with Trickling Filter
(Source: experimental result, 2025)

| Time (hours) | TSS value [mg/L] | | BOD value [mg/L] | | Oils and fats value [mg/L] | |
|---|---|---|---|---|---|---|
| | stone media | plastic hose pieces | stone media | plastic hose pieces | stone media | plastic hose pieces |
| 0 | 340 | 340 | 980 | 980 | 74 | 74 |
| 24 | 300 | 320 | 196 | 214 | 40 | 25 |
| 96 | 280 | 300 | 130 | 140 | 25 | 10 |
| 186 | 260 | 280 | 126 | 63 | 9 | 4 |

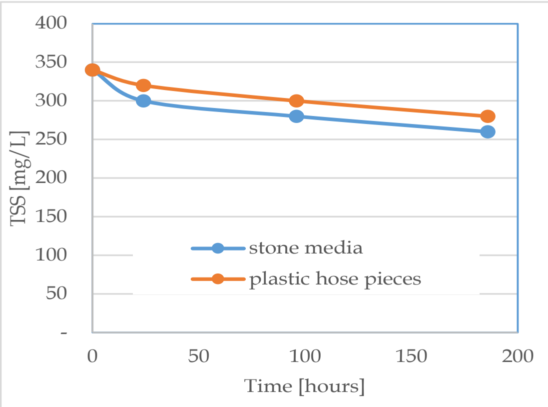


**Figure 6:** Reduction of Total Suspended Solids (TSS) in Poultry Slaughterhouse Wastewater Using Trickling Filter

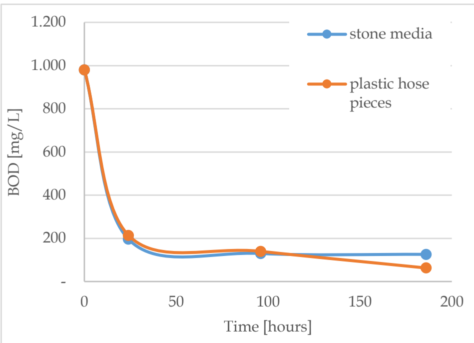


**Figure 6:** Reduction of BOD in Poultry Slaughterhouse Wastewater Using Trickling Filter

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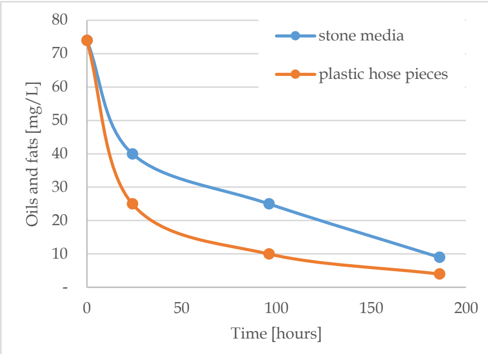


**Figure 6:** Reduction of Oils and Fats in Poultry Slaughterhouse Wastewater Using Trickling Filter

Figure 7 below shows the performance of the trickling filter using stone media and pieces of hose to treat poultry slaughterhouse wastewater. The observed parameters include TSS (Total Suspended Solids), BOD (Biological Oxygen Demand), and oils and fats.

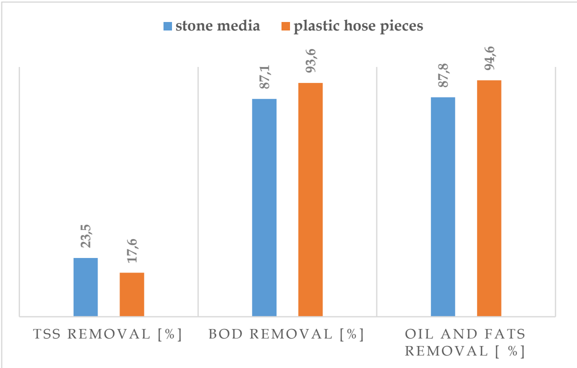


Figure 7 Efficiency comparison between stone media and plastic hose pieces, Trickling filter

A trickling filter was employed to treat poultry slaughterhouse wastewater over 186 hours. The system demonstrated effective removal of biochemical oxygen demand (BOD) at over 80% and chemical oxygen demand (COD) at over 85%. However, total suspended solids (TSS) removal remained low, at approximately 20%. This limited TSS reduction is likely attributed to the absence of preliminary treatment steps, such as sedimentation or flotation, which are commonly used to decrease the concentration of suspended solids before biological treatment. As a result, the effluent from the trickling filter still contained relatively high levels of TSS. For future research, it is recommended to extend the duration of the study and explore variations in both the size and type of filter media used.

Table 3 presents a comparison of trickling filter performance based on previous studies. Trickling filters have been applied in the treatment of various types of wastewater, including domestic wastewater, catering wastewater, tofu industry effluent, and poultry slaughterhouse wastewater. Overall, the data indicate that trickling filters are generally effective in reducing biochemical oxygen demand (BOD), achieving removal efficiencies exceeding 60%.

Tabel 3. Comparison with Other Types of Trickling Filter Reactors

| N | **Type waste water** | **Trickling filter media** | **Height filterbed [cm]** | **Removal BOD (%)** | **Sources** |
|---|---|---|---|---|---|
| 1 | Domestic Wastewater | Piece Of Bamboo | 30 | 72 | Churchil Febrion, et.al. [7] |
| 2 | Domestic Wastewater | Coconut Fiber Husks | 2,6 | 91.3 | Teuku Maimun et.al [8] |
| 3 | Catering Wastewater | Bioball And Pumice | 15 | 82,1 | Desi Fatimatur Rizkiyanti, et.al. [6] |
| 4 | Tofu Wastewater | Piece Of Bamboo | 50 | 66,67 | Tri Mulyani [9] |
| 5 | Tofu Wastewater | Gravel And Bioball | --- | 91 | Ika Meicahayanti, at.al. [5] |

## 4. Conclusion

Poultry slaughterhouse wastewater can be treated using a trickling filter. In a 186-hour experiment, the trickling filter with stone media and plastic hose pieces achieved BOD removal above 80% and COD removal above 85%, but had a low TSS removal of around 20%.

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