Separation of Oil, Grease and TSS in Chicken Intestine Chips Factory Wastewater Using a Laboratory-Scale Grease Trap Reactor

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Abstract.

The chicken intestine chips factory UD Ratna in Mojosari, Mojokerto generates wastewater and has been operating a wastewater treatment plant (WWTP) using sedimentation and aeration processes powered by solar panels. However, the performance of the WWTP, which was constructed in 2023, has not yet met the effluent quality standards. The initial sedimentation process is often disrupted by floating oil and grease, which obstruct the flow and cause agglomeration of solid and suspended particles, making them difficult to settle.. This study is a laboratory-scale experimental research designed to evaluate the effectiveness of a laboratory-scale grease trap reactor in reducing oil and grease as well as total suspended solids (TSS) concentrations at flow velocity variations of 2 m/h, 4 m/h, and 6 m/h. The research stages began with sample collection followed by the operation of the grease trap reactor conducted at the Chicken Intestine Chips Factory UD Ratna. The results showed that the grease trap reactor was able to remove oil and grease and TSS concentrations. The highest removal of oil grease and TSS was obtained at a flow velocity of 2 m/h, with effluent concentrations of 10 mg/L and 323.33 mg/L, and removal efficiencies of 88.68% and 71.47%, respectively. At a flow velocity of 2 m/h, the oil and grease concentration met the wastewater quality standard, while the TSS concentration remained above the permitted standard according to Peraturan Menteri Lingkungan Hidup Republik Indonesia Nomor 5 Tahun 2014 tentang Quality standards Air Limbah.

Keywords: *Grease trap; Flow velocity; Oil grease and TSS.*

I. INTRODUCTION

Wastewater is the residual water from household or industrial activities that use water as a primary material. It has specific characteristics that can be analyzed based on its physical, chemical, and biological properties[1]. Wastewater is generally classified into two types: industrial wastewater, generated from production processes in various industries, and domestic wastewater, originating from non-industrial activities such as households, offices, markets, and healthcare facilities like hospitals [2].The UD Ratna chicken intestine chip factory, located in Mojosari, Mojokerto, produces liquid waste and has operated a wastewater treatment plant (WWTP)[3]. The plant employs sedimentation and aeration technologies, and it is powered by solar panels that supply electricity to the inlet and aeration pumps[4]. Funded by the Dutch government in 2023, the WWTP's effluent quality has not yet met the required wastewater standards. Initial sedimentation is often disrupted by floating oil and grease, which block the water flow into the sedimentation tank. Sedimentation is intended to settle solids before aeration for organic matter oxidation; however, the oil and grease layer contributes to the agglomeration of solid and suspended particles, making settling difficult [5].Decreased sedimentation performance can escalate to overflow, where water cannot enter the sedimentation reactor, causing the WWTP to shut down. Consequently, chicken intestine washing wastewater flows directly into receiving water bodies, contaminating them with high levels of organic matter and oil.

Discharge of organic pollutants can reduce dissolved oxygen in rivers, threatening aquatic life [6]. According to the Indonesian Ministry of Environment Regulation No. 5 of 2014 on Wastewater Quality Standards, industries and other activities must treat their wastewater to prevent environmental pollution and maintain water quality.One effective method to reduce oil and grease content is the use of a grease trap, which operates on a physical principle based on differences in density and gravity between oil and water when flow is slowed [7]. Grease traps can remove up to 80% of oil and grease (EPA, 1998) and 50–80% of total suspended solids (TSS) (DPH, 1998) at flow velocitys of 2–6 m/h with a retention time of 5–20 minutes. According to Akbar (2021), grease traps can reduce oil and grease by 45.50% and TSS by 27.72%. Therefore, all businesses generating wastewater are required to implement treatment to ensure effluent meets the standards stipulated in Regulation No. 5 of 2014. In this study, the main Parameter tested is oil and grease removal using a laboratory-scale grease trap (GT).

II. METHODS

This study employed a laboratory-scale experimental design to evaluate the effectiveness of a grease trap in reducing oil and grease as well as total suspended solids (TSS) in wastewater generated by a chicken intestine chip factory. The research was conducted from September 2025 to February 2026. Wastewater samples were collected at the inlet point prior to entering the wastewater treatment plant (WWTP) of UD Ratna, located in Mojosari, Mojokerto, while laboratory analyses were carried out at the Environmental Engineering Laboratory, Malang National Institute of Technology (ITN Malang). Primary data were obtained from experimental measurements of oil and grease and TSS concentrations before (influent) and after (effluent) treatment using a laboratory-scale grease trap reactor, whereas secondary data were derived from Indonesian Ministry of Environment Regulation No. 5 of 2014 concerning wastewater quality standards [8].The experimental setup consisted of a stainless-steel grease trap reactor equipped with zig-zag baffles and a solid grease filter to enhance the separation of oil, grease, and suspended solids.

Factory wastewater was used as the test material. Flow velocity was controlled by adjusting the inlet valve opening, with three variations applied: 2 m/h, 4 m/h, and 6 m/h. These flow velocitys were selected based on grease trap design standards and previous studies, which indicate effective separation performance within this range. Grab sampling was conducted during active production following SNI 8990:2021 procedures, with samples collected prior to sedimentation to represent raw wastewater conditions[9].Oil and grease concentrations were analyzed using the gravimetric method in accordance with SNI 6989.10-2011, while TSS concentrations were determined using the gravimetric method based on SNI 06-6989.3-2004. Data analysis included descriptive analysis to evaluate the removal efficiency of the grease trap and one-way analysis of variance (One-Way ANOVA) to determine the effect of flow velocity on the reduction of oil and grease and TSS concentrations.

III. RESULT AND DISCUSSION

This chapter presents the results and discussion of the study on the separation of oil and grease and total suspended solids (TSS) from chicken intestine chip factory wastewater using a laboratory-scale batch-flow grease trap reactor. The analysis focuses on evaluating the effect of flow velocity variations of 2, 4, and 6 m/h on the reactor’s removal performance. Experimental data were analyzed descriptively to illustrate trends in Parameter concentration changes and inferentially to assess the influence of flow velocity as the independent variable on the removal efficiency of oil and grease and TSS as dependent variables. The findings are discussed with reference to relevant theories and previous related studies.

Characteristics of Chicken Intestine Chips Factory Wastewater

The initial wastewater characteristics were obtained from grab samples collected at the WWTP inlet of the UD Ratna chicken intestine chip factory in Mojosari, Mojokerto, at 10:30 a.m. during peak production to represent maximum pollutant loads. The samples were taken prior to any treatment and analyzed in the laboratory to determine the initial pollutant Parameters before processing with the grease trap reactor, as presented in the following table:

Table 1. Characteristics of Chicken Intestine Chips Factory Wastewater

No	Parameter	Concentration of Chicken Intestine Chips Liquid Waste(mg/l)*	Quality standards (mg/l)**
1	Oil and grease	88	10
2	TSS	1133	100

Based on Table 1, the oil and grease and TSS parameters in the chicken intestine chip factory wastewater do not comply with the wastewater quality standards stipulated in the Indonesian Ministry of Environment Regulation No. 5 of 2014. High oil and grease concentrations can disrupt the initial sedimentation process by forming a floating layer on the water surface, which obstructs influent flow into the sedimentation tank and reduces the hydraulic retention time (HRT). In addition, oil and grease promote the agglomeration of solid and suspended particles, making them more difficult to settle (Khuntia et al., 2020). These conditions may reduce WWTP performance and increase the risk of receiving water body pollution due to elevated organic matter and oil and grease contents, highlighting the need for appropriate wastewater treatment to reduce oil and grease and TSS concentrations and prevent environmental contamination.

Descriptive Analysis

Oil and Grease Removal

The results indicate a reduction in oil and grease concentration, demonstrating the capability of the laboratory-scale grease trap reactor to separate oil and grease from chicken intestine chip factory wastewater under batch-flow conditions at flow velocities of 2 m/h, 4 m/h, and 6 m/h. The experimental data are presented in Table 2. The oil and grease removal efficiency was calculated using the equation ((a - b)/a \times 100%), where *a* represents the initial concentration (mg/L) and *b* denotes the final concentration (mg/L). For example, a decrease in oil and grease concentration from 88.33 mg/L to 10 mg/L resulted in a removal efficiency of 88.68%.

Table 2. Oil and Grease Concentration Removal

No	Flow velocity (m/hour)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Elimination Efficiency (%)
1	2		10,00	88,68
2	4	88,33	13,33	84,91
3	6		15,00	83,02

Source: Research Results, 2026

Based on Table 2, the final oil and grease concentration in wastewater from the chicken intestine chip factory after treatment using a laboratory-scale grease trap varied across flow velocitys. At a flow velocity of 2 m/h, the final oil and grease concentration was 10 mg/L, which increased to 13.33 mg/L at 4 m/h and further to 15 mg/L at 6 m/h. A similar trend was observed for removal performance, where the oil and grease elimination efficiency decreased with increasing flow velocity, reaching 88.68% at 2 m/h, 84.91% at 4 m/h, and 83.02% at 6 m/h.

TSS Elimination

The data show a reduction in TSS concentration, indicating that the laboratory-scale grease trap reactor is effective in removing TSS from chicken intestine chips factory wastewater at flow velocitys of 2 m/h, 4 m/h, and 6 m/h under a batch flow system, as presented in Table 3. For example, a decrease in TSS concentration from 1133.33 mg/L to 323.33 mg/L resulted in a removal efficiency of 71.47%.

Table 3. TSS Concentration Removal

No	Flow velocity (m/hour)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Elimination Efficiency (%)
1	2		323,33	71,47
2	4	1133,33	443,33	60,88
3	6		503,33	55,59

Source: Research Results, 2026

Based on the data analysis, the final TSS concentration of wastewater from the chicken intestine chips factory after treatment using a laboratory-scale grease trap varied with flow velocity. At flow velocitys of 2, 4, and 6 m/h, the final TSS concentrations were 323.33 mg/L, 443.33 mg/L, and 503.33 mg/L, respectively. Correspondingly, TSS elimination efficiency decreased as the flow velocity increased, from 71.47% at 2 m/h to 60.88% at 4 m/h, and reached the lowest value of 55.59% at 6 m/h..

Inferential Analysis

Inferential analysis in this study was conducted using a one-way ANOVA to examine the effect of flow velocity (independent variable) on the removal efficiency of Oil and grease and TSS (dependent variables). Prior to the ANOVA, normality and homogeneity tests were performed, and the analysis proceeded only if these assumptions were satisfied. The decision criteria were as follows: if the significance value was less than 0.05, H_0 was rejected and H_1 accepted, indicating that the mean Oil and grease or TSS concentrations differed among flow velocity variations; conversely, if the significance value exceeded 0.05,

H_0 was accepted and H_1 rejected, indicating no significant difference in mean concentrations across the flow velocitys.

Statistical Analysis of Oil and grease Parameters

Normality Test

The results of the normality test on the TSS can be seen in table 4 below..

Table 4. Tests of Normality for Oil and Grease Concentration at Different Flow velocitys

Parameter	Flow velocity	Kolmogorov–Smirnov Statistic	df	Sig.	Shapiro–Wilk Statistic	df
Oil and grease Concentration	2 m/h	0.175	3	–	1.000	3
Oil and grease Concentration	4 m/h	0.253	3	–	0.964	3
Oil and grease Concentration	6 m/h	0.175	3	–	1.000	3

Based on the normality test results, the significance values for Oil and grease concentration were 1.000 at a flow velocity of 2 m/h, 0.637 at 4 m/h, and 1.000 at 6 m/h, all of which exceeded 0.05. Therefore, it can be concluded that the Oil and grease concentration data for all flow velocity variations are normally distributed, indicating that this dataset satisfies a key assumption of ANOVA and is suitable for further statistical analysis.

Homogeneity Test

The results of the Oil and grease parameter homogeneity test can be seen in table 5 below.

Table 5. Oil and Grease parameter homogeneity test result

Parameter	Test Basis	Levene Statistic	df1	df2	Sig.
Oil and grease Concentration	Based on Mean	0.047	2	6	0.954
Oil and grease Concentration	Based on Median	0.091	2	6	0.914
Oil and grease Concentration	Based on Median (Adjusted df)	0.091	2	5.902	0.914

Based on the homogeneity test results, the significance value (Sig.) was 0.952, which is greater than 0.05, indicating that the variance of Oil and grease concentration data across different flow velocity variations is homogeneous. Since the assumption of variance homogeneity is satisfied, the data meet the requirements for further statistical analysis using the ANOVA method.

One-Way ANOVA Test

The results of the One-Way ANOVA test for the Oil and grease parameter can be seen in table 6 below.

Table 6. One-Way ANOVA Oil and Grease Test Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	38.889	2	19.444	5.645	0.042
Within Groups	20.667	6	3.444		
Total	59.556	8			

Based on the one-way ANOVA results, the significance value (Sig.) of 0.042 was lower than 0.05, leading to the rejection of H_0 and acceptance of H_1. This indicates a significant difference in Oil and grease concentration among the flow velocity variations in the separation process using a laboratory-scale grease trap reactor; therefore, a post hoc test was subsequently conducted to identify which flow velocity pairs exhibited the most significant differences.

Tukey Test

The results of the Tukey test for the Oil and grease parameter can be seen in Table 7 below.

Table 7. Tukey Oil and Grease Test Results

Flow velocity	N	Subset for Alpha = 0.05	
		1	2
2 m/hour	3	10.00	
4 m/hour	3	13.33	13.33
6 m/hour	3		15.00
Sig.		0.150	0.548

Based on the Tukey test results, the mean Oil and grease concentrations were 10.00 mg/L at a flow velocity of 2 m/h, 13.33 mg/L at 4 m/h, and 15.00 mg/L at 6 m/h. The homogeneous subset grouping showed that 2 m/h belonged to the first subset, 4 m/h to both the first and second subsets, and 6 m/h to the second subset, indicating no significant differences between 2 and 4 m/h or between 4 and 6 m/h, as reflected by significance values greater than 0.05. Nevertheless, an increasing trend in Oil and grease concentration was observed with increasing flow velocity. Overall, the Tukey test confirmed that flow velocity variation significantly affected Oil and grease concentration in the wastewater treatment of a chicken intestine chips factory using a laboratory-scale grease trap reactor, with a flow velocity of 2 m/h being the most effective condition for reducing Oil and grease concentration.

Statistical Analysis of TSS Parameters

Normality Test

The results of the normality test on the TSS can be seen in Table 8 below.

Table 8. TSS Normality Test Results

		Kolmogorov-Smirnov			Shapiro-Wilk		
	Flow velocity	Statistic		Sig	Statistic	df	Si.
TSS concentration	2 m/hour	0.292	3		0.923	3	0.463
	2 m/hour	0.253	3		0.964	3	0.637
	6 m/hour	0.292	3		0.923	3	0.463

Based on the normality test results, the significance values of TSS concentration were 1.000 at a flow velocity of 2 m/h, 0.637 at 4 m/h, and 1.000 at 6 m/h, all of which exceeded the 0.05 threshold. This indicates that the TSS concentration data for all flow velocity variations were normally distributed. Therefore, the normality assumption required for ANOVA was satisfied, allowing further statistical analysis to be conducted.

Homogeneity Test

The results of the TSS parameter homogeneity test can be seen in Table 9 below.

Table 9. TSS Homogeneity Test Results

		Levene Statistic	df1	df2	sig
TSS concentration	Based on Mean	0.314	2	6	0.742
	Based on Median	0.059	2	6	0.943
	Based on Median and With Adjusted df	0.059	2	5.402	0.943
	Based on trimmed mean	0.284	2	6	0.762

Based on the homogeneity test results, the significance value (Sig.) was 0.762, which is greater than 0.05, indicating that the variances of TSS concentration across the different flow velocity variations are homogeneous. As this assumption is satisfied, the data meet the requirements for further statistical analysis using the ANOVA method.

Homogeneity Test

The results of the TSS parameter homogeneity test can be seen in Table 9 below.

Table 9. TSS Homogeneity Test Results

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	50400.000	2	25200.000	68.727	0.000
Within Groups	2200.000	6	366.667		
Total	52600.000	2			

Based on the results of the one-way ANOVA, the significance value (Sig.) was 0.000, which is less than 0.05; therefore, H_0 was rejected and H_1 accepted. This indicates a significant difference in TSS concentrations among the different flow velocity variations during the separation process using a laboratory-scale grease trap reactor. Accordingly, it can be concluded that flow velocity has a significant effect on TSS concentration in wastewater from the chicken intestine chips industry, and further analysis using a post hoc test is required to identify which flow velocity pairs exhibit the most significant differences.

Tukey's test

Table 10. Tukey TSS Test Results

Flow velocity	N	Subset 1	Subset 2	Subset 3
2 m/h	3	323.33		
4 m/h	3		443.33	
6 m/h	3			503.33
Sig.		1.000	1.000	1.000

Based on the Tukey HSD post hoc test, the mean TSS concentration was 323.33 mg/L at a flow velocity of 2 m/h, 443.33 mg/L at 4 m/h, and 503.33 mg/L at 6 m/h. The homogeneous subset grouping showed that each flow velocity fell into a different subset, indicating statistically significant differences among treatments. These results confirm that flow velocity has a significant effect on TSS concentration in the wastewater treatment of chicken intestine chips processing using a laboratory-scale grease trap reactor, with a flow velocity of 2 m/h being the most effective condition for reducing TSS concentration.

Discussion

The Effect of Flow velocity on Oil and grease Removal

Based on Table 2, the highest Oil and grease elimination efficiency was achieved at a flow velocity of 2 m/h (88.68%), followed by a decrease at 4 m/h (84.91%) and 6 m/h (83.02%). This declining trend indicates a clear relationship between flow velocity and Oil and grease separation performance. Inferential analysis using one-way ANOVA yielded a significance value of 0.042 (< 0.05), confirming that variations in flow velocity have a statistically significant effect on Oil and grease concentration. Higher flow velocitys increase turbulence within the reactor, causing oil droplets to disperse more uniformly in water and inhibiting the coalescence process [10]. Oil/grease coalescence refers to the collision and merging of small oil droplets into larger ones due to interfacial instability, which promotes phase separation in emulsion systems [11].Under calm or laminar flow conditions, oil droplets have a greater opportunity to coalesce and rise efficiently to the surface, whereas at higher flow velocities, dispersed oil droplets cannot separate effectively, resulting in reduced grease trap performance [12]. This is consistent with the results presented in Table 2, where higher flow velocitys exhibited lower oil separation efficiency because the oil lacked sufficient time to float to the surface before exiting the grease trap reactor.

Flow velocity also strongly influences detention time, which is a critical factor in determining oil and grease separation efficiency[13]. Lower flow velocitys provide longer detention times, allowing Oil and grease sufficient time to separate optimally, as lighter oil droplets tend to rise and become trapped within the grease trap [14]. The detention time calculations in Table 3.2 show that lower flow velocitys correspond to longer detention times, thereby enhancing the flotation process and resulting in lower Oil and grease concentrations.Oil and grease waste is an organic pollutant that can cause environmental problems by increasing oxygen demand in receiving waters. Although some oil and grease are biodegradable, high concentrations stimulate microbial activity that consumes large amounts of dissolved oxygen during degradation, reflected as increased Biological Oxygen Demand (BOD) [15]. In this study, the analyzed parameters were limited to Oil and grease and TSS; however, oil and grease are closely related to BOD as contributors to organic loading in wastewater. Therefore, BOD analysis in future studies is recommended to better assess the biological impact of oil and grease separation on wastewater quality. According to the Indonesian Ministry of Environment Regulation No. 5 of 2014, сюда the maximum allowable oil and grease concentration is 10 mg/L; consequently, only the 2 m/h flow velocity met the required quality standard, while effluent Oil and grease concentrations at 4 m/h and 6 m/h remained above the permissible limit.

Effect of Flow velocity on TSS Removal

Based on Table 3, variations in flow velocity significantly affected the TSS elimination efficiency in the laboratory-scale grease trap reactor. The highest TSS elimination efficiency was achieved at a flow velocity of 2 m/h (71.47%), followed by decreases at 4 m/h (60.88%) and 6 m/h (55.59%). The one-way ANOVA results showed a significance value of 0.000 (< 0.05), indicating that flow velocity has a highly significant effect on TSS concentration. Lower flow velocitys enhance TSS separation efficiency by allowing longer hydraulic retention times, which promote sedimentation and enable more suspended particles to be effectively trapped and separated from the wastewater [16]. Consequently, a flow velocity of 2 m/h resulted in the most effective TSS removal compared to higher flow velocitys, as longer retention times improve sedimentation performance, whereas higher flow velocitys shorten retention time and reduce settling efficiency [17].Wastewater generated from chicken washing processes, residual blood, and fat sludge contains high levels of TSS, BOD, and COD [18]. Previous studies have reported that TSS contributes more than 50% to the prediction of BOD and COD values, as suspended solids contain substantial amounts of organic compounds [19].

Therefore, evaluating BOD and COD parameters is essential to assess whether the separation of TSS and oil and grease in the grease trap reactor not only provides physical removal but also effectively reduces the biological and chemical organic pollution loads of the wastewater.According to the Regulation of the

Minister of Environment of the Republic of Indonesia No. 5 of 2014, the maximum allowable TSS concentration in effluent is 100 mg/L; however, all flow velocity variations tested in this study produced effluent TSS concentrations exceeding this limit. The high TSS levels in the effluent are likely due to relatively high flow velocitys, which create unstable flow conditions within the grease trap and reduce hydraulic retention time, preventing optimal sedimentation and allowing suspended particles to be carried out with the effluent [20]. Thus, additional treatment is required to further reduce TSS levels, such as filtration processes. Previous research has demonstrated that combining a grease trap reactor with a filtration unit can effectively reduce TSS, achieving an elimination efficiency of up to 97.89% [21].

IV. CONCLUSION

In conclusion, the grease trap reactor flow velocity effectively reduced Oil and grease and TSS concentrations in wastewater from the chicken intestine chips industry, with the highest removal achieved at a flow velocity of 2 m/h, resulting in Oil and grease and TSS concentrations of 10 mg/L and 323.33 mg/L and elimination efficiencies of 88.68% and 71.47%, respectively. At this flow velocity, the Oil and grease concentration met the regulatory quality standards, while the TSS concentration remained above the limit specified by the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014. Therefore, future studies are recommended to combine the grease trap reactor with additional treatment units such as filtration to enhance Oil and grease and TSS removal efficiency and improve effluent quality, as well as to include additional wastewater quality parameters, such as BOD and COD, for a more comprehensive evaluation of reactor performance.

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