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EFFECT OF PLATE SETTLER SLOPE IN GREASE TRAP ON OIL AND FAT REDUCTION

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ABSTRACT

Effect of Plate Settler Slope in Grease Trap on Oil and Fat Reduction. *Canteens involve food processing, presentation, and dishwashing activities, which generate domestic wastewater daily from washing used dishes. The canteen wastewater at PT. X contains oil and fat levels exceeding the threshold of 57.4 mg/L, which can harm aquatic ecosystems by inhibiting oxygen transfer into the water and reducing dissolved oxygen concentration (Patel et al., 2021). A grease trap equipped with a plate settler slope can reduce oil and fat levels in wastewater. This experimental study used a pre-test post-test design without control. The population comprised all domestic canteen wastewater at PT. X, with a total of 24 samples (6 pre-test, 18 post-test). Sampling was conducted using grab sampling. Instruments included gravimetric measurement, pH meters, thermometers, and cameras. Data collection involved testing oil and fat levels, measuring wastewater temperature, and pH. Data were analyzed using the Kruskal-Wallis test. Results showed a reduction in oil and fat levels for a 65° plate settler slope of 64.91 mg/L, for a 70° slope of 85.50 mg/L, and for a 75° slope of 92.85 mg/L. A significant difference was found among the three plate settler slopes in reducing oil and fat levels. However, none of the three slopes were effective in achieving oil levels below the standard threshold. Further research is recommended on plate settler slopes greater than 75°.*

INTRODUCTION

Liquid Waste is the residue from production or activities that are no longer used and may cause negative impacts if not properly treated and managed. One of the activities that generates liquid waste daily is industrial activity. Industry is an economic sector related to the production of goods or services on a large scale, involving the processing of raw materials or components into finished products that can be consumed or used by the public, which always produces waste from production activities within the industry.[1].

Yuni's research (2020) shows that grease traps using plate settlers with a 60˚ inclination provide the highest reduction of oil and fat content in canteen liquid waste by 80.4%.[2] Pratiwi's study (2014) found that grease traps equipped with plate settlers inclined at 60˚ can reduce fat and oil content in motor vehicle wash wastewater by 84.93% [3]. According to

Indrawan (2017), plate settlers with a 60° inclination can provide an efficiency of 62% in treating oily wastewater in oil separators [4,5]

Grease traps are divided into two types: conventional grease traps and grease traps using plate settlers. Plate settlers consist of parallel plates arranged at specific lengths, spacing, and angles so that they can act as barriers to oil and fat, thereby enhancing separation efficiency without requiring large land areas. Grease traps with plate settlers have advantages such as proven effectiveness in reducing oil and fat levels, relatively low cost, ease of operation, and simple maintenance.[6]

PT. X is a manufacturing industry producing automotive spare parts. It employs 1,200 workers, and according to the Ministry of Manpower and Transmigration Circular No: SE.01/MEN/1979 on the provision of canteens and eating areas, companies with more than 200 employees are required to provide a canteen. PT. X's canteen operates daily from 11:00 to 13:00. The canteen's activities include food processing, serving, and washing dishes used by employees. Consequently, liquid domestic waste is generated daily from washing used eating utensils.

PT. X has not yet implemented treatment for the domestic liquid waste generated from the canteen's activities, which is in contradiction with the Minister of Health Decree No. 1098/menkes/SK/VII/2003 concerning hygiene requirements for restaurants and eateries, stating that kitchen drainage must have grease traps. Visually, the canteen's liquid waste at PT. X appears turbid, contains many food residues, and has oil and fat content. The oil and fat content in liquid waste negatively impacts the environment by damaging aquatic ecosystems when discharged into water bodies, forming a thin layer on the water surface. This layer inhibits oxygen transfer into the water, causing a decrease in dissolved oxygen concentration. [7–9]

Initial examination showed that the oil and fat content in PT. X's canteen liquid waste was 57.9 mg/L. According to the Indonesian Ministry of Environment and Forestry Regulation No. 68 of 2016 on Domestic Wastewater Quality Standards, the permissible limit for oil and fat content is 5 mg/L.

The researcher is interested in studying the effect of different plate settler inclinations on grease traps in reducing oil and fat content in canteen liquid waste at PT. X, with variations of 65°, 70°, and 75°.

MATERIALS AND RESEARCH METHODS

This study used an experimental design. Experimental research aims to examine the effect of a certain treatment or intervention on specific groups. This study applied different treatments in the form of variations in the plate settler inclination angle on grease traps to reduce oil and fat content in PT. X's canteen. The research design was a pre-test and post-test without control, meaning the study measured oil and fat content before and after the intervention without a control group.

Data collection involved sampling and analysis of oil and fat content in PT. X's canteen wastewater at the Karawang Environmental Laboratory, along with measurements of temperature and pH of the wastewater. The research was conducted from June 13 to June 18, 2023.

Bivariate analysis was performed using the Kruskal-Wallis test to determine differences in effectiveness among the plate settler inclination variations of 65°, 70°, and 75° in reducing oil and fat content at PT. X.

RESEARCH RESULTS AND DISCUSSION

The results of oil and fat content measurements in the domestic liquid waste from PT. X's canteen are presented in the following table:

Table 1 Results of Oil and Fat Content Examination in Domestic Liquid Waste from PT. X's Canteen Date: June 13–18, 2023

Treatment	Measurement Results of Oil and Fat Content			
	Pre-test	**65˚ Inclination (mg/L)**	**70˚ Inclination (mg/L)**	**75˚ Inclination (mg/L)**
1 (13 june)	99,8	31,5	10,5	5,3
2 (14 june)	80,6	32,8	12,7	6,2
3 (15 june)	77,47	25,6	11,68	5,8
4 (16 june)	91,07	33,8	13,3	5,1
5 (17 june)	85,3	27,4	14,8	7,3
6 (18 june)	79,48	28,6	11,06	6,5
Total	513,72	179,7	74,04	36,2
Average	85,62	29,95	12,34	6,03

Based on Table 1, it can be seen that the average oil and grease concentration during the pre-test was 85.62 mg/L. The post-test average concentrations at plate settler inclinations of 65˚, 70˚, and 75˚ were 29.95 mg/L, 12.34 mg/L, and 6.03 mg/L, respectively.

Table 2 Percentage Reduction of Oil and Grease Concentration in Domestic Wastewater from PT.X's Canteen, June 13–18, 2023

Replication	Percentage Reduction Results of Oil and Grease Levels at Different Plate Settler Inclinations		
	65˚ Inclination (%)	**70˚ Inclination (%)**	**75˚ Inclination (%)**
1 (13 june)	68,43%	89,47%	94,68%
2 (14 June)	59,30%	84,34%	92,30%
3 (15 June)	66,95%	84,92%	92,51%
4 (16 June)	62,88%	85,39%	94,34%
5 (17 June)	67,87%	82,64%	92,37%
6 (18 June)	64,01%	86,08%	90,81%
Total	389,47%	512,78%	557,10%
Average	64,91%	85,47%	92,84%

Based on Table 2, the percentage reduction of oil and grease levels in each treatment is quite significant. At a plate settler inclination of 65˚, the average percentage reduction was 64.91%, at 70˚ it was 85.47%, and at 75˚ it reached 92.84%.

This study employed univariate analysis to determine the mean values of oil and grease reduction in the wastewater from PT. X's canteen using a grease trap with plate settlers at different inclinations of 65˚, 70˚, and 75˚. The results of the univariate test are presented below:

Table 3 Results of Univariate Analysis

Variable	Mean (%)	Minimum (%)	Maximum (%)	Standar deviation
65˚ **Inclination**	64,91	59,30	68,44	3,51
70˚ **Inclination**	85,15	82,70	89,50	2,29
75˚ **Inclination**	92,85	90,81	94,70	1,46

Based on the results of the univariate analysis in Table 3, it was found that the mean value at a 65˚ inclination was 64.91%, with a range of 59.30%–68.44% and a standard deviation of 3.51. The mean value at a 70˚ inclination was 85.15%, with a range of 82.70%–89.50% and a standard deviation of 2.29. The mean value at a 75˚ inclination was 92.85%, with a range of 90.81%–94.70% and a standard deviation of 1.46.

Bivariate analysis was conducted using the Kruskal-Wallis test. The Kruskal-Wallis test was performed to determine the differences in the effectiveness of the plate settler inclinations of 65˚, 70˚, and 75˚ in reducing fat and oil content at PT. X. The following are the results of the Kruskal-Wallis test:

Table 4 Results of the Kruskal-Wallis Test

Variable	Sig.
Percentage Reduction of Oil and Fat Content	0,00

Based on Table 4, the results of the Kruskal-Wallis test on the data from the plate settler inclination variations of 65°, 70°, and 75° showed that the p-value was < α (0.00 < 0.05). Thus, the null hypothesis (Ho) was rejected, indicating that there is a statistically significant difference among the plate settler inclinations in the grease trap in reducing oil and fat content.

Domestic activities such as those from the canteen within the industrial area are one of the primary sources of oily wastewater. Preliminary test results indicated that the oil and fat content in the wastewater from the canteen of PT. X was 57.9 mg/L, which exceeds the maximum permissible limit of 5 mg/L as stipulated in the Regulation of the Minister of Environment and Forestry No. 68 of 2016.

PT. X is an automotive spare parts manufacturing industry employing approximately 1,200 workers. According to the Circular Letter of the Minister of Manpower and Transmigration No. SE.01/MEN/1979, companies with more than 200 employees are required to provide canteen facilities. Dishwashing activities in the canteen constitute the main source of oil and fat contamination in the wastewater.

Physicochemical Parameters of Wastewater

Measurement results indicated that the wastewater temperature ranged between 25°C and 27°C across all treatments, including at plate settler inclinations of 65°, 70°, and 75°. This temperature range did not show a significant influence on the separation efficiency but was still within a favorable range to support gravity separation processes, considering that the temperature was not high enough to form oil emulsions that are more difficult to separate.[1] Meanwhile, the pH values ranged from 7.2 to 7.9, which is classified as neutral. This range is ideal for maintaining the physical stability of oil and fat characteristics, without inducing chemical reactions or emulsification that could interfere with the separation process. No extreme fluctuations were observed that might affect the grease trap efficiency during the treatment process.

Effectiveness of Plate Settlers in Reducing Oil and Fat

The percentage reduction in oil and fat content for each treatment was as follows: Plate settler at 65°: 64.91%; Plate settler at 70°: 85.47%; and Plate settler at 75°: 92.84%.

The highest efficiency was observed at a 75° inclination, which mechanically provides a greater flow surface area and accelerates the settling of the oil phase from the wastewater. A steeper inclination tends to form a laminar flow that enhances the separation mechanism based on the density differences. [10–17]

These findings reinforce previous studies that reported a reduction of oil and fat content by up to 52.11% using 12 plate settlers. The addition of plate settlers is known to reduce the overflow rate [18–20], thereby improving separation efficiency by decreasing the vertical flow velocity of particles. Moreover, a study by Indrawan Fajar et al. (2017) demonstrated that a narrower spacing between plate settlers shortens the settling path of particles, thus increasing separation efficiency. [5]

Effect of Plate Settler Inclination and Its Implications

The addition of plate settlers with optimal inclination angles serves as a technical innovation to enhance grease trap performance. In this study, the 75° inclination was found to be the

most optimal, differing from the findings of Joni H (2014), who identified the optimal angle at 60°, with decreased efficiency at steeper angles due to changes in sedimentation geometry. Despite this discrepancy, the high effectiveness observed at 75° in this study may be attributed to the flow characteristics and the nature of the domestic wastewater originating from dishwashing activities, which have different density and viscosity profiles compared to industrial lubricant oil. [21–35]

These findings are supported by the study of Pratiwi et al. (2014), which reported an efficiency of 84.93% at a 60° angle in lubricant oil treatment, and by Husaeni and Nurul (2016), who reported a 92.31% reduction in TSS at a similar angle.

Therefore, the results of this study demonstrate that the design of grease traps with appropriate plate settler inclination can significantly improve the efficiency of oil and fat separation, and can be recommended as a simple yet effective technical solution in managing domestic kitchen or industrial canteen-based wastewater.

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates that the inclination of the plate settler within the grease trap has a significant effect on the reduction of oil and fat concentrations in the canteen wastewater of PT. X. The highest average reduction in oil and fat concentration was observed at a 75° inclination, amounting to 92.84% or 92.85 mg/L, followed by a 70° inclination at 85.47% or 85.50 mg/L, and a 65° inclination at 64.91% or 64.91 mg/L. Although the percentage reductions were substantial, the final concentrations of oil and fat still did not meet the effluent quality standard set by the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 68 of 2016, which specifies a maximum limit of 5 mg/L. The average oil and fat concentration at the outlet remained at 6.03 mg/L.

Therefore, it can be concluded that although an increase in the efficiency of oil and fat reduction is evident with greater plate settler inclinations, none of the tested configurations were capable of reducing the concentration to below the regulated threshold. Other factors, such as flow rate, retention time, and additional design elements in the grease trap system, are likely to influence the overall effectiveness of the treatment. Further studies are recommended to evaluate the impact of these variables and to explore more optimal separation system designs or combinations, in order to ensure that treatment outcomes comply with prevailing environmental standards.

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