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Differences in thickness variations of activated carbon in decreasing oil and grease levels using modified grease trap on the canteen wastewater

Key words: canteen wastewater, modified grease trap, thickness, activated carbon, oil, and grease

Introduction

Wastewater is residual water from either or both industrial activities and non-industrial activities. Non-industrial wastewater such as domestic wastewater is derived from human daily life activities related to water use according to the Indonesian Regulation of the Minister of Environment and Forestry No 68 of 2016 concerning domestic wastewater quality standards (Peraturan Menteri Lingkungan Hidup tentang baku mutu air limbah, BNRI No 1323, 2016). Domestic wastewater (greywater) is wastewater originating from kitchen activities, toilets, sinks, and more, which will cause water pollution and impact on the aquatic life when directly discharged into the environment without any prior treatment.

The characteristics of domestic wastewater are generally grouped into physical, chemical, and biological characteristics. The physical characteristics of domestic wastewater include TSS (suspended residue), chemical characteristics include pH, ammonium, COD, and BOD, while organic chemistry includes oil and grease, and biological characteristics such as total coliform according to the aforementioned regulation.

Wastewaters with those parameters are prohibited from being discharged into water bodies if they do not meet the predetermined quality standards. Wastewater quality standards are a tolerable limit or level of pollution in the wastewater that will be disposed or released into the water bodies as a result of either

or both industrial activities and non-industrial activities, according to the aforementioned regulation.

Currently, the most dominant pollutant in water bodies is domestic wastewater with a percentage that can reach up to 60–70%. Domestic wastewater consists of parameters such as BOD, TSS, pH, oil, and grease, when all these parameters are discharged directly into the water body it will cause water pollution (Faulconer & Mazyck, 2017).

Oil and grease are one source of contaminants that have not been handled properly in Indonesia (Abuzar, Afrianita & Notrilauvia, 2012). Oil and grease are one of the parameters with a number of maximum concentrations determined as a requirement for the discharge of industrial wastewater and surface water (Rahmi, 2016). High concentrations of oil and grease can damage aquatic ecosystems (Abuzar et al., 2012). Oil and grease contained in water bodies will form a layer on the surface because the density of oil is lower than the density of water. The layers of oil and grease will block the entry of sunlight thus the aquatic plants could not process photosynthesis. For that, the wastewater should be treated first to meet the predetermined quality standards.

Based on the quality standards used for domestic wastewater, namely the aforementioned regulation concerning the domestic wastewater quality standards, the quality standard for organic chemical wastewater for oil and grease is 5 $mg \cdot L^{-1}$. This regulation must be applied by the wastewater producer, both industrial wastewater or domestic wastewater producer (Putu & Nieke, 2012).

PT. Sipatex Putri Lestari is a textile industry that facilitates a canteen in the company, the canteen operates every day at 11.00–13.00 Western Indonesian Time, as a result, PT. Sipatex Putri Lestari produces domestic wastewater as a residue of canteen kitchen activities. In February 2020 a laboratory test has been carried out to find out the concentration of oil and grease from the wastewater of residual kitchen activities with a result of oil and grease as 10.40 $mg \cdot L^{-1}$. The examination was carried out by the West Java Provincial Laboratory using the gravimetric method based on the SNI 6989.10:2011 standard (Badan Standardisasi Nasional [BSN], 2011).

Based on the result, the concentration of oil and grease from the wastewater of residual kitchen activities at PT. Sipatex Putri Lestari does not meet the predetermined quality standards on the aforementioned regulation concerning domestic wastewater quality standards, the quality standard for organic chemical waste for oil and grease is 5 $mg \cdot L^{-1}$. Therefore, it is necessary to carry out a wastewater treatment before discharging it into the water body.

Rahmi (2016) conducted research related to the reduction of oil and grease levels using various activated carbon, such as by using coconut shells, palm kernel shells, rice husks, and sawdust, with a thickness of 10 cm each. This activated carbon is used as an adsorption medium for domestic wastewater. The results of the research have stated that coconut shells and rice husks activated carbon was able to reduce oil and grease by 66.66%. Meanwhile, palm kernel shells activated carbon was only able

to reduce oil and grease by 29.16% and sawdust activated carbon was very ineffective because it was unable to reduce oil and grease (Rahmi, 2016).

Zaharah, Nurlina and Moelyani (2017) have also conducted research in 2017 related to reducing oil and grease levels using activated carbon modified grease traps. The results of the research stated that there was a decrease in oil and grease level, which was more effective, compared to simple grease traps without modification of activated carbon. The oil and grease in the wastewater that has passed through the grease trap will be passed through the container containing activated carbon and the output will be stored into a container. When passing through a 20 cm PVC pipe containing activated carbon, organic matter from oil and grease is reduced based on the principle of adsorption by activated carbon which can occur due to the pores that the adsorbent.

Activated carbon will be in contact with pollutants, where activated carbon will adsorb pollutant molecules until equilibrium conditions are reached. In this process, particles or molecules of pollutants will attach to the surface of activated carbon, which happened due to the difference in the weak charge between the two, this occurs due to the van der Waals Force (Zaharah et al., 2017). The van der Waals force is founded on the recognition that spontaneous, transient electric polarization can arise at a center due to the motion of electrons, molecular distortion, or molecular orientation. This polarization will act on the surrounding region to perturb spontaneous fluctuations elsewhere (Ninham & Parsegian, 1970). According to Wongthanate, Mapracha, Prapagdee and Arunlertaree (2014), modified oil traps have a higher efficiency of reducing TSS, BOD, oil, and grease than simple grease traps.

Based on this research, the researchers are interested in researching the differences in the thickness variation of activated carbon to reduce oil and grease levels using a modified grease trap on the canteen wastewater of PT. Sipatex Putri Lestari because the wastewater contains quite high levels of oil and grease. The modified grease trap is a grease trap reactor modified with activated carbon added to one of its parts, the purpose of modification or adding activated carbon is to increase the amount of reduction in oil and grease levels.

Rahmi (2016) conducted research using various variations of activated carbon with a thickness of 10 cm, the results of the study stated that it could reduce oil and grease levels by 66%. Zaharah et al. (2017) also conducted research using activated carbon, the thickness used was adjusted to the length of the PVC pipe used, which was 20 cm, the results showed the effectiveness in reducing oil and grease levels. Kasman, Riyanti, Sy and Ridwan (2018) also used additional activated carbon in reducing oil and grease levels by using water jasmine (*Echinodorus palaefolius*) with a thickness of activated carbon of 5 cm, but the results showed that the reduction in oil and grease levels was ineffective and it has still exceeded the determined quality standard.

Based on this, the thickness variations that will be used by the researcher are 10, 20 (that has been suggested by previous researchers) and 30 cm because Umar,

Baiquni and Ritohardoyo (2011) have stated that the thicker the media the better the results will be obtained s thus if the thickness is added to the arrangement of the media, it will be better in decreasing the oil and grease levels (Umar et al., 2011). Kasman et al. (2018) research stated that the lower the thickness of the activated carbon used, the less effective it is to reduce the existing oil and grease levels. As a result, the oil and grease levels produced are below the quality standard values that have been determined in the aforementioned regulation concerning domestic wastewater quality standards.

The type of activated carbon that will be used in this research is activated carbon from coconut shells. According to Rahmi (2016), the effective activated carbon in reducing the oil and grease is by using the coconut shell charcoal and rice husk charcoal. Tamado et al. (2013) stated that the use of basic material from coconut shells is not only used because of the affordable price and it's easy to obtain, but also because of the properties and characteristics of the content in the coconut shells both chemically and physically, coconut shells have a high carbon content thus they have the potential to become an alternative renewable energy source. A good coconut shell for activated carbon is an old and dry shell because its carbon content is higher than that of younger ones.

The utilization choice of activated carbon made from coconut shells is because coconut shells activated carbon has a wide surface, lightweight, and it has many pores thus it supports the attaching process of pollutants in the wastewater (Wardhani, Dirgawati & dan Alvina, 2013).

Material and methods

The type of research used is experimental research, which aims to determine the difference in the thickness variations of activated carbon to reduce oil and grease levels using a modified grease trap on the canteen wastewater of PT. Sipatex Putri Lestari. Concentrate on research used true experiment pretest posttest without control. The modified grease trap is a grease trap reactor with activated carbon added to one of its parts, the purpose of modification of activated carbon added is to increase the amount of reduction in oil and grease levels.

Work procedures

Table 1 lists tools and materials used for the research. The wastewater is passed through the modified grease trap with a thickness variation of activated carbon as 10, 20 and 30 cm.

Data processing

The data processing stage is carried out by doing the editing process, such

TABLE 1. Preparation of tools and materials used for research

Tools/Materials	Size	Quantity
Grease trap	90 × 30 × 40 (30 × 30 × 40 of each chamber)	1
Pipe	0.0254 m	1 m
Pipe	0.0508 m	1 m
T-pipe	0.0508 m	2
Grill plat	–	0.5 m
Jerrycan	5 L	10
Activated carbon	10 kg	–
Canteen wastewater sample	100 L	–

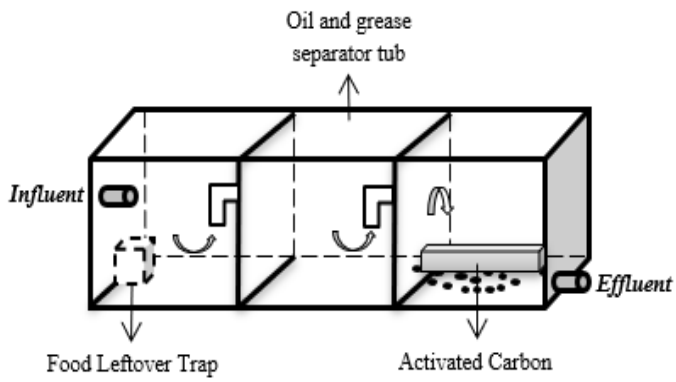

FIGURE 1. Modified grease trap (Zaharah et al., 2017)

as rechecking the measurement results of the data, the coding process which is coding the measurement data, the data entry process which is entering the measurement results of the data into the data analysis software called SPSS for further analysis and the cleaning process which is the re-checking process of the measured data that has been entered to see any possibility of coding errors and incomplete measurement data for further correction process.

The data analysis used in this research is the univariate analysis and bivariate analysis. In this study, univariate analysis was used to determine the normality of the data using the Shapiro–Wilk test, the mean, minimum and maximum values and standard deviation values of the decreasing levels results in the measurements of oil and grease levels while the bivariate analysis was carried out using the one-way ANOVA test because the data results from the measurement of decreasing oil and grease levels is in the normal distribution.

Results and discussion

Temperature test result

The results obtained in measuring the temperature of the canteen wastewater before and after the treatment was ranging from 24 to 27°C (Fig. 2). The higher the temperature, the lower the viscosity, and density which will cause the liquid to flow quickly. The viscosity of a liquid will cause a certain amount of friction between parts or layers of fluid that move one against another. The friction or resistance that occurs is due to the cohesion force in the liquid, thus the viscosity of a liquid is due to the cohesion force between particles or molecules of the liquid. The change in temperature of the reaction causes the motion of the molecules to accelerate (collisions between reactant molecules increases) (Wahyuni, 2015).

The reduction in oil and grease level is affected by the room temperature that will transform grease into a solid form

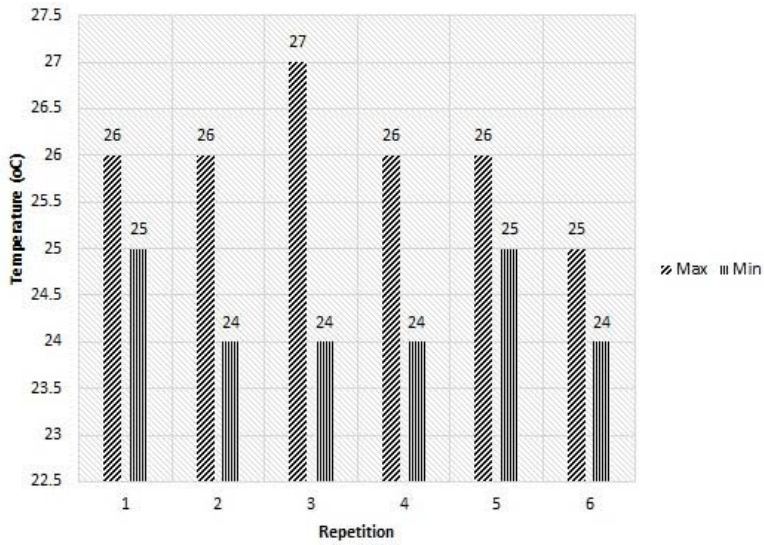

FIGURE 2. The temperature of canteen wastewater in PT. Sipatex Puti Lestari

and oil into a liquid form. When this situation occurs, it will make the adsorption process carried out by activated carbon easier. The temperature measured in this study corresponds to room temperature, which is in the range of 24–27°C.

The pH test result

The pH of wastewater from PT. Sipatex Putri Lestari ranges at 7.0–8.5, thus it can be concluded that the pH of the canteen wastewater tends to be alkaline due to the process of dish-washing using soap. The pH is one of the factors that affect the rate and ability of adsorption. At pH conditions greater than or equal to 7.0, the efficiency of reducing oil and grease concentration increases (Valencia, 2017). The pH of the wastewater is measured from PT. Sipatex Putri Lestari ranges from 7.0–8.5 with that result that the adsorption process to reduce oil and grease levels runs optimally (Fig. 3).

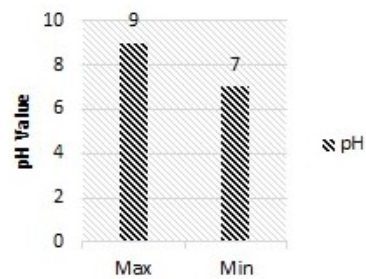

FIGURE 3. The pH test result

Measurement result of oil and grease levels of the wastewater

The oil and grease levels of the canteen wastewater before given treatment was at an average result of 27.4 $mg \cdot L^{-1}$, and after being treated with a thickness variation of activated carbon using a modified grease trap, the oil and grease levels of activated carbon with a thickness of 10 cm was at an average of 15 $mg \cdot L^{-1}$, activated carbon with a thickness of 20 cm was at an average of

TABLE 3. Measurement result of oil and grease level on each activated carbon thickness

Specification	10 cm activated carbon thickness		20 cm activated carbon thickness		30 cm activated carbon thickness	
	pretest	posttest	pretest	posttest	pretest	posttest
	$mg \cdot L^{-1}$					
Repitition 1	31.8	18.8	31.5	12.7	31.7	4.2
Repitition 2	23.1	13.2	23.4	11.6	23.8	2.2
Repitition 3	26.6	13.8	26.8	10.8	26.7	3.1
Repitition 4	25.5	12.9	25.7	9.7	25.8	2.8
Repitition 5	29.3	17.3	29.5	11.9	28.8	4
Repitition 6	27.8	14.2	27.9	12.2	27.3	3.5
Average	27.4	15.0	27.5	11.5	27.4	3.7
Max	31.8	18.8	31.5	12.7	31.7	4.5
Min	23.1	12.9	23.4	9.7	23.8	2.2
SD	3.03	2.43	2.85	1.08	2.70	0.66

11.5 $mg \cdot L^{-1}$, and activated carbon with a thickness of 30 cm was at 3.7 $mg \cdot L^{-1}$ (Table 3).

The average result of the reduction in oil and grease levels with a thickness variation of 10 cm was at 12.32 $mg \cdot L^{-1}$ with a percentage of 49%, an average reduction in oil and grease levels with a thickness variation of 20 cm was at 15.98 $mg \cdot L^{-1}$ with a percentage of 62% and an average reduction in oil and grease levels of 13 cm thickness was at 23.67 $mg \cdot L^{-1}$. The highest percentage reduction in oil and grease levels occurred in the third treatment variation, which was the thickness variation of activated carbon at 30 cm with an average result of 86% in the reduction of oil and grease levels (Fig. 4).

Besides, the results of statistical tests, namely the post hoc test, have shown that activated carbon with a thickness of 30 cm obtained the greatest *p*-value 0.001) at 11.35 (95% *CI* = 8.65 – 14.04), which means that there is a very optimal

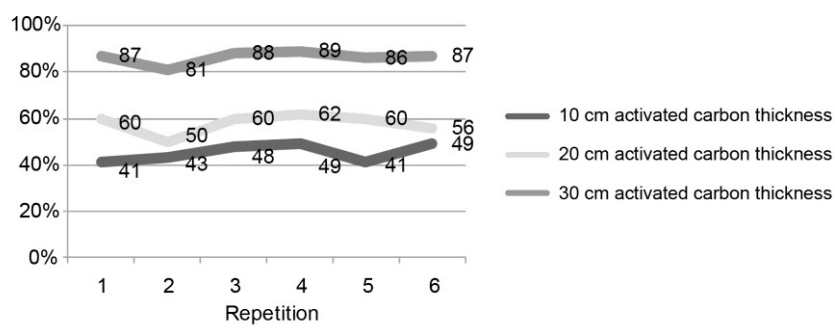

FIGURE 4. Percentage of reduction in oil and grease level

difference in this variation. The reduction that occurs after the treatment with the thickness variation of activated carbon using a modified grease trap happened due to the sedimentation process where oil and grease particles will rise to the surface and then followed by the adsorption process where activated carbon will be in contact with the pollutants, activated carbon will adsorb pollutant molecules until equilibrium conditions are reached. The reduction in oil and grease levels of PT. Sipatex Putri Lestari occurs because of the physical processing, namely the sedimentation and adsorption process with activated carbon adsorbents using a modified grease trap. Sedimentation is a deposition process in which these oils and grease will float to the surface of the water because the oil density is lower than the water density. Adsorption is either or both physical and chemical processes in which the substance accumulates on a surface layer of the absorbent substance.

In this process, particles or molecules of pollutants will attach to the surface of the activated carbon which is caused by the difference of the weak charge between the two, this occurs due to the van der Waals force (Zaharah et al., 2017).

Activated carbon is a carbon-based material that has a broad surface and internal porous structure with a pore distribution that varies in size, and a broad spectrum of oxygenated functional groups (Wardhani et al., 2013; Faulconer & Mazyck, 2017; Valencia, 2017). The type of activated carbon used in this study is coconut shell-based activated carbon. Because coconut shells are very easy to obtain and they are one of the abundant renewable resources, one of the efforts made to utilize them is by processing coconut shells into activated carbon. This activated carbon material is widely used in industry, especially in the field of oil, water treatment, gas, food, beverage, medicine, and chemical industry (Rizky, 2017). According to Rahmi (2016), the effective type of activated carbon used in the filtration in reducing the value of oil and grease is coconut shell charcoal and rice husk charcoal.

The particle size of activated carbon used in this study was 8–16 mesh, the type of activated carbon used was coconut shell. In the research of Putu and Nieke (2012), activated carbon with a diameter of 1.19 mm (16 mesh) had the best removal efficiency to reduce oil levels. The smaller the media diameter, the greater the effective surface area, which will increase the ability to absorb organic pollutants. The thicker the activated carbon used, the more activated carbon particles will absorb the levels of oil and grease in the canteen wastewater of PT. Sipatex Putri Lestari, this also affects the increase of contact time of pollutants with activated carbon particles. Therefore, the thickness of activated carbon affects the reduction in oil and grease levels of PT. Sipatex Putri Lestari. The reduction that occurred in the 30 cm thickness variation of activated carbon reached the most optimal and effective point in reducing oil and grease levels of the canteen wastewater at PT. Sipatex Putri Lestari has finally met the requirements whereas the result was following the quality standard because it does not exceed the maximum of 5 $mg \cdot L^{-1}$ based on the aforementioned regulation concerning domestic wastewater quality standards.

The flow rate used in the research was 2.22 $L \cdot min^{-1}$ which is adjusted to the existing flow rate conditions in the industry so that the condition or characteristics of the flowing water will be similar to as it was in the industry.

Conclusions

The reduction in oil and grease level that has occurred was at an average of 12.32 $mg \cdot L^{-1}$ and the percentage of reduction in oil and grease levels of canteen wastewater with thickness variation of activated carbon at 10 cm was 49%, 20 cm was 62% (average: 15.98 $mg \cdot L^{-1}$), and 30 cm was 89% (average: 23.67 $mg \cdot L^{-1}$).

Based on the result the most effective reduction of oil and greases levels using the modified grease trap in the canteen wastewater of PT. Sipatex Putri Lestari, was a variation thickness of activated carbon at 30 cm. Because it can reduce the oil and grease levels of the wastewater with a percentage of 89% and the result has met the quality standards which is maximum at 5 $mg \cdot L^{-1}$ based on with the aforementioned regulation concerning domestic wastewater quality standards.

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Summary

Differences in thickness variations of activated carbon in decreasing oil and grease levels using modified grease trap on the canteen wastewater. Wastewater is residual water of industrial activities and domestic wastewater that is derived from daily activities of human life related to water usage, such wastewater should not be discharged into water bodies if it has not met the standards based on the regulation. Oil and grease contained in the water bodies will form a layer on the surface because the density of oil is lower than the density of water. The layer of oil and grease will block the entry of sunlight and cause the inability in the photosynthesis process of aquatic plants. The textile industry facilitates canteens within the company which operates daily at 11.00–13.00 Western Indonesian Time, resulting in the domestic wastewater from the canteen kitchen activities. The purpose of this study was to determine differences in the thickness variations of activated carbon to reduce oil and grease levels using modified grease traps on the canteen wastewater at PT. Sipatex Putri Lestari. The type of study used was categorized as a field experiment with a pretest–posttest research design. The population of the study was the entire canteen wastewater of PT. Sipatex Putri Lestari. The sampling technique used the time composite method. The univariate analysis of the study showed the average number of decreases in oil and grease levels in the treatment as 12.32, 15.98 and 23.67 $mg \cdot L^{-1}$. The bivariate data analysis

used the one-way ANOVA test. The results of the experiment on the three thickness variations of activated carbon within six times repetitions resulted in a decrease of oil and grease levels, which is 49% at 10 cm, 62% at 20 cm, and 88% at 30 cm. The conclusion of the study showed differences in the thickness variations of activated carbon to reduce oil and grease levels using a modified grease trap on the canteen wastewater at PT. Sipatex Putri Lestari. Furthur suggestions for this study are to determine the saturation period of activated carbon and periodic maintenance of the tool.

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