Unravelling the FOG Deposit Sources Characteristic in the South Jakarta City Wastewater Network

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Abstract. DKI Jakarta is the largest wastewater contributor in Indonesia, where 75% of it comes from domestic activities. Typically, effluent will enter the river via a system of wastewater pipelines. Numerous wastewater networks have been observed to have FOG deposits (FD), particularly in South Jakarta. FD is an accumulation of oil and grease in sewerage systems that results in blockages and gas accumulation, leading to explosions in closed networks. Despite the impact being well known, there are currently very few studies that focus on Indonesia's FD, particularly FD in Jakarta's centralized wastewater network. This study aims to analyse the main sources and characteristics of wastewater that forms FD. Samples from two locations were used to compare the conditions of sewerage without FD and those with FD (A and B, respectively). Results showed that Padang restaurants and catering are the main sources of pollutants affecting FD formation. The FOG concentration in sample B was $2x10^7$ times higher than in sample A, while the TSS concentration was $1.8x10^4$ times higher. The dominant free fatty acid (FFA) in sample B was palmitic acid (51%), resulting in a dense precipitate structure and composition.

1 Background

DKI Jakarta is Indonesia's largest wastewater contributor, with 75% coming from domestic activities [1]. Despite 80% of river contamination coming from domestic activities [2], Jakarta releases its wastewater into rivers. Inadequate networks for domestic wastewater disposal are a potential concern, making it crucial to establish an adequate network to mitigate the issue. Perumda Paljaya is one of the centralized wastewater service providers in Jakarta. Since the network's operation, they have encountered challenges with fat and oil formations, also known as FOG deposit (FD) [3].

FD are significant aggregations of fat, oil, and grease in sewerage [4] that can cause blockages and gas accumulation [3] which may result in explosions in closed networks. Despite notable media coverage and possible concerns, FD has not been a primary topic of discussion in the wastewater industry. Studies have explored some aspects of FD, such as its physical, chemical, and biological characteristics [5] and the effect of pH variations on its

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composition [6]. However, these studies tend to focus on wastewater characteristics and conditions from other countries. There's a likelihood that these findings aren't relevant to Indonesia's wastewater networks [7]. Because of the different cultures, weather, and climate conditions [7], FD formed in Indonesia might have different characteristics, resulting in different approaches to handling it too. Understanding the main sources and characteristics of wastewater that forms FD is necessary to solve the problem of FD in the sewer.

Research concerning FD within sewer systems remains limited, and the findings obtained so far exhibit significant fluctuations. Thus, this study will focus on factors that induce FD formation in South Jakarta, by collecting wastewater samples from 2 different points. Sample A will represent the area without FD presence, while sample B will be collected from the area with FD problems. Characteristic comparisons can be conducted and analysed to provide a more accurate understanding of FD in Indonesia.

2 Methods

The study involves interviews with Palajaya's operators and residents followed by observations surrounding the test points in the Menteng Atas area in January 2023. The characteristic test was done at the University of Indonesia's Environmental Engineering Laboratory on the following days after the interview and observation.

Operators of the Paljaya network and residents were interviewed, followed by site observations to validate findings and understand field conditions. These steps were taken to establish two test point (manhole) locations, which represent networks with and without FD (A and B, respectively). After obtaining 2 test points, samples of wastewater were collected using a jug (SNI 6989.59-2008) and taken to the lab for analysis.

Characteristic tests were conducted on samples A and B, focusing on total suspended solids (TSS), volatile suspended solids (VSS), and fat, oil, and grease (FOG). TSS was gravimetrically dried at 105^{o}C for 1 hour (SNI 06-6989.3-2004), while VSS was obtained by heating the TSS sample at 550^{o}C for 15 minutes. FOG analysis was performed using a gravimetric method with Soxhlet for 4 hours (SNI 06-6989.10-2004), while the FFA test was performed using the titration method to determine free fatty acid composition.

3 Results

3.1 Interview and Observation

Based on the interview result with the operator, it is known that there are approximately 20 – 30 out of 5000 manholes with FD problems in Paljaya's network. The selected area for this study is Menteng Atas, South Jakarta (see **Fig. 1**) because it is known to host some of the most problematic manholes with FD issues.

Fig. 1. Study Area; Menteng Atas, South Jakarta, Indonesia

Manhole A, representing manhole without FD is located on Salak Street, Guntur, South Jakarta, 1.15 km from the wastewater treatment plant (WWTP). The manhole is a straight channel, 6 meters deep, and measuring 60 cm in diameter. The design is in accordance with the regulations [8]. From the interview, it is known that this point is collecting wastewater from the surrounding house. There is no definite data regarding the source of each manhole, but observation results show there are four domestic houses that directly dispose their wastewater to this point. The water collected (Sample A) has a transparent color that tends to be cloudy and doesn't have a strong odor **(Fig. 2)**. The results of the interview with locals revealed that this site has never had any issues, even during the wettest months.

Manhole B, representing manhole with FD is located on Kota Gedang Street, Pasar Manggis, South Jakarta, 2.45 km from the WWTP. It is a straight channel, 1 meter deep, and measuring 60 cm in diameter, all in accordance with the regulations. There are 1 Padang Restaurant, 1 catering house, 4 roadside stalls, 1 office building, and 2 houses that dispose their wastewater directly into this manhole. The water collected (Sample B) is very yellow and has an almost muddy consistency **(Fig. 3)**. It also has a very strong rotten odor. This location is infamous for its FD problem, especially in the rainy season. According to the interview, locals claimed that this manhole's water regularly overflows into the streets, contributing to motorbike accidents due to the slippery roadways. The manhole also occasionally emits an unpleasant odor that disturbs surrounding activity, such as activities involving food and beverages in the nearby stalls. The operator claimed that due to the Padang Restaurant and catering house, the water in this area has a very high oil content, based on visible naked-eye observation. Based on the interview, it was discovered that the grease trap used by the catering company occasionally has issues and may be under capacity. Paljaya and the head of the neighborhood have contacted the catering company regarding this issue, but they have not received any response yet.

Fig. 2. Manhole A

Fig. 3. Manhole B

Whenever there is a blockage or other issue, the Paljaya network operational team conducts special cleaning for locations holding FD at least once every one to two months. The issue typically arises during the rainy season, particularly following heavy downpours. Cleaning involves stabbing and agitating the hardened oil layer until the water starts to flow again. In cases of restricted water flow, the solidified sediment is dislodged through suction and subsequently flushed using a high-pressure jet cleaner. Operators assert that the cleaning process is notably more intricate for manholes of larger diameters compared to those with smaller diameters due to the increased presence of FD within the larger structures.

3.2 Characteristic Test

At the University of Indonesia's Environmental Engineering Laboratory, wastewater samples from manhole A and B were examined. The FOG, TSS, and VSS parameters results are listed in Table 1 along with typical values for South Jakarta as well as the national regulation on domestic wastewater.

Table 1. Wastewater Sample Characteristic

Parameter	A	B	Typical Domestic Wastewater in South Jakarta	Domestic Wastewater Regulation Standard
FOG (mg/L)	0,02	500.000	11,53	5
TSS (mg/L)	28	500.000	61,5	30
VSS (mg/L)	27,95	499.872	-	-

Notes:
A: Sample A (domestic)
B: Sample B (domestic + Padang restaurant + catering)
Typical Domestic Wastewater in South Jakarta: Setiabudi's WWTP Influent Data [9]
Domestic Wastewater Regulation Standard: PermenLHK 68/2016 [10]

Sample A has relatively low concentrations of oil and grease, TSS, and VSS when compared to sample B (see **Table 1**). This is influenced by the characteristics of different water sources. Sample A comes from houses only, so the results describe domestic conditions in general (without the admixture of food industry wastewater). When compared with the

standard for domestic wastewater quality standard [10], the concentration of oil and grease and TSS parameters in sample A still meet the standard. In addition, these parameters are still far below the typical characteristics of domestic wastewater in South Jakarta [9]. This shows that in this case, domestic activities alone produce wastewater with very low concentrations of FOG and relatively small TSS as well.

Sample B, which received loads from catering and Padang restaurants, had significantly higher concentrations of the three parameters compared to the quality standards. The FOG values in sample B are 2 x 10^7 times greater and the TSS value is 1.8 x 10^4 times greater when compared to sample A (see **Table 1**). These results support the study [11] which states that waste from Padang restaurants has an FOG and TSS which is much greater when compared to domestic wastewater. A significant difference occurs because the cooking frequency and the quantity of oil used in Padang restaurants and catering are far greater than domestic activities in general. Wastewater from Padang restaurants and catering comes from washing cooking tools, wastewater, and food scraps, such as fat, rice, vegetables, and others [12]. Because of the leftovers that are carried, the wastewater becomes rich in organic matter which causes the concentration of TSS and VSS to become very large [13]. In this context, the composition of the wastewater is primarily characterized by high levels of FOG (50%) and TSS (50%), rendering the resultant wastewater akin to sludge in terms of consistency. These findings align with a previous study [14], indicating that over 50% of the sample comprises oil content. Furthermore, the inclusion of suspended solids originating from food sources contributes to the emission of a noxious odor from the sludge. Notably, the attributes of the water sample from manhole B exhibit a substantial profile, sufficient to facilitate the formation of FD within the sewerage system.

In general, the VSS value describes the total organic content, so the greater the VSS/TSS ratio (close to 1), the greater the organic content [16]. The ratio will affect the type of treatment that is appropriate for the substance to be treated. The VSS/TSS ratio results for samples A and B were 0.998 and 0.999 respectively. This figure indicates a very high organic content in both samples. Studies [17] show that the average VSS/TSS ratio of canteen wastewater is 0.85. This supports the previous explanation which states that wastewater originating from cooking activities and carrying food scraps will have a very high organic content [13]. For this reason, when viewed from the solid composition, both samples A and B are most suitable for biological treatment.

Given the significant volume of oil and fat present, a comprehensive analysis of free fatty acids (FFAs) was conducted on sample B to ascertain the specific types of FFAs present. The examination reveals that the oil composition within sample B is primarily characterized by palmitic acid, constituting 51.22% of the total composition, followed by stearic acid at 15.75%, and oleic acid at 9.84% (see **Fig. 4**).

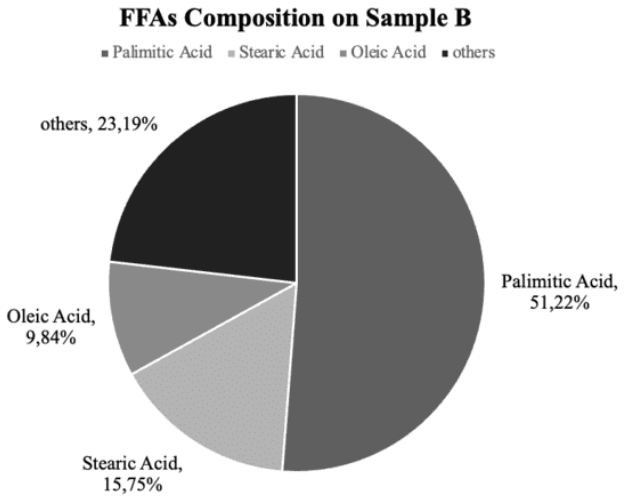

Fig. 4. FFAs Composition on Sample B

Studies [18] state that the majority of the population in Indonesia uses palm oil for cooking, where the fatty acid composition is dominated by palmitic acid (44%). The results of this analysis are also consistent with a study [14] that stated that palmitic acid dominated the FD samples. After palmitic, another type of oil derived from cooking meat (animals) will fill the fatty acid composition of the wastewater. This supports the results of the FFA analysis of sample B which comes from cooking activities. Catering and Padang restaurant's menu that provides meat also explains the presence of stearic and oleic acid in the samples. According to research results [19], FD typically has an FFA composition that is also dominated by palmitic acid. The presence of dominant fatty acids will determine the characteristics of the FD [20]. In this case, the predominance of palmitic acid makes the deposit have a more compact structure.

4 Conclusion

The issue of FOG Deposit (FD) presents a substantial challenge in Indonesia, particularly evident within the sewer network of South Jakarta. The main contributors to the contamination in the domestic wastewater system are Padang restaurants and catering establishments, which significantly exacerbate the formation of FD. These sources notably elevate the concentration of Fat, Oil, and Grease (FOG) within the surrounding network to an extent that surpasses samples from networks lacking such sources by a staggering factor of 2.5×10^7 and even exceeds domestic wastewater quality standards by a factor of 10^7. This considerable FOG abundance is predominantly constituted by palmitic acid (51%), contributing to the relatively denser composition of the formed FD. Additionally, these sources play a role in escalating the levels of Total Suspended Solids (TSS) and Volatile Suspended Solids (VSS), thereby rendering the wastewater rich in organic content. Given the high VSS/TSS ratio observed, biological treatment emerges as a recommended approach for managing this particular type of wastewater.

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