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Public Awareness and Performance Assessment of Communal Grease Traps in Klang Valley, Malaysia

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ABSTRACT

The presence of fat, oil and grease (FOG) in wastewater has become an alarming concern worldwide, and Malaysia is no exception. FOG that escapes into the sewer system can cause sewer network blockages and overflow, contamination of water bodies and inefficient sewerage treatment plant processes, which will harm the ecosystem. This paper aims to investigate the level of awareness and current practices on FOG management among food operators and management staff in selected hotels and shopping malls in Klang Valley, Malaysia. Analysis revealed that most respondents (81.2%) had perceived awareness of FOG, and 76.2% were aware of FOG management and practices on their premises. Although awareness levels for both management and operators are high, in reality, they have not been translated into practice. This is evident from investigating the effectiveness of the existing communal grease trap design by analyzing the effluent samples. The highest levels of biochemical oxygen demand (BOD) for hotel and shopping mall effluents were 9000 mg/L and 13000 mg/L, respectively, while chemical oxygen demand (COD) values in the effluent range from 30000 to 93000 mg/L. The oil and grease (O&G) and total suspended solids (TSS) values in the effluent were in the range of 50000-85000 mg/L and 10,000-72,000 mg/L, respectively. All tested parameters were well above the permissible limit based on Malaysia's Water Services Industry (Prohibited Effluent) Regulations 2021 (Regulation 4). This concludes that the communal grease traps investigated in this study are ineffective and most likely allow non-permissible effluent into the environment.

Keywords: Awareness, communal grease trap, fat, oil and grease (FOG), management

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INTRODUCTION

Fat, oil, and grease (FOG) are harmful to the existing sewer network regardless of the origin of its source (Wallace et al., 2017). For this reason, legislation ensuring that effective FOG management is in place by food service operators is now being heavily enforced worldwide. In the Southeast Asian region, Thailand and Indonesia have emphasized the installation of grease traps for any food service establishment due to the potential of discharging significant amounts of FOG deposition in the sewer system. Malaysia, Brunei and Singapore have imposed strict regulations on installing grease traps to limit the discharge of FOG that is less than 50 to 100 mg/L into the sewer lines (Tang et al., 2024). In 2021, Malaysia introduced the Water Services Industry (Prohibited Effluent) Regulations 2021, which stipulated that no person is permitted to discharge any prohibited effluent, including discharges containing pollutants such as oil and grease, to a public sewage system or treatment plant without the approval of the National Water Services Commission (SPAN). Table 1 shows the discharge limit specified under the Water Services Industry (Prohibited Effluent) Regulations 2021.

Table 1
Discharge limit specified under Water Services Industry (Prohibited Effluent) Regulations 2021

Item	Parameter	Unit	Limit
1.	Temperature	°C	40
2.	pH	-	6.0 – 9.0
3.	Biological Oxygen Demand (BOD)	mg/L	250
4.	Suspended Solids (SS)	mg/L	300
5.	Chemical Oxygen Demand (COD)	mg/L	500
6.	Total Nitrogen (TN)	mg/L	50
7.	Ammoniacal Nitrogen (AMN)	mg/L	30
8.	Total Phosphorus (TP)	mg/L	10
9.	Oil and Grease (O&G)	mg/L	50

A grease trap is the most common and economical solution to intercept the FOG and, therefore, reduces the amount that enters the main sewers, which can cause inconvenience to the authorities, contractors, end users and the public such as blocked sewer pipelines, overflowing manholes, and flooding of walkways, roads and public amenities (Nieuwenhuis et al., 2018). Grease traps work on the basic principle of gravity, where FOG floats on water and solid particles sink (Aziz, 2010). Baffles within the trap slow the inflow of wastewater from the kitchen sinks. This encourages a settlement period where the separation of fats, oils, grease, water and solid food particles occur within the unit. A trap on the inlet prevents FOG from flowing directly through the unit, with the FOG retained within the unit with food particles, allowing cleaner water to flow through. The retained waste will build up over time and requires regular service and removal of waste for disposal (Aziz et al., 2011).

Today, most pipelines from commercial kitchens, such as floor traps and pot wash areas that use dishwashing detergent, are connected to the sink wastewater pipeline carrying FOG. If the purity of the wastewater or effluent is questionable, the grease trap will be deemed unfit or ineffective (Chinwetkitvanich & Ektaku, 2020).

The fact that FOG is considered accountable for 50–70% of sewer blockages worldwide triggers questions about the claimed efficacy of grease traps in retaining 50%–90% of FOG (Sultana et al., 2022). The consultants usually determine the dimension of the grease trap during the design phase based on kitchen capacity and usage factors. The unprecedented pipeline modifications and unplanned increased usage contribute to the ineffectiveness of the grease trap, which is designed for a specific population or person equivalent. The uncontrolled flow of effluent more than often forces the FOG from the first chamber to the next and subsequently to the grease trap outlet, thus escaping the trap. This is often related to the unexpected increase in usage compared to the expected volume during the design phase. Over time, modifications to the pipeline due to additional sinks, cooking stations, and new pipelines have also contributed to the increased flow of FOG. In addition, the maintenance of grease traps by emptying, cleaning, and disposing of the collected FOG in a timely manner influences the grease traps' efficiency (He et al., 2017; Sultana et al., 2022). Current monitoring of the grease traps is done manually based on historical data with poor closed-loop inspection and improvements, thus resulting in overflows, spillages and, in some cases, blockages causing backflow (Wallace et al., 2017; Ali et al., 2022). The cost of clearance, the acute and complex treatment requirements, and the potential for environmental pollution and health risks during sewer overflows make this issue a concern.

Studies have shown that grease trap efficiency is influenced by volatile influent flow that impacts the hydraulic residence times and physical and chemical characteristics of the FOG, such as pH, chemical oxygen demand, dissolved oxygen, biological oxygen demand, total solids and depth of FOG layer. Understanding the physicochemical properties of the FOG, as well as the discharge characteristics, will help in the successful control of FOG deposition. Tang et al. (2024) conducted several site investigations at different food service establishments in Kuching, Sarawak. A significant difference in solid and dissolved constituents was discovered between the inlet and outlet chambers of the grease traps, indicating that the baffle wall could affect the separation mechanism. Ahmad et al. (2023) characterized the restaurant wastewater collected from a central grease interceptor situated at UTM Residensi, Kuala Lumpur. It was found that the COD, BOD and FOG values were 9948, 3170, and 1640 mg/l, respectively, well above the permitted discharge standards given by the Department of Environment, Malaysia.

On top of design standards, inspection and enforcement, one of the key elements in the FOG program is public awareness directed at reducing the amount of FOG discharged from food establishments and ensuring those handling the FOG waste are properly trained

(Wallace et al., 2017). Ultimately, awareness among food establishment operators on the grease trap installation and maintenance determines the success or failure of FOG management. Collin et al. (2023) investigated the awareness of and experiences with FOG by those working within food service establishments. Findings demonstrate that awareness of issues caused by FOG in sewer networks is independent of job role or position and that most respondents (74%) are acquainted with the impacts of poor FOG management.

Understanding the objectives of FOG management and its impact on the environment will help ensure that the waste is handled correctly from its origin until disposal. However, this is only viable when the standard operating procedures are governed by strict legislation to ensure compliance. In the United Kingdom, Water UK, in collaboration with several agencies, has established a guidance document to advise food establishments on the need to keep FOG out of drains and sewers (Water UK, 2017). Singapore's 2019 Code of Practice on Sewerage and Sanitary Works incorporates guidelines on the sizing of grease traps for all establishments that handle food, including restaurants, coffee shops and hawker centers (PUB, 2017). In Malaysia, the Ministry of Local Government Development has established a guideline stipulating the recommended design, installation, operation and maintenance of grease traps (KPKT, 2017). The existing law requires evidence of grease trap installation during business license applications or renewal with the local authorities. However, improvements must be made to the guidelines to include specific volumes and dimensions of the grease traps, as well as monitoring the cleaning schedule and frequency to avoid noncompliance.

This study investigated communal grease traps in 14 premises in Klang Valley, Malaysia, comprising hotels and shopping malls. Hotels have multiple kitchens working around the clock to cater to major events such as parties, weddings, company dinners, and room service. On the other hand, shopping malls have shared communal grease traps due to the high number of food and beverage eateries operating within the premises. Both hotels and shopping malls require significant manpower resources to ensure operations continue without disruption. Furthermore, they need to be properly trained to comply with standard operating procedures (SOP) to ensure standardization in food preparation, cleaning and waste management, particularly FOG.

While food service establishments are often assumed to be the major source of FOG deposits in the sewer, their contribution to the problem has not been thoroughly investigated. This research aims to (1) investigate the current practices and level of awareness of FOG management among food operators and management staff in selected hotels and shopping malls through questionnaire distribution and (2) quantify the discharge characteristics of the grease trap to assess the effectiveness of existing communal grease trap design. Samples were collected before and after passing through the grease traps and analyzed based on the following parameters: biochemical oxygen demand (BOD), chemical oxygen demand

(COD), dissolved oxygen (DO), oil and grease (O&G), total suspended solids (TSS) and pH. The investigation was carried out to determine if these parameters comply with the permitted discharge standards given by the Department of Environment, Malaysia. The information gathered from this study may be the basis for redesigning the grease trap or developing a sustainable and smart grease trap to reduce and mitigate discharges of FOG.

METHODOLOGY

Premises

The study focuses on 14 premises in Klang Valley, divided into two categories: shopping malls and hotels. Seven hotels and seven shopping malls were selected. For confidentiality reasons, the hotels and shopping malls are denoted as H and S, respectively. All the grease traps at the respective premises have relatively similar frequency in terms of usage, size and maintenance. Details related to hotel and restaurant operating information are described in Tables 2 and 3.

Table 2
Hotel operating information

Hotel	Number of kitchens	Kitchen cooking frequency	Hotel rating	Number of grease traps	Grease trap size (GPM)	Frequency of service (per month)
H1	6	Minimum 3 meals per day	5	8	500	4
H2	7		5	3	500	1
H3	5		5	2	500	8
H4	4		5	4	500	4
H5	3		4	2	500	4
H6	2		5	1	500	1
H7	1		3	1	500	2

Table 3
Shopping mall operating information

Shopping malls	Number of F&B	Kitchen cooking frequency	Number of grease traps	Grease trap size (GPM)	Frequency of service (per month)
S1	10	Continuously from 10 am to 9 pm	10	250	2
S2	30		6	250	4
S3	25		17	250	1
S4	5		2	250	1
S5	30		3	250	2
S6	56		21	250	2
S7	3		3	250	2

Instrument

The questionnaire was constructed based on expert consultation and an intensive literature review. Data collection was carried out by sharing questionnaires through Google Forms and face-to-face interviews with the respondents. The first section of the questionnaire included demography surveys on age, educational level, job categories, and premises location. The second section covered awareness questions regarding FOG management. Current practices of FOG management at the premises were assessed in the third part of the instrument. Upon data collection, descriptive analysis in SPSS was used.

This survey used a nominal scale to gather the respondents' basic demographic information. The data required to understand awareness and practices were gathered using a 5-point Likert Scale ranging from (1) Strongly Disagree to (5) Strongly Agree. The questionnaire has gone through a process of validity and reliability testing. A pilot test was conducted to determine the questionnaire's reliability and ensure that the overall structure of the survey was in no way ambiguous. Cronbach's Alpha was found to be 0.84 and 0.81 for Sections 2 and 3, respectively. It is stated that a survey construct has a high level of reliability when the Alpha coefficient of the reliability test in the survey falls within the range of 0.7 and 0.9 (Straub et al., 2004).

Sampling

Wastewater samples were collected from the premises during the weekly maintenance of the grease traps by a local service provider. Two samples were taken from each grease trap; influent samples were collected from the second chamber, where most of the FOG remained, while effluent samples were obtained from the final chamber before exiting into the sewer network. All samples were taken during the morning hours between 12:00 am and 3:00 am, and the sampling procedure was consistent throughout the study. The composite samples were collected using a 1-liter plastic bottle, a 500 mL plastic bottle preserved with sulphuric acid and a 1-liter glass bottle preserved with hydrochloric acid. Any foreign materials and rubbish found were discarded before samples were sent to an accredited lab to test for pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), oil and grease (O&G) and total suspended solids (TSS). Figure 1 summarizes the research activities involved in this work.

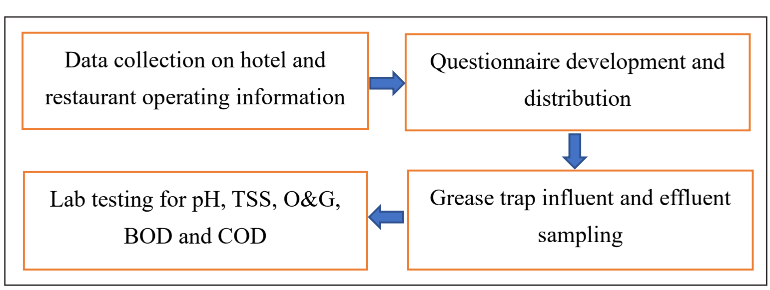

Figure 1. Flowchart of research activities

RESULT AND DISCUSSIONS

Analysis of Public Awareness

A total of 336 respondents were involved in the survey to evaluate FOG management practices and levels of awareness in the pre-determined premises. Table 4 shows the demographic analysis of the respondents.

Table 4
Demographic of respondents

Demographic	Population (n)	Percentage (%)
Types of premises		
Hotels	175	52.1
Shopping malls	161	47.9
Categories of respondents		
Food operators	207	61.6
Administration	129	38.4
Level of education		
Malaysian Certificate of Education (*Sijil Pelajaran Malaysia (SPM)*)	81	24.1
Diploma	132	39.3
Degree	117	34.8
Masters	6	1.8

175 respondents (52.1%) work in the hotel industry, while 161 (47.9%) were shopping mall employees. Further breakdown amongst the respondents shows that 38.4% (129 respondents) are from the management, whereas 61.6% (207 respondents) are food operators. Management refers to supervisors and those working in an office environment, whereas operators are those working in the kitchen or dealing directly with customers. A huge difference in the breakdown can be noticed as there are generally a small number of people in the management team per venue. In contrast, food operators at any single premises would be on the higher side due to the number of kitchens per venue.

It was found that most respondents are diploma (39.3%) and degree (34.8%) holders, and only 6 are Master's degree holders. Upon further investigation among the diploma holders, 35.6% were at a management level, and 64.4% were food operators. Through verbal communication, it was deduced that a high number of food operators were diploma holders working part-time jobs while awaiting further education. In management, it can be commended that those with a diploma were able to work rank and file to reach a management level. Among the degree holders, 68.4% were at a management level, and 31.6% were food operators. The degree holders could be working as part-time food operators to earn extra income or while waiting for a permanent job offer. 100% of Master's degree holders were from the management level. Figure 2 shows the level of education among the management team and food operators. It can be concluded that most management teams hold a degree or at least a diploma, while the food operators are school leavers with a secondary school certificate or diploma holder.

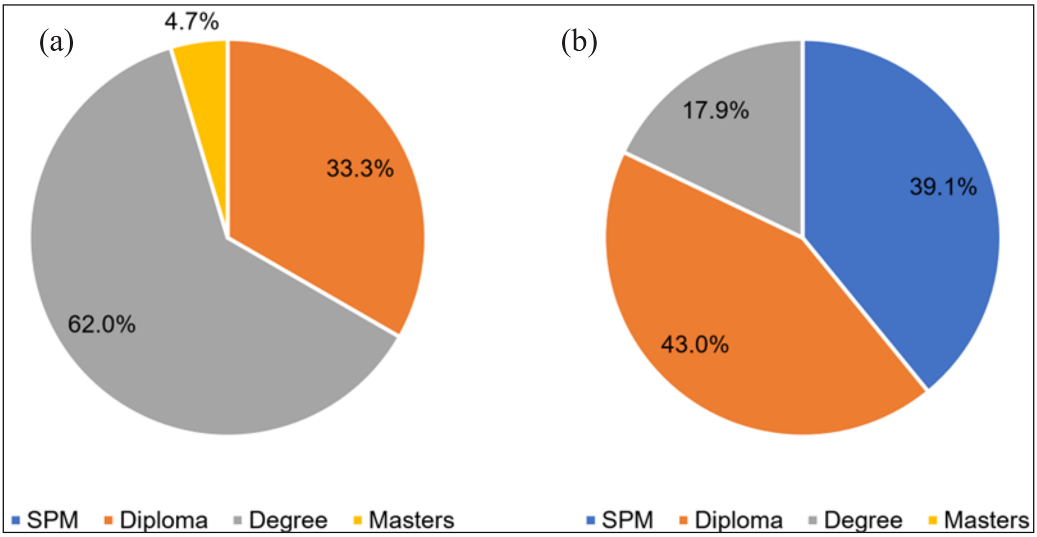

Figure 2. Level of education among the respondents: a) management, b) food operators

Successful control and management of FOG is largely dependent on public awareness and a clear understanding of its impact on the environment. Table 5 shows respondent's awareness of FOG in general. The survey revealed that 85% of the respondents understood that FOG is a by-product of food preparation and production and that food service establishments are a significant source of FOG. Although 14% of the respondents are uncertain about the substance, all respondents are well aware that their premises are producing FOG.

Waste cooking oil (WCO) consists of oils and fats used for cooking or frying in the food processing industry, food handling businesses, and households. Although both WCO and FOG are by-products from food establishments, collecting WCO is much easier and can be recycled to make soap, lubricants, candles, animal and pet feed as well as renewable energy (Awogbemi et al., 2021). Considering that WCO has become a valuable commodity and may constitute a great proportion of FOG, respondents were enquired on the difference between WCO and FOG. 81.6% were aware of the difference and understood that pouring WCO down the kitchen sink and into the drain is detrimental to the environment. *The Star* has reported that in 2016, Klang Municipal Council spent almost RM6 million to remove clogging caused by hardened cooking oil in drains (Edward, 2016).

Drainage systems in food processing facilities can experience a build-up of FOG. When FOG is allowed to go down the drain, it solidifies, reducing and preventing water flow in drains and sewer pipes, causing sewage backups and overflows, leading to property damage, environmental problems, and other health hazards (Owolabi et al., 2022). This survey revealed that 83.1% of the respondents agree that FOG is a potential environmental threat if disposed of inappropriately. However, only 67.6% knew that the Housing and Local Government Ministry made it a requirement since 2005 for all food premises to install, maintain and desludge grease trap systems to obtain or renew business licenses. Under the present guidelines, restaurant operators must clean and dislodge a grease inceptor installed at their premises once every two weeks. The remaining respondents were unaware of any rules or regulations imposed by the government.

Table 5
Respondent's awareness of FOG

Awareness	Population, n (total 336)				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
FOGs are by-products from food preparation and production	276 (82.1%)	10 (3.0%)	3 (0.9%)	47 (14.0%)	0
FOG is produced in the premise	322 (95.8%)	14 (4.2%)	0	0	0
FOG differs from WCO (waste cooking oil)	260 (77.4%)	14 (4.2%)	2 (0.6%)	60 (17.9%)	0
FOG has a negative impact on the environment	261 (77.7%)	18 (5.4%)	20 (6.0%)	37 (11.0%)	0
Rules and regulations exist related to FOG	219 (65.2%)	8 (2.4%)	25 (7.4%)	84 (25.0%)	0

The median was calculated for the data set, and it was found that 81.2% of the total respondents perceived awareness of FOG, and 18.5% can be considered neutral. Only 0.3% of respondents had very limited knowledge of FOG. Crosstabulation between the median and categories of respondents found that 98.44% of the management personnel have an awareness of FOG, compared to 70.53% among the food operators.

FOG management is vital to running an efficient, hygienic and compliant kitchen. Typically, a grease trap is used as a receptacle into which wastewater containing FOG flows before entering a drainage system. From Table 6, all respondents reported that their premises installed individual grease traps and that FOG produced at their premises was channeled to these grease traps and subsequently to a communal grease trap. However, a small number of businesses chose to pour FOG into containers and dispose of it in the bin once it had hardened, as reported by six respondents. Also, 6% of the respondents admitted that their premises flushed the FOG down the drains and sinks and into the sewer system. This may cause sanitary sewer overflows, which are clogs in the collection systems, that can potentially result in raw sewage being released into communities, causing potentially dangerous health conditions (Owolabi et al., 2022). Although the numbers are not alarming, food establishments should make conscious efforts to dispose of FOG safely. There are a plethora of ways restaurants and eateries can stop FOG from going down the drain and into the sewer. Even making small changes, such as wiping down plates and pans with paper towels, can make a huge difference in washing areas of kitchens, where blockages frequently occur in the sink units.

The types of cleaning agents most commonly used in commercial kitchens are detergents, degreasers, abrasives and acids. Detergents are usually neutral chemicals with pH 6-8 and contain surfactants to break up dirt or soil for easy washing. Degreasers remove grease from surfaces such as oven tops and counters, while abrasives are usually used to clean floors, pots and pans. Acids are the most powerful type of cleaning agent and are usually used to clean drains and sinks in the kitchen as well as descaling the dishwashers. From this survey, 96.7% of total respondents agreed to use the stated chemicals in their premises. The use of acids and alkaline can potentially cause damage to the pipes as well as alter the constituents of the FOG. Detergents in background water increase the production of calcium-based saponified solids that may clog sewer lines and eventually cause sanitary sewer overflows (Iasmin et al., 2016). The use of detergents and sanitizers may also affect the emulsification characteristics, such as the droplet size of FOG discharges, and thus impact the separation ability in the grease trap (Sello, 2021).

Table 6
Respondent's awareness of FOG management in the premise

Awareness	**Population, n (total 336)**				
	Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**
The presence of a grease trap in the premise	316 (94.0%)	20 (6.0%)	0	0	0
FOG is channeled directly to the grease trap	316 (94.0%)	20 (6.0%)	0	0	0
FOG is discarded into the dustbin	0	6 (1.8%)	19 (5.7%)	311 (92.6%)	0
FOG is flushed into the sewer line	0	20 (6.0%)	18 (5.4%)	298 (88.7%)	0
Chemicals are used as cleaning materials in the kitchen	293 (87.2%)	32 (9.5%)	11 (3.3%)	0	0

Based on the median, 76.2% of the respondents perceived awareness of FOG management in their premises. Crosstabulation between the median and categories of respondents found that 85.3% of management respondents understood good FOG management practices, whereas only 70.5% of food operators practiced good FOG management.

Performance Evaluation of Communal Grease Trap

Restaurants and the food processing industry are the main sources of FOG; therefore, it is important that the grease traps used at these establishments are effective in removing the substance from wastewater before entering the sewer system. Ensuring that grease traps are properly installed and, most importantly, properly maintained is challenging. Poorly maintained and low capacity of grease traps will allow FOG to flow into the sewer pipes, causing the build-up of fatberg. A fatberg is a coagulated mass of congealed grease and non-biodegradable matter found in sewers and drains that cause extensive damage to drainage systems (Abdullah, 2021).

The principal constituents of concern for restaurant wastewater are its organic strength (BOD and COD), particulate loading (TSS), and oil and grease (O&G). The strength of the wastewater is affected by many factors, including cuisine type, kitchen capacity, grease trap size and FOG management practices (Gurd et al., 2019). Ultimately, the effluent from food establishments must meet certain discharge limits before entering the public sewer system.

Figures 3 and 4 show the BOD and COD values for communal grease traps at selected hotels and shopping malls for both influent and effluent streams. As evident from Figure 3, all premises have exceeded the allowable BOD discharge limit of 250 mg/L. Unexpectedly, BOD values of the effluent for most premises were found to increase from the influent values, which indicated that the effluent was contaminated with high organic loading. Only one hotel premise, H1, was able to remove 40% of BOD compared to four shopping malls (S4, S5, S6 and S7) that were able to remove as low as 3% to 75% of BOD. Figure 4 shows similar observations for COD where concentrations at the effluent were higher than the influent and exceeded the permissible limit of 500 mg/L. The highest level of COD for hotel effluent was almost 30000 mg/L, while for shopping malls, soar to 93000 mg/L. Although some communal grease traps at the shopping malls (S4, S5, S6 and S7) were able to treat between 5% to 62% of COD, the final effluent still did not meet the discharge requirement. This indicates that the grease traps did not work as anticipated.

It has been reported that grease traps are capable of removing up to 80% of FOG from the influent. However, little evidence was presented for BOD and COD removal. A study by the United States Environmental Protection Agency (U.S. EPA) reported that the grease trap unit was able to remove 26%–65% of BOD, 40%–80% of TSS and 70%–80% of FOG, while a laboratory scale study proved that grease traps can remove 50%–80% of BOD and TSS (U.S. EPA, 2012; Wongthanate et al., 2014). The incapability of grease traps to treat BOD and COD usually stems from a lack of timely servicing and poor maintenance. A regular grease trap cleaning schedule prevents FOG from building up and ensures that the trap continues to operate effectively. Also, the inadequate size of the grease trap may cause insufficient retention time for organic/inorganic matter breakdown, leading to significant variations of BOD and COD.

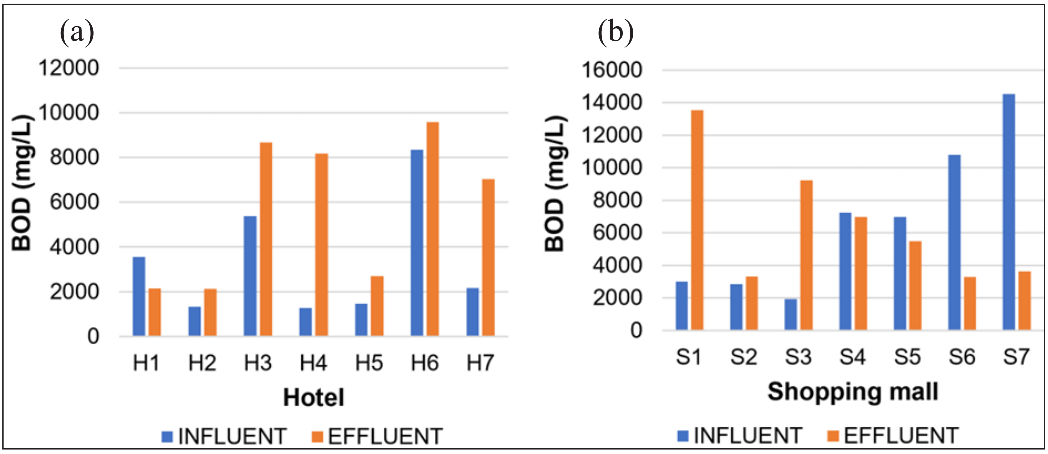

Figure 3. BOD results for communal grease traps at (a) hotels and (b) shopping malls

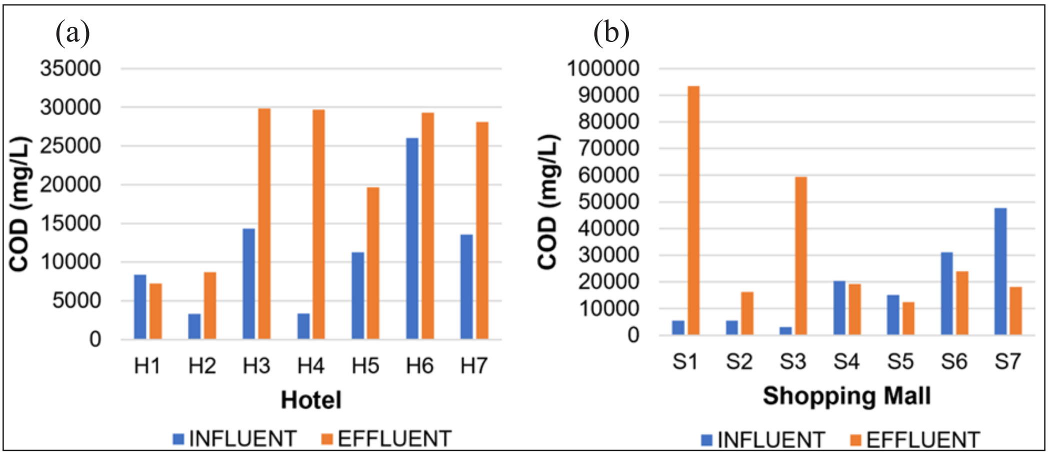

Figure 4. COD results for communal grease traps at (a) hotels and (b) shopping malls

High COD in water indicates greater levels of oxidizable organic matter and, consequently, a lower amount of DO. All hotels and shopping malls depict a DO reading of less than 1 mg/L before and after the grease trap, which indicates a symptom of excessive contamination. Low dissolved oxygen may result from high water temperature and suspended solids. It is well known that food premises use hot water together with acidic cleaning agents to clean utensils and the kitchen at the end of the operation. When there is a rise in effluent temperature due to the discarded hot water during the cleaning process, the suspended solids will absorb the heat and decrease the DO levels (Mutalib et al., 2015). Also, hot water holds less DO compared to cold water (Bozorg-Haddad et al., 2021). The presence of O&G in the grease trap forms an impenetrable layer above the effluent surface. This decreases interaction in the open air and thus reduces the DO level in the effluent. Grease traps are usually situated in secluded areas of the hotel and shopping mall premises due to bad odor and unexpected backflow or flooding. It is usually not in an open area with adequate air circulation, thus reducing the opportunity for any sort of sunlight, natural aeration or ventilation.

As presented in Figure 5, all premises have exceeded the allowable discharge limit of 50 mg/L for O&G. Three of the hotel premises (H1, H3 and H4) were able to reduce the O&G content between 39% to 65%, and three of the shopping malls (S3, S4 and S6) were able to remove 25%–83% of the O&G. The rest of the grease traps in both hotels and shopping malls showed an increment of O&G content in the effluent. Ideally, the O&G content should be reduced when subjected to an efficient working condition of the grease trap, as it would stay afloat in the first and second chambers. FOG is derived from many organic non-polar compound food sources with a density of approximately 0.863–0.926 g/cm^3 (Wallace et al., 2017; Ali et al., 2022), while water is a polar solvent which has a density of 1.000 g/cm^3. Hence, density and polarity contribute towards the floating of FOG over water. Issues occur when high water temperatures are used for washing and cleaning in the kitchen. The heating of oils causes FOG to liquefy, emulsify and react with other organic compounds, thus changing the chemical composition of FOG and its polarity.

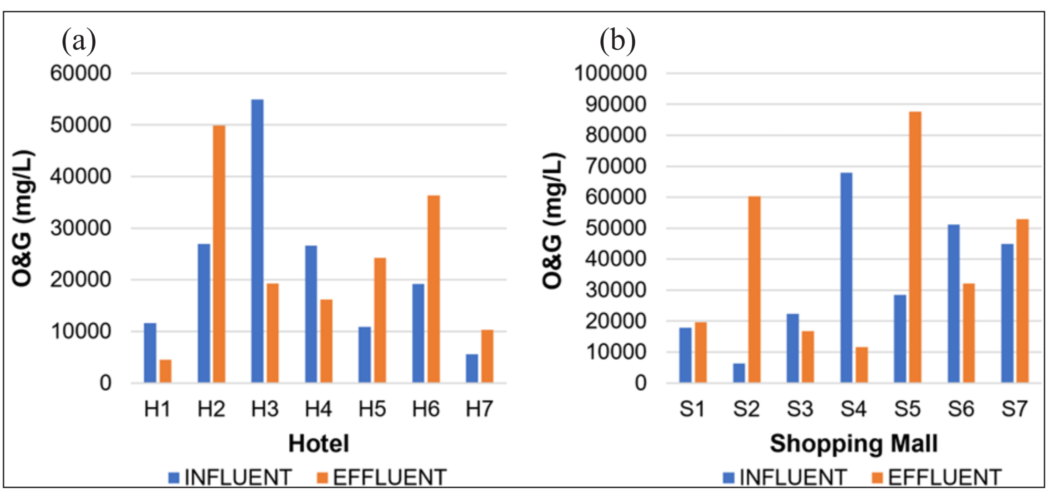

Figure 5. O&G results for communal grease traps at (a) hotels and (b) shopping malls

Compared to hotel premises, the shopping malls are bigger in size; for this reason, the content and quantity of the O&G differs greatly between the two premises. The quality of the effluent also differs depending on the type of grease traps used in the premises and the frequency of service. The type of grease trap plays a vital role in ensuring that the O&G is retained in the first and second chambers while the water exits the grease trap through the outlet pipe. In this study, hotel H2 has been in the industry for 40 years and operates with concrete-based grease traps with only two chambers. The baffles are worn out, and the concept of O&G retaining them in the first chamber is almost impossible. The baffle in the grease trap is the integral component that serves to slow down the flow of water and lengthen the detention time to maximize the separation of the FOG and settling of the solids (Hendrasarie & Maria, 2021). The failure of the grease trap is clearly depicted in the O&G effluent value, which increased significantly by almost 84.7%. Similarly, hotel H5 has an increased O&G effluent value of almost 122.3% as it uses a two-chamber grease trap of insufficient size.

Be it a hotel or a shopping mall, items discarded into the kitchen sink vary from cooking oil to organic materials such as food waste, raw materials, meats, margarine and flour. The pipelines carry this waste through its channel to the respective grease traps. High grease loads, emulsified grease, and fast flow volume have caused FOG to bypass the grease trap and discharge in the effluents. Grease traps with a higher frequency of service will have O&G concentrated in the first and second chambers, whilst the third chamber would only contain clouded water with minimal oil traces floating. In comparison with grease traps that are serviced monthly or bi-monthly, traces of O&G will be evident in all three chambers and can be seen flowing out via the outlet as well when agitated. With timely service, the O&G will be removed, and the process will stay efficient.

High TSS values in the effluent are often related to excessive solids generation due to an increase in BOD loading. Figure 6 shows that the TSS values in the effluent for both hotels and shopping malls range from 10,000 mg/L to 72,000 mg/L. Grease traps at the shopping malls S4, S5, S6 and S7 could reduce 39%–88% of the TSS, while a very low removal rate was observed for hotel grease traps (H3 and H7). The high flow rate of the influence was found to affect the TSS removal, although the same could not be said for BOD and FOG removal.

Solids in the grease trap may originate from different areas of the premise. In some premises, the kitchen pipelines are shared amongst floor traps, stove areas, food preparation areas, sink pipelines, and dishwashers, which end up in the grease trap. Apart from the organic compound, other materials are discarded into the pipeline that contributes to the significant level of TSS in hotels and shopping malls, such as cleaning the kitchen flooring, which results in dirt, sand, and even sometimes gravel-washed into the pipeline. Another important factor to consider is that the grease trap main pipeline is usually made of cast iron or PVC pipes. Over time, cast iron pipes tend to corrode due to the use of acidic cleaning agents and the rodding process that scrapes the inner layer of the pipe and releases metal particles. As the effluent passes through these pipes, the above residues join the affluent and end in the grease traps, which was the case with hotels H3, H6 and H7 and shopping malls S4, S6 and S7.

At the grease trap itself, there were signs of damage due to wear and tear and evidence of corrosion, which further contributed to the increment of TSS values in the effluent stream. Furthermore, if the grease traps are made of old traditional concrete design, they are more likely to have sand, silt, and gravel residue in the grease trap, as in the case of hotel H2. Also, the grease traps are usually located in the basement or car park areas, with significant amounts of sand, silt, dried leaves and dirt escaping into the grease traps due to vehicle movement. Although the grease traps are covered, the contractors will lift the lid during scheduled servicing, which causes these elements to fall into the traps.

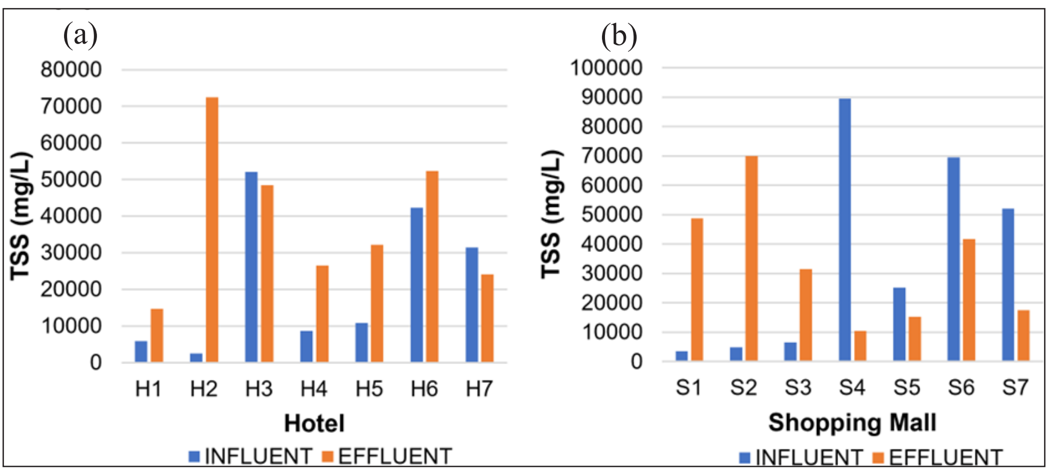

Figure 6. TSS results for communal grease traps at (a) hotels and (b) shopping malls

The permitted pH value of effluent in the sewer network is between pH 6.0 to 9.0. As shown in Figure 7, all hotels and shopping malls recorded a pH value of less than 6.0, which is acidic and not permissible to be discharged into the sewer network. FOG in the grease trap will begin to float as the influent cools down, after which it will start to break down by hydrolysis, where the fatty acids are released. The decrease in pH value is a result of the release of a significant volume of free fatty acids (FFA), which eventually will cause corrosion inside the grease trap (Husain et al., 2014). Also, food operators in hotels and shopping malls are usually instructed to wash and discard all wastewater via the sink, which connects to the floor trap pipeline. By the same token, during closing hours, the workstations, food preparation tables, floors and sinks are washed down using cleaning agents, which are commonly acidic.

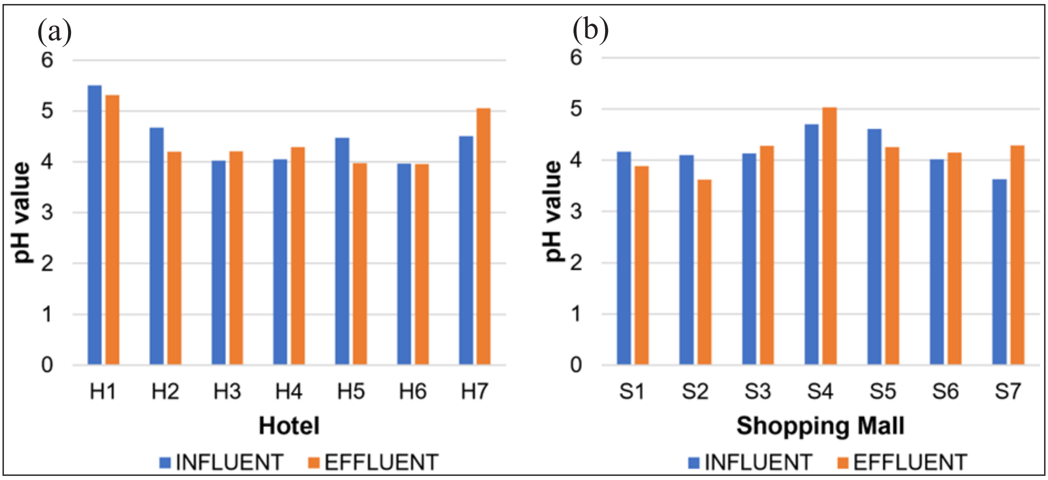

Figure 7. pH values for communal grease traps at (a) hotel and (b) shopping malls

An improper discard of organic food wastes into the pipeline will end up in the first chamber basket. Depending on the frequency of service, this food waste will remain in the grease trap basket and begin to decompose. Organic matter, such as vegetables and meat products, contains carbon elements, which will be released into the effluent during decomposition. Due to the instability of these organic compounds and their ability to be easily oxidized, carbon dioxide will be produced. As a result, the dissolved carbon content will increase the hydrogen ions, causing the pH value to decrease, denoting its acidity.

In addition, certain kitchens and floor traps may experience the gargling effect or slow exit as foreign materials may build up or harden FOG, which reduces the pipe's clearance for a smooth effluent flow out. At this point, it is a common practice in hotels and shopping malls to pour acid-based FOG cutters into these floor traps to help them clear the line. This is a quick fix in practice that helps hotel, and shopping mall kitchen operators expedite the cleaning process. Another factor that causes an increase in effluent acidity is the dumping of cleaning agents into the grease trap by unauthorized personnel. The housekeeping personnel are usually scheduled to clean the grease trap area as it is commonly used as temporary storage. The housekeepers dumped the leftover solutions into the grease traps for convenience during the cleaning process using acidic detergents and cleaning agents.

CONCLUSION

Awareness among those working within food service establishments determines the success or failure of the FOG management initiatives. In this work, we reported that 81.2% of the respondents had a perceived understanding of FOG, while 76.2% possessed an awareness of how it is managed within their premises. The awareness level is independent of job position; however, a vast majority of the respondents who work in management are more acquainted with the knowledge of FOG and its management compared to the operators. Further investigation of the communal grease traps at selected hotels and shopping malls revealed that none of the effluent parameters met the permissible discharge level stipulated in the Water Services Industry (Prohibited Effluent) Regulations 2021 (Regulation 4). The highest level of O&G for hotel and shopping mall effluents were 50000 mg/L and 85000 mg/L, respectively, while TSS values in the effluent range from 10,000 mg/L to 72,000 mg/L. This important finding demonstrates poor design, maintenance, and monitoring of the grease traps by the premises owner and local authorities. Further work will be focusing on upgrading the conventional grease trap to a smart grease trap with sensor incorporation that will enable accurate level measurements and an effective alarm system to indicate the user and contractor for maintenance services.

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