ASSESSMENT OF GREASE TRAPS USED IN THE SMALL-SCALE FOOD INDUSTRY: A PILOT STUDY

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Environment / infrastructure

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ABSTRACT

Fat, oil and grease (FOG) deposits in sewer systems are becoming a serious environmental concern for infrastructure engineers and council managers. These deposits can come from both domestic and commercial wastewater. Water and wastewater company Watercare has reported that 70% of sewer blockages in Auckland, New Zealand, are due to material such as rags, wet wipes, wood, tissues, hygiene products, etc., that shouldn't go down the sewer drain. These materials can lead to the blockage of pipes when combined with FOG. This preliminary study was about assessing the grease traps (GTs) that are being used in the small-scale food industry in Auckland. The purpose of this study was to address four key questions: How are FOG deposits actually formed? What types and sizes of GTs are being used? Do the sizes that are used comply with the recommended sizes? What are the issues and/or what is missing in terms of the operation and maintenance of GTs? A questionnaire was prepared to collect data such as type of food service, type of GTs used and their sizes, type of fixtures that are used in the small-scale commercial kitchen area, etc. This study shows that there are some issues with the way the GTs are being operated, maintained and monitored (i.e., some regulatory gaps). The paper also gives a brief overview of different types of GTs, reviews the current compliance practice, and then provides some recommendations and solutions that could lead to improved practice to mitigate wastewater pipe blockages.

KEYWORDS

infrastructure, grease traps, FOG deposits, wastewater, food industry

INTRODUCTION

Fats, oil and grease (FOG) in wastewater systems are predominantly discharged from food service establishments (FSEs) such as food preparation and processing facilities (including restaurants, etc.) and potentially from residential properties (He et al., 2017). FOG undergo reactions with other constituents in the wastewater to form insoluble solids known as FOG deposits, which lead to blockage in pipes and end up in wastewater overflows (He et al., 2017).

As reported by water and wastewater company Watercare (Harrowell, 2018), 70% of pipe blockages in Auckland are caused by rags, concrete, wood, wet wipes, hygiene products, etc. These materials combine with FOG and then stick to the pipes' inner surfaces. Watercare spends almost $1 million each year to remove FOG deposits and clear pipe blockages in Auckland. In the recent past, the *New Zealand Herald* (Neilson, 2019) reported wastewater overflow in Kaipatiki Stream in Glenfield, Auckland. This overflow was due to a blockage in wastewater pipes that basically carry anything that comes from domestic and industrial waste. It is well knowing that 'fatbergs' are likely to form when FOG harden in the wastewater reticulation system (WWRS).

A number of studies have shown that FOG deposits in sewer systems are a global problem. For example, in the USA, FOG deposits, which reduce the wastewater pipes' flow area, were responsible for around 40% to 50% of annual blockages (He et al., 2011; Ducoste et al., 2008). Williams et al. (2012) reported that around 25,000 flooding events occurred throughout the UK annually, due to sewer blockages, and FOG was thought to be a contributing factor for around 50% of the incidents. The annual cost for removal of FOG deposits was US$25 billion (around NZ$41 billion) for the USA, and UK£15–50 million (around NZ$31–103 million) for the UK as reported by Williams et al. (2012) and Del Mundo and Sutheerawattananonda (2017). Further, Marlow et al. (2011) reported that FOG was the primary cause for 21% of blockages in Australian wastewater systems. Husain et al. (2014) reported that 70% of sanitary sewer overflows (SSOs) in Malaysia were due to FOG deposits.

According to M. Harrison of Watercare, Auckland (personal communication, April 3, 2020) there hasn't been research done in Auckland on characterising FOG deposits. Watercare (in Auckland) uses a 'fingerprinting' method to find high concentrations of contaminants. The fingerprinting method is used to backtrack or trace the source(s) of unwanted substances in the wastewater that are responsible for the mass production of FOG deposits and/or 'fatbergs.' This method is used for wastewater flows from large industry, but wouldn't be applicable to the food industry.

It is well known that it is not permitted to directly discharge FOG into wastewater pipelines in most municipalities within and outside New Zealand. FOG can form hard, solid fatbergs when combined with wipes, paper towels, toilet paper and other sanitary products going down the drain. From the researchers' personal experience, fatbergs can not only block pipes but can also have a detrimental effect on the primary, secondary and tertiary treatment processes that are designed to treat wastewater at wastewater treatment plants (WWTP).

Thus, it is important to have GTs at food preparing and food serving (FPFS) facilities (NZTIWF, 2017) in order to remove animal fats, vegetable oils, etc., at source. However, GTs require maintenance on a regular basis so that the oil and water can be separated at the source. It is not easy to remove FOG once in the pipeline, and also it is an expensive exercise to clear the wastewater-pipe blockages.

That is why FOG deposits in wastewater pipelines are becoming a serious environmental concern globally. Infrastructure engineers are challenged by sewer-pipe blockages (due to FOG deposits), and managers of WWTP are challenged by how to treat and dispose of fatbergs that are coming into the plant. Thus, significant research has recently been carried out in this area. Unfortunately, we still have complaints of pipe blockages in and around Auckland. Therefore, the focus of this pilot-scale study was to assess the GTs that are used in the small-scale FPFS industry in Auckland in order to identify the potential reasons for FOG being discharged into our wastewater pipelines. The aim of the study was to address the key questions:

- How are FOG deposits actually formed?
- What types and sizes of GTs are being used?
- Do the sizes that are used comply with the recommended sizes?
- What are the issues and/or what is missing in terms of the operation and maintenance of GTs?

FORMATION AND CHARACTERISATION OF FOG DEPOSITS

What is FOG?

"FOG are the by-products of cooking (also called brown grease)" (Husain et al., 2014, p. 748). It is well known that FOG is normally produced at food preparation and processing facilities (such as restaurants, cafés, takeaway outlets, etc.). Animal fat, butter, cheese, used cooking oil, sauces, dressing, gravy, deep-frying oil and baking ingredients (either at commercial or domestic levels) are considered as FOG or greasy material (Husain et al., 2014; He et al., 2011). When these wastes are discharged (via a network of pipes from restaurants and homes) to local wastewater pipes, then they can form FOG deposits via a saponification process – which is the conversion of FOG into soap, and is briefly explained below. These FOG deposits build up on the inner surfaces of wastewater pipes over time and are likely to reduce the pipes' flow capacity (Husain et al., 2014; He et al., 2011). Further, FOG deposits keep growing inside the pipes and eventually block them. An overflow or flooding situation can then happen, which is a serious environmental concern both at a local level and more widely.

FOG deposit formation

It was initially believed that FOG material that is discharged from restaurants and the food preparation industry interacts with calcium released from wastewater pipes, which forms calcium-based fatty acid salts (aka FOG deposits) via saponification reaction (He et al., 2011; Keener et al., 2008). Later, a laboratory-scale experiment was also conducted by He et al. (2011) to verify the theory that FOG deposits were formed from the reaction between free fatty acids (FFAs) and calcium chloride. The deposits formed in the lab experiment had strong similarities with the deposits collected from wastewater pipes, which confirmed that FOG deposits were indeed formed by a process called saponification.

FOG deposits are adhesive in nature, which allows them to easily stick to the inner walls of pipes (He et al., 2017, 2011). Further studies on the physical and chemical properties of FOG showed that FOG deposits are likely to have a grainy and sandstone-like texture. The color of FOG deposits ranges from light brown to white (Keener et al., 2008; He et al., 2017, 2011). The adhesive quality of FOG deposit is determined by the composition of FFAs and the ratio of FOG to calcium involved during reaction. He et al. (2013) observed that calcium salts of saturated fatty acids (palmitic) were less adhesive than the calcium salts of unsaturated fatty acids (oleic or linoleic).

Iasmin et al. (2014) and Del Mundo and Sutheerawattananonda (2017) undertook some work to see the effect of calcium chloride and calcium sulphate on the colour and texture of FOG deposits. Calcium sulphate was used to simulate calcium release from corrosion of concrete pipes. It was found that a wastewater pipe with calcium chloride present produced slightly whitish and soft-textured fatty-acid salts. Whereas a wastewater pipe with calcium sulphate present produced slightly whiter, rough and granular fatty-acid salts (Iasmin et al., 2014). Del Mund and Sutheerawattananonda (2017 as cited in He et al., 2017, p. 1195) also reported that all “saponified solids” produced a “distinct colour” when fats reacted with calcium chloride.

As reported by He et al. (2017, p. 1196), “In addition to saponification, the aggregation of unreacted fatty acids (e.g., palmitic, oleic, and linoleic) and calcium was identified as another process in FOG deposit formation … The importance of aggregation in FOG deposit formation was revealed by a recent finding that fatty acids, rather than fatty acid salts … were the predominant species in FOG deposits.”

Figure 1 clearly shows how FOG deposits are formed in concrete wastewater pipes. Further details of the formation of FOG deposits can also be found in Otsuka et al. (2020) and He et al. (2017, 2013).

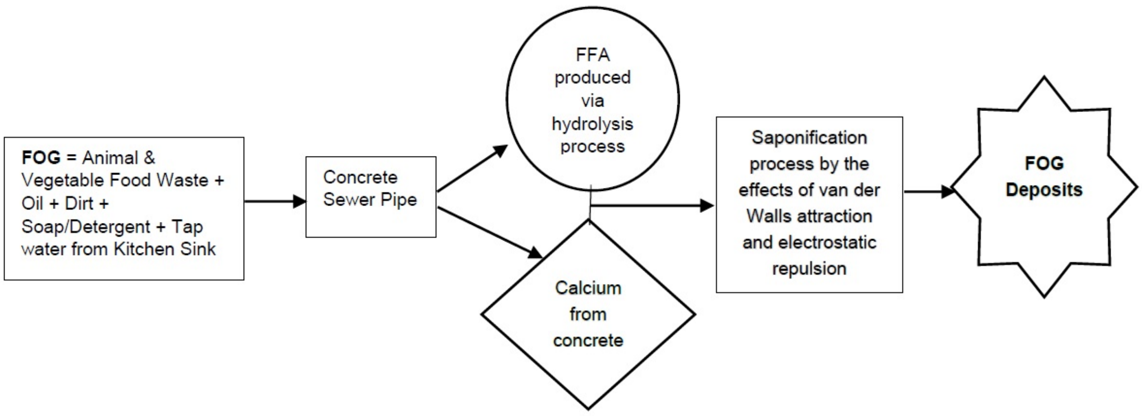

Figure 1. A line diagram showing the formation of FOG deposits in a concrete wastewater pipeline.

Furthermore, researchers have proposed that FOG deposits in wastewater pipes undergo biodegradation (He et al., 2015). FOG deposits were found to be degradable under aerobic and nitrate-reducing conditions in a simulated sewer environment (He et al., 2015). It was concluded that the surface of the FOG deposit undergoes aerobic biodegradation, while the interior nitrogen-containing compound present in the deposit undergoes nitrate-reducing biodegradation. However, compared to the rapid rate of FOG deposit formation, the slow biodegradation on the FOG deposit would seem negligible (He et al., 2015). A brief discussion of sources of FOG and calcium is provided below.

FOG, FFA AND CALCIUM

According to the Restaurant Association of New Zealand, there are more than 17,000 hospitality businesses in New Zealand (Restaurant Association of New Zealand, 2018). Auckland has the highest number of hospitality businesses, with around 1200 FSEs currently operating (Restaurant Association of New Zealand, 2018). Since restaurants are large contributors of FOG, wide distribution of such establishments can result in a heavy build-up of FOG in our wastewater system. Ducoste et al. (2008) identified Asian restaurants as a major contributor of FOG in the United States, followed by seafood restaurants and fast food establishments. Ice cream or coffee shops may also be a source of FOG due to the use of dairy products, which contain high fat levels.

There is no explicit data available that show the contribution of domestic households to FOG discharges into the wastewater system (He et al., 2017). Mattsson et al. (2014) conducted a study in Norway and Sweden that showed that residential areas were the second highest contributors of FOG. Similarly, among industrial areas, fishing and meat industries have been identified as the most likely contributors of FOG.

It is evident that the process of FOG deposit formation (as explained previously) is a complex one, and depends on many factors, such as type of food cooked, type and quantity of oil used, quantity and quality of FOG material leaving the kitchen sink, velocity, volume, temperature and pH of wastewater once in the pipelines, retention and travelling time (from source to wastewater treatment facility) and type of pipes used. All these factors can have a detrimental effect on the production of FFAs and the formation of FOG deposits in sewer pipelines. FFAs are formed by the hydrolysis of FOG (as shown in Figure 1). For example, during cooking, fast hydrolysis has been found to generate FFAs as soon as fat meets moisture (He et al., 2017). It is also suggested that FFAs are produced due to prolonged contact time and mixing between FOG and high moisture along wastewater pipes (while travelling) and at sewer crowns due to release of calcium hydroxide (i.e., from corrosion of concrete pipes).

Further, soap products, including hard soaps, gels and shaving cream, contribute to the presence of FFAs in the wastewater system (Szostak, 2013). FFAs have not been found in laundry detergents or kitchen cleaning products, and no FOG deposits were found downstream of laundry facilities, as reported by Szostak (2013). Human solid waste is another potential source of FFAs in sewers. Human excreta are known to be comprised of 4% to 7% of stearic acid and palmitic acid, which are types of fatty acids (He et al., 2017). However, these materials have not been used in studies as a source of FOG deposit formation due to their negligible quantity.

Similarly, calcium can come from many sources, for example, human urine, and food waste, such as milk, tofu, broccoli, green beans, etc. (He et al., 2017). The concentration of calcium in human urine is estimated to range from 100 to 300mg per day per capita (He et al., 2017). However, further research is needed to investigate the formation of FOG deposits (in wastewater pipelines) from the release of calcium from human urine. Further details of sources of FOG, FFAs, and calcium can be found in He et al. (2017).

TYPES OF GREASE TRAPS

GTs are the primary approach for removing FOG from wastewater produced at FPFS premises before it enters the wastewater reticulation system. There are three main types of GT that are being used in Auckland. A brief description of each is provided below.

Passive grease trap (PGT)

PGTs are normally large, in-ground tanks with two or three compartments (Figure 2), which are constructed outside a restaurant premises. The wastewater from the kitchen enters the tank, and is retained to cool down so that the grease solidifies and floats to the top, and food debris settles at the bottom. As we know, FOG doesn't mix with water and therefore rises to the top. The partially treated wastewater is then slowly discharged from the bottom of the first compartment to the second chamber, and then to the third compartment (Figure 2). The minimum size (as per Auckland Council's requirements [NZTIWF, 2017]) of a PGT is 500 litres (conditional on local council approval). However, in general a PGT size can be calculated based on the number of seats in a restaurant. For example, five litres per seat is the standard, which means a 100-seat restaurant will require a 500-litre PGT (Mactrap, n.d.).

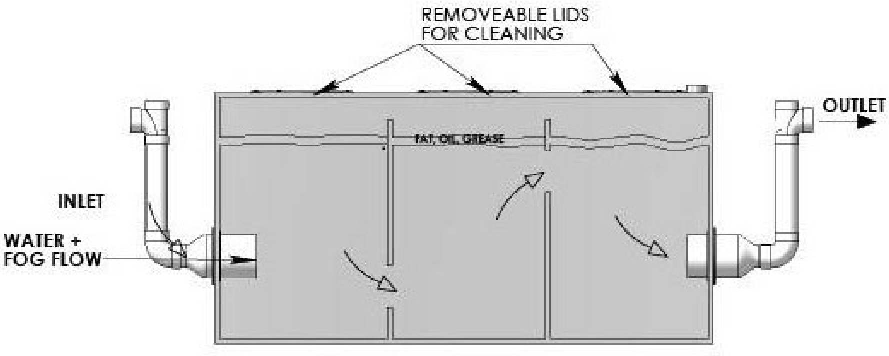

Figure 2. A type of PGT that is currently used in small-scale food outlets (Mactrap, n.d.).

Grease interceptor (GI) or grease removal unit (GRU)

GIs divert the path of grease from flowing into the wastewater system. They separate FOG from the wastewater and store it in a container. This type of trap is normally made of stainless steel (Figure 3). It is installed internally and wastewater (with FOG) is allowed to flow into the trap via a filter to remove food particles. A baffle system is used to separate FOG, which rises to the top (Mactrap, n.d.). A mechanical system is used to continuously remove FOG into a container – which can later be reused, recycled or discarded as required. This type of trap requires professional cleaning every six months (Mactrap, n.d.).

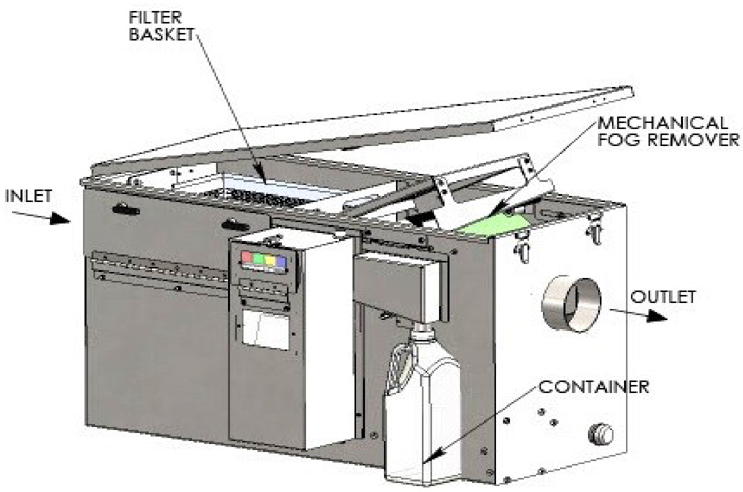

Figure 3. A Mactrap GI or GRU that is available in the market (Mactrap, n.d.).

Grease converter trap (GCT)

In a GCT, FOG is broken down using enzymes and bacteria, in a natural process. The size of the GCT depends on the volume of wastewater produced at the food preparation facility. A baffle system is used in a GCT to prevent FOG material leaving the trap (Figure 4), which causes the FOG to float on the water surface (NZTIWF, 2017; Mactrap, n.d.). Normally, a dose of bio-enzyme is used at night to break down FOG that is built up during the day. After breaking down, it is discharged to the wastewater pipeline, ensuring that drains remain free from blockage. It is a requirement from councils to have an automatic dosing system for GCTs, which allows four hours to break down the FOG material (NZTIWF, 2017). This trap is also made of stainless steel (Mactrap, n.d.), and is cheaper than other traps but costly to maintain. The cost of enzymes could be between $600 and $2000 per annum depending on what type of oil is used (low- or high-fat) (Mactrap, n.d.).

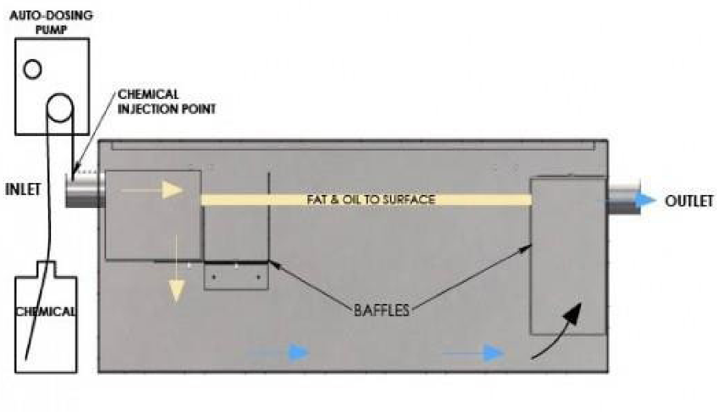

Figure 4. A diagram showing the different parts of a GCT (Mactrap, n.d.).

METHODOLOGY

A questionnaire was prepared to collect data (described in the following sections) from a range of small-scale FPFS businesses in Auckland. Each restaurant was physically visited and the questionnaire was completed at the site. A number of calls were made to numerous small-scale food businesses in Auckland, but only few agreed to participate in the survey. Thus, data could only be collected from eight food services, due to Covid-19 restrictions in Auckland. It would have been preferable to be able to survey a larger number of food services. Also, some business owners were not comfortable to share some of the information in terms of operation, maintenance frequency and costs, etc. There was no data available or accessible in terms of volume/flow rate of wastewater that is being discharged from FPFS businesses in the Auckland region.

Type and size of GT used

The data regarding the type of GT was collected to determine whether the respective FPFS facilities were using a GT, and if yes then what type, a PGT or GCT or GI trap. The GT size data was also collected to check and compare the sizes used with the recommended or required sizes.

Fixture Unit Rating (Fur) to estimate GT size

GT size also depends on the type of fixtures that are installed in a kitchen, and therefore the information regarding the type of fixtures installed in a kitchen was collected. This information helped to determine whether the current GT is an appropriate size (or not) for the effective pre-treatment of FOG.

According to the GT guidelines for New Zealand Trade Waste Officers (NZTIWF, 2017), there are two methods available to estimate the appropriate size of GTs.

The first method (which was used in this study) is based on the Fixture Unit Rating (FUR), in which a rating value is given for each type of fixture (refer to NZTIWF, 2017). In this method, the FUR value was used for each type of fixture (i.e., steamer, wok, hand basin, rinse basin, kitchen sink, etc.). This FUR value was then multiplied by the number of each of that fixture to estimate the maximum number of Fixture Units (FU). All FU values were added and then multiplied by 100 litres (as per NZTIWF, 2017) to determine the appropriate size (in litres) of the GT for that facility.

The second method is based on hourly peak-flow rates of wastewater (NZTIWF, 2017), and could not be used as there was no wastewater flow-rate data available for the surveyed food services.

Types of food prepared

Data regarding types of food prepared at the surveyed FPFS businesses were collected to determine what sort of food was prepared and what type of food preparation required high usage of oil in the kitchen. This information assisted in determining which type of FPFS facility might be producing wastewater with the most FOG material.

Type and quantity of oil used

It is known that the amount of oil used each day is directly proportional to the amount of oil found in the wastewater leaving the kitchen area. Also, different oils have different fat contents. Therefore, data on the type and amount of oil used was also collected for this study.

Operation and maintenance data

GT operation and maintenance data for the FPFS facilities in the study were collected. It was intended to compare this data set with the grease trap guidelines on how often a grease trap needs to be cleaned.

Location of GT

The data on where the GT is located were collected to check whether the wastewater draining from the kitchen area was passing through the GT for pre-treatment. This data also assisted in checking whether the GT is installed at a place that is easy to access for cleaning and clearing purposes.

RESULTS AND DISCUSSION

Food industry

Table 1 shows the type of FPFS industry visited and the type of food prepared at those facilities (refer to Figure 5). There was a total of eight small-scale food businesses that could be visited during the Covid-19 restrictions in Auckland, which was a challenge under the given circumstances. Thus, there were three Chinese restaurants, two cafés, and one each of Japanese food, pizza and burger services that could be surveyed (Table 1).

Food industry	Number
Café	2
Pizza service	1
Japanese food service	1
Chinese restaurant	3
Burger service	1

Table 1: Small-scale FPFS industry surveyed/visited.

Type of food and oil used

Most of the food prepared at the surveyed food services involved deep frying (Figure 5). The results show that 50% to 90% of food services were preparing deep-fried potato chips, fish, chicken and red meat, etc., which does require a reasonable quantity of oil.

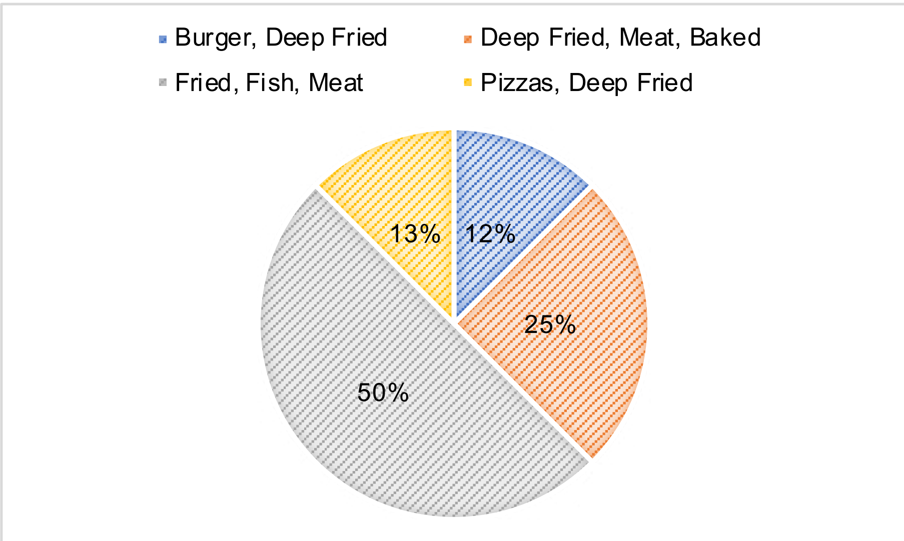

Figure 5: The type of food that was prepared at the surveyed FPFS facilities.

All food services were using vegetable oils (i.e., canola, soybean, sunflower, etc.). However, most of the food services were using canola oil (more than 50%, see Figure 6), being the cheapest oil available in the market.

The quantity of oil used at the respective food services varied between 3 and 6 litres per day (L/d) (Figure 7). At the end of the day the used oil was discharged into the sink, which is considered to be a bad practice.

To give an idea of how much used oil may be going down the drain, based on an estimated average of 5L of oil used in a day, 35L in a week (assuming a 7-day working week), 1750L of waste oil would be produced in a year (based on 50 working weeks of the year). This means 1750L of used oil may be drained every year by a single FPFS business – multiply this number by the number of these businesses in the Auckland region, and that would give us an idea of how much FOG material maybe going to the WWRS.

The used oil, which should be recycled, was going down the drain and contributing to the formation of FOG deposits, which means that it is very likely that a pipe blockage will occur. Further, this also indicates that the formation of fatbergs is likely to occur further down the pipe lines. Eventually, these fatbergs are likely to travel towards the WWTP and create challenges for plant engineers, managers and operators to treat or remove them.

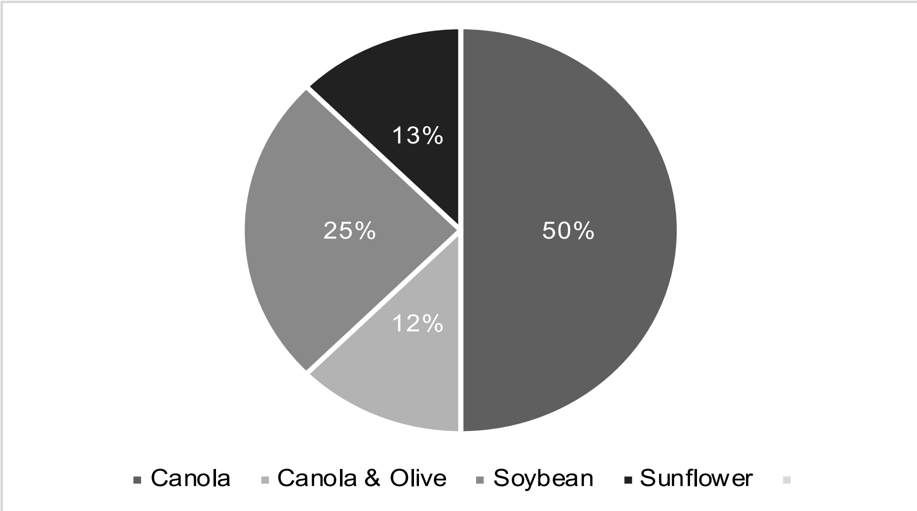

Figure 6. The type of oil used at the surveyed FPFS facilities.

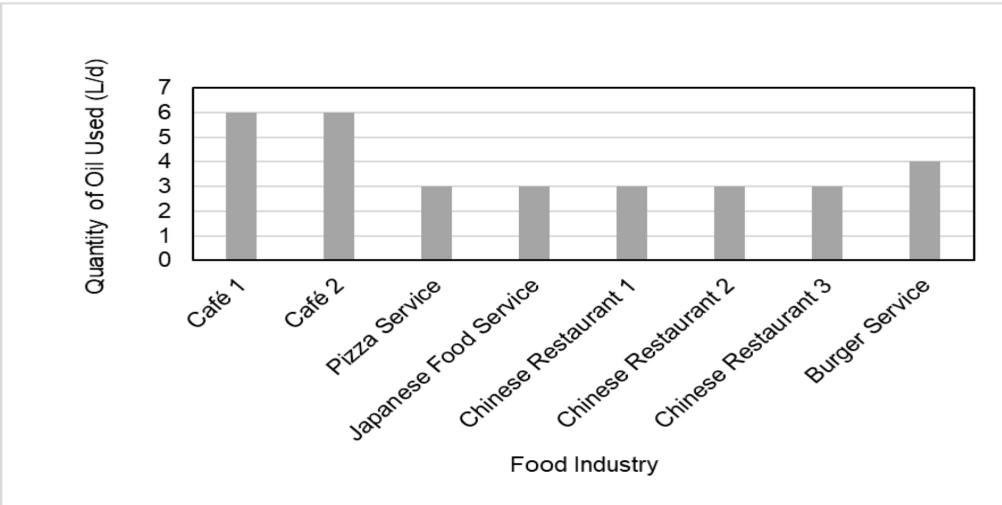

Figure 7: The quantity of oil used per day at the respective FPFS facilities.

GT types and sizes

The results show that two types of GTs (i.e., PGT and GC) were used in the surveyed food facilities (Figure 8). Fifty percent of the food services used GCs, 25% used PGTs and 25% of the facilities didn't have any GT installed on site. It is not known what was the reason, but it was revealed that the staff were unaware of the fact that there is a requirement to have a GT installed on the premises.

Having no GT installed means that there is no process in place to separate FOG from the wastewater at source (before it goes to the wastewater pipelines). Further, it was observed that there is no system of checking to see whether a GT is installed on an FPFS facility such as the ones in this study.

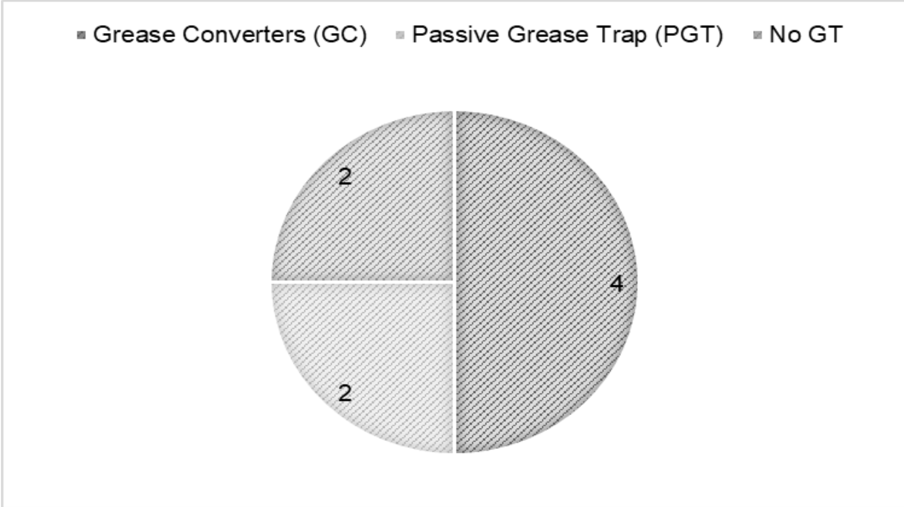

Figure 8: The types of GTs used at the surveyed FPFS facilities.

Figure 9 shows the size of GTs used at the respective food facilities. The GT size used ranged between 75L and 800L. The biggest size was 800L, which was used at the Chinese restaurants. Again, no GT was installed at two facilities (Figure 9).

It should be noted that a PGT works on the principle of retention and sedimentation, and therefore it normally has a large capacity in order to work efficiently. On the other hand, GCs work with the help of bio-enzymes and do not require long retention times, hence they come in different sizes to accommodate the wastewater produced by different FPFS businesses.

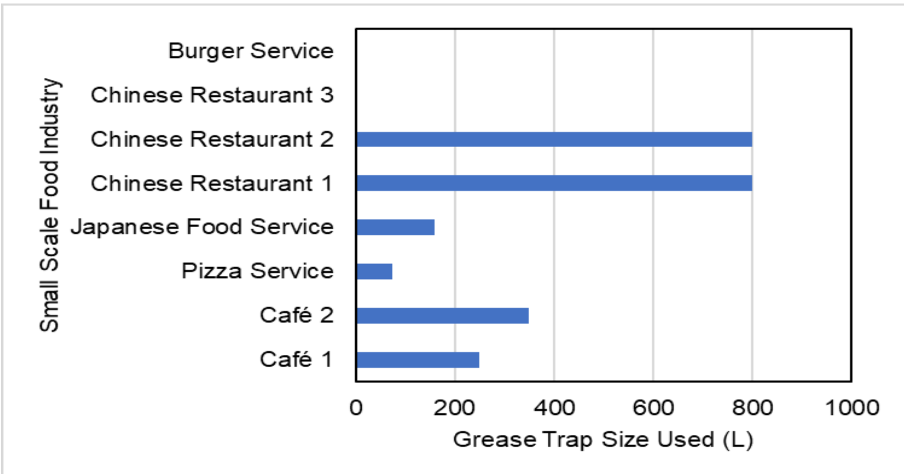

Figure 9: Sizes of the GTs used.

Fixture Unit Rating and recommended GT size

As mentioned previously, FUR values (NZTIWF, 2017) and the actual number of fixtures employed at the FPFS facility were used to estimate the number of Fixture Units for each facility. Then the total number of FUs was multiplied by 100L to determine the appropriate size of the GT for each facility.

Basically, the size of the GT depends on the number of FUs used – the GT's required size increases as the number of FUs increases (Figure 10).

The results show that the GT sizes that were used at the facilities surveyed ranged between 75L and 800L (Figures 9 and 10). The estimated number of FUs varied between 7 and 16 (Figure 10).

It is clear from the results that the pizza food service had the smallest GT installed (i.e., a 75L GC trap, Figure 10), but the required GT size for this facility is 500L (estimated as per NZTIWF, 2017). The small size of the GT used at this service may be due to space constraints, but there was no documentation available to check that. The GT used at this facility is under sized, and therefore there is a possibility that the GC trap may not be breaking down the FOG effectively (using enzymes and bacteria). Therefore, it is very likely that untreated or partially treated FOG was going down the wastewater pipelines, which leads to blockage of pipes and reduction in flow area due to the formation of FOG deposits on the inner surfaces of the pipes.

Further, results show that all surveyed FPFS facilities had an under-sized GT installed (Figure 10), which means FOG were being released untreated or partially treated (at the source) and were likely to be contributing to FOG deposit formation, which may end up blocking the pipes at a later stage.

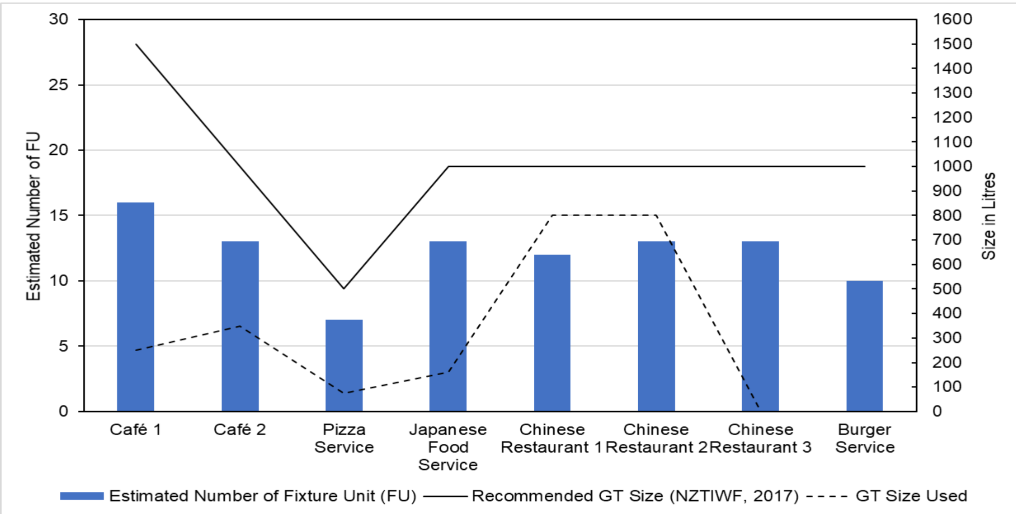

Figure 10. The estimated number of FUs, sizes of GTs used, and the recommended GT size as per calculations.

Location of GT

Table 2 shows the location of GTs used at each food service facility. It was observed that the locations of the GTs at the FPFS facilities were easily accessible for cleaning and maintenance purposes. The PGTs were located underground behind the buildings of the respective food services (Table 2). The GCs were placed under the sinks as per the instructions in the GT guidelines (NZTIWF, 2017), which was a good practice. The GC for Café 2 was kept near the back door due to space restrictions inside the kitchen (Table 2).

Food industry	Type of GT	Location of GT
Café 1	Grease converter	Under the sink
Café 2	Grease converter	Near the back door
Pizza service	Grease converter	Under the sink
Japanese food service	Grease converter	Under the sink
Chinese food service 1	Passive grease trap	Behind the building
Chinese food service 2	Passive grease trap	Behind the building
Chinese food service 3	No grease trap	N/A
Burger service	No grease trap	N/A

Table 2. Location of GTs.

Further, it was observed that all GC traps had an automatic bio-enzyme dosing system, which is good news, as NZTIWF (2017) guidelines state that all GCs should have this in order to effectively break down the FOG. Therefore, the only manual work required for these is to refill the bio-enzyme liquid. Refilling depends on the time of operation of the trap, but no data was available.

Required maintenance of GTs

It should be noted here that GTs aren't a rubbish bin. It is important that solid rubbish (at the FPFS facilities) is removed using the sink filter before wastewater goes to the GT. Table 3 shows the required frequency of maintenance of GTs (NZTIWF, 2017). The frequency of cleaning and maintenance depends on the use and size of the GTs. For example, Mactrap (n.d.) recommends that a PGT needs to be cleaned twice a year, using a vacuum pump.

However, it was observed that no record was kept or available for the time and frequency of cleaning of the GTs at the surveyed FPFS facilities.

GT Types	Recommended frequency of maintenance
Grease converter	6 months
Grease converter	4–5 months
Grease converter	6 weeks
Grease converter	3 months
Passive GT	5–6 months
Passive GT	5–6 months

Table 3. Recommended frequency of cleaning for the different types of GTs in the FPFS facilities surveyed.

SUMMARY AND CONCLUSIONS

Accumulation of FOG deposits in wastewater pipelines is becoming a global challenge for environmental engineers and managers, and the sustainability of WWRSs may be at some risk. This pilot study was about understanding and addressing the key questions:

- How are FOG deposits actually formed?
- What types and sizes of grease traps are being used at small-scale food preparation and service industries in Auckland?
- Do the sizes that are being used comply with the recommended sizes?
- What are the issues and/or what is missing?

Based on the results of this study, the following conclusions can be drawn:

1. The literature review (He et al., 2017, 2015, 2013, 2011) shows that FOG deposits are formed from the chemical reactions of FFA and calcium chloride (as a result of the saponification process). FOG deposits are the main cause of wastewater pipeline blockages, which lead to wastewater pipes overflowing, which is a serious environmental concern today.
2. Knowledge of the FOG-deposit formation process is important, as it will ultimately improve our understanding of how they are formed and what possible measures could be undertaken to prevent or minimise the risk of formation of FOG deposits.
3. The direct discharge of FOG is not allowed in the FPFS industry in New Zealand, and therefore it is required that each facility has a GT installed onsite. This study shows that 25% of the surveyed food facilities didn't have a GT installed onsite at the time of the survey. The reason for that is unknown. What is also unknown is how many other cases like these might be present in Auckland and elsewhere.
4. The study shows that 50% to 90% of food that was prepared at the food services surveyed involved deep frying, which means a lot of FOG is produced onsite. Most of the food industry uses canola oil, that being a cheaper option.
5. The quantity of oil used on a daily basis ranged between 3L and 6L. Used oil was drained to GTs, which is an unacceptable practice.
6. The size of GTs used ranged between 75L and 800L. The results show GTs used at all the FPFS facilities surveyed were under sized. This is a worry, as untreated or partially treated FOG is being discharged from these facilities, which is likely the cause of overflow and blockages of wastewater pipes.
7. All GTs were installed at the recommended places (either under the sink inside, or outside the facility) where it was easy to access, clean and maintain them.
8. There was no proper record of how and when the GTs were cleaned and maintained.
9. In terms of size, the GTs being used at the surveyed FPFS facilities in Auckland at the time of the survey did not comply with the criteria set out by the Auckland Council guidelines for GTs (NZTIWF, 2017). According to the guidelines, the minimum required size for any GT is 500L unless restricted by space. None of the facilities surveyed had a GT of recommended capacity installed for the effective treatment of FOG at the source.

What was missing?

1. No mechanism is in place to check whether a GT is installed in a FPFS facility or not.
2. No mechanism is in place to keep and check GT cleaning and maintenance records.
3. No process or mechanism is in place to check whether used oil is recycled or not.

Recommendations

It is recommended that:

- When a food licence is issued by the respective local council, there should be a mandatory compliance criterion of installing a GT. Apparently, there is a process currently in place; however, it is suggested that this process be reviewed for effective implementation.
- The council should keep a record of all GTs installed, possibly online, to ensure that a recommended or required GT size is installed.
- An online system should be developed in which a record of cleaning and maintenance data is kept, and business owners should be required to keep that record up to date. In this way, local councils could keep up-to-date information on GT operations, which would eventually reduce the FOG levels released at the source.

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