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REALITY IN PACKAGE ON-SITE GREASE TRAP PERFORMANCE: SUCCESS AND FAILURE IN FOG REMOVAL

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ABSTRACT: Package on-site grease traps are widely used in household and restaurant in Thailand for oil and grease removal although frequent failures in FOG removal have been reported. Theoretically, too small of operating hydraulic retention time (HRT) takes the blame, but some suppliers claim that their grease traps can be well operated even with HRT of 15 minutes. This study was to investigate the performance of grease trap with various HRTs (15 minutes to 20 hours) and FOG concentrations in the feed (50 to 600 mg/l). Results showed that the operating HRTs of 15, 30 and 60 minutes could represent a kind of shock hydraulic loading condition, which insufficient FOG removal efficiencies were observed. Also, the experiment to enhance the grease trap's performance was set up by withdrawing certain volume of grease trap waste. The operating HRT of 60 minutes with the feed contained FOG of 200 mg/l and dishwashing detergent of 0.5% (v/v) was investigated for seven-day period. The experiment without daily withdrawal was operated in parallel as a control. The results showed that the FOG removal efficiencies in the control began to fall down to 50% on the fifth day of operation. The experiment with daily withdrawal showed more stable FOG removal efficiencies, which its efficiencies was still higher than 50% after seven days of the experiment. However, this could be said that the 15-litre package on-site grease trap fed with operating HRT of 60 minutes (or lower) could not maintain sufficient removal efficiency for long period (months).

Keywords: Package on-site grease trap, Fat oil and grease (FOG), Dishwashing detergent, Oil and grease removal, Hydraulic retention time (HRT).

1. INTRODUCTION

Fats, oils and greases contaminated in water or wastewater are commonly referred to FOG, which can be categorized based on their origin. That is, FOG based on animal and vegetable is considered to be edible, and that based on mineral (petroleum and coal sources) is not edible. FOG in domestic wastewater is mostly generated from food processing either in household or commercial scale (e.g., restaurant, canteen, food plaza, etc.). FOG is a major problem for both onsite or public sewer systems due to it may continually accumulate and cause clogging problem within the drainage system [1–4]. Sometimes, clogging occurs in the crossover line between compartments of grease traps [3]. Although grease traps are supposed to remove FOG before entering a septic tank or sewer system, high FOG loads or emulsified oils as well as surge wastewater flows often cause FOG bypassing through the sewer system. The utilization of grease from kitchen waste was mentioned elsewhere [5] by esterification, and subsequently transformation to be biodiesel products.

Oil contaminated in water or wastewater may exist in several forms such as free oil, physically or chemically emulsified oil, or dissolved oil. Usually, FOG in wastewater from households or restaurants is a free oil, which eventually rise to surface of the container or the receiving water. Most conventional grease traps are basically designed to allow free oil to float up to the surface. Physically emulsified oil means a free oil broken into small droplets by agitation or mixing with water. Also, high water temperatures concurred with liquid vegetable oils can promote physically emulsification. However, these physically emulsified oils will eventually separate from water again when enough hydraulic retention time is given. Chemically emulsified oil is a mixture of oil and water caused by chemical reagents, resulting in very small oil particles and not able to separate and float up to the surface of water regardless how much retention time is allowed. Kitchen wastewater may contain high chemically emulsified oil proportion due to the use of detergents and other alkalis.

Several methods have been attempted to treat oil contaminated wastewater such as ordinary grease traps, dissolved air floatation, adsorption, coagulation, chemical destabilization, etc. Electrocoagulation coupled with microfiltration was also proposed and reported of success in grease removal [6]. However, the package on-site grease traps are widely used by household for oil and grease removal. Typically, a grease trap is used to intercept liquid grease waste or garbage and retain it for an adequate period of time. The configuration of the tank allows cooling down the incoming liquid,

which helps solidify this grease and separation from water. However, sufficient detention time will be required to enhance an efficient floatation of this oil and grease.

In Thailand, there are several types and sizes of commercial package on-site grease traps sold in the market. However, failures of grease traps have been frequently mentioned among customers, whereas too small operating hydraulic retention time (HRT) should be the cause. Pollution Control Department (PCD) of Thailand suggested that HRT for grease removal should not be less than 6 hours [7]. However, some suppliers declared their grease traps could be operated with design HRT of 15 minutes. Therefore, this study was to investigate a performance and optimum HRT for oil and grease removal by a package on-site grease trap. In addition, the effects of dishwashing detergent mingling in wastewater were compared.

2. MATERIALS AND METHOD

2.1 Synthetic Oil Contaminated Wastewater

Cooking oil made from soybeans was used for preparation of synthetic wastewater by mixing cooking oil with tap water till the designated FOG concentrations were reached. The cooking oil was boiled for a few minutes in order to imitate used cooking oil. Then, boiled oil was diluted in tap water using mixer with speed of 110 rpm.

2.2 Reactor Setup

A package on-site grease trap used in this study is a commercial type generally found in Thailand market. It was made of polypropylene (PP) with effective volume of 15 L, dimension of which was 290 mm (W) x 395 mm (L) x 330 mm (H) as shown in Fig. 1. Reactor setup consists of a 15-litre package on-site grease trap, storage influent container equipped with mixer and pump feeding, and effluent container (Fig. 2). The mixer in storage container is to prevent separation of oil from water before fed into the grease trap.

2.3 Experimental Procedures

This study was divided into two parts; the first part was to investigate effect of operating hydraulic retention time (HRT) and dishwashing detergent addition on FOG removal efficiencies. Factorial design of four FOG concentrations (50, 200, 400 and 600 mg/l) and five operating HRTs (15, 30, 60 minutes and 6 and 20 hrs.) were assigned, resulting in total of twenty experiments. Another twenty experiments were setup in parallel, with the addition of 0.5% (v/v) dishwashing detergent into the synthetic wastewater.

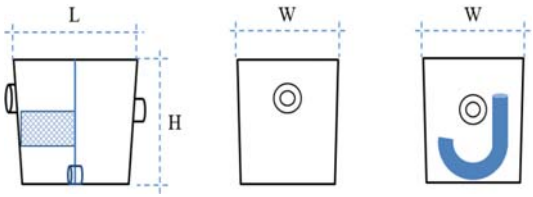

Fig.1 A package on-site grease trap

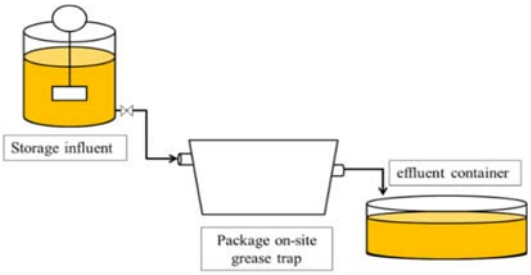

Fig. 2 A schematic diagram of reactor setup

For experiments with HRTs of 15, 30 and 60 minutes, the synthetic wastewater was fed into the package on-site grease trap with designated HRTs for four hours continuously. Then, the feed was stopped for the rest hours of the day with the package on-site grease trap filled. Effluent samples were collected hourly and acidified for preservation till analysis. The same feeding was repeated on the next day for four days continuously. Therefore, for each operation, there were totally sixteen (4x4) samples for analysis. For experiments with HRTs of 6 and 20 hours, the synthetic wastewater was fed into the package on-site grease trap with designated HRTs. The operating hours of each day was according to HRTs, then, the feed was stopped for the rest hours of the day with the grease trap filled. The same feeding was repeated on the next day for four days continuously. Effluent samples were collected after each operating HRT was finished; therefore, there were four samples for analysis.

After four-day operation of each experiment were achieved, the reactors were cleaned to remove all residual oil attached within reactor before the operation was repeated. Each experiment was conducted in triplicates to obtained reasonably statistical results. Those samples were determined for oil and grease (as FOG) and COD according to Standard Methods for the Examination of Water and Wastewater [8].

The second part was set up to investigate the performance of the grease trap in case of daily withdrawing certain amount of floated grease trap waste was applied. The experiment was operated for seven days with selected HRT of 60 minutes for four hours each day. The synthetic wastewater composed of FOG concentration of 200 mg/l and dishwashing detergent of 0.5% by volume. Two reactors were operated in parallel, one of which was

acted as a control with no daily withdrawing (named as Reactor G1), while another one was operated with daily withdrawing of certain amount of floated grease trap waste from the first compartment (Reactor G2). After seven-day operation, reactors were cleaned and the experiments were done in triplicates.

3. RESULTS AND DISCUSSION

3.1 Part I: Effects of Operating HRT on FOG Removal

Figure 3 showed the removal performance of fat, oil and grease (FOG) from the experiments with four influent FOG concentrations.

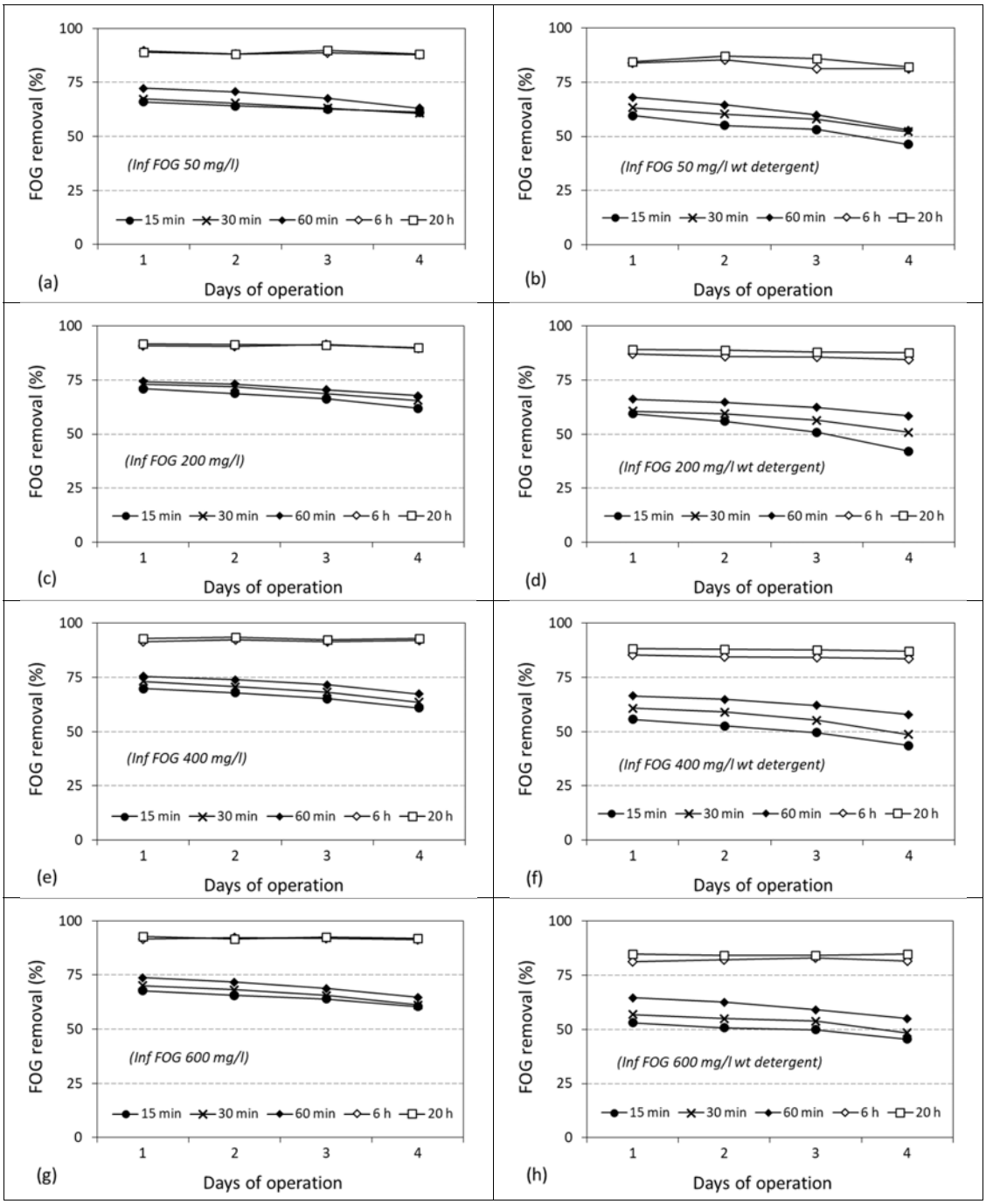

Fig. 3 Performance of FOG removals at various influent FOG concentrations and operating HRTs

The experiments with small operating HRTs, i.e., 15, 30 and 60 minutes, clearly showed less FOG removal efficiencies than the others (6 and 20 hours) either with or without addition of dishwashing detergent. That is, the daily FOG removal efficiencies with operating HRTs of 15 – 60 minutes were in the ranges of 60 – 76% and increased to the range of 88 – 94% with the operating HRTs of 6 – 20 hours in the case of without dishwashing detergent.

Obviously, dishwashing deteriorated FOG removal performance of the trap, especially with the smaller HRTs (15 – 60 minutes). Their daily FOG removal efficiencies were in the ranges of 42 – 68% and 81 – 89%, respectively.

Table 1 concluded the averages of FOG removal efficiencies from this study. The results of both groups (without and with dishwashing detergent) illustrated that higher operating HRTs (6 and 20 hours) resulted in more FOG removal efficiencies. The variation of HRTs in the range of 15 to 60 minutes did not make substantial difference in FOG removal efficiency. The experiments with influent FOG concentration of 50 mg/l without addition of dishwashing detergent obtained a little less removal efficiencies than other concentrations. However, with addition of dishwashing detergent, their removal efficiencies of FOG 50 mg/l experiments were similar to the others.

Table 1 The average FOG removal efficiencies

Average FOG removal efficiencies (%)								
	Influent FOG concentrations (mg/l)							
	50		200		400		600	
HRTs	No D	wt D	No D	wt D	No D	wt D	No D	wt D
15 min.	63	54	67	52	66	50	64	50
30 min.	64	58	70	57	69	56	66	53
60 min.	68	61	71	63	72	63	70	63
6 h.	89	83	91	86	92	84	92	82
20 h.	89	85	91	88	93	88	92	84

Remark: D = dishwashing detergent

It could be said that the variation of influent FOG concentrations (50, 200, 400 and 600 mg/l) did not affect much on the FOG removal efficiencies, especially in the same operating HRT. Consistently, Chu and Ng [9] similarly reported their COD and FOG removal efficiencies were not influenced by influent FOG concentrations ranging from 400 to 1600 mg/l. They also mentioned that a grease trap should be implemented with appropriate HRT that most of oil droplets would be separated and floated to water surface. Unfortunately, the grease trap often came across with these short HRTs in practice, especially during the peak hours of kitchen activities. Large quantities of wastewater both from meal processing or utensils washing were generated within a couple hours. This high volume of wastewater forced the grease trap to be overloaded with both high FOG concentration and hydraulic flow.

In addition, the adverse effect of dishwashing detergent was obviously found in every operating HRTs. The dishwashing detergent substantially reduced FOG removal efficiencies in comparison with the experiments without detergent, especially when the operating HRTs of 15, 30 and 60 minutes were employed. This could be explained that dishwashing detergent caused higher emulsification of oil and grease in wastewater, resulting in more difficulty to be separated from water. Thus, more retention time (or operating HRT) would be extensively required for this slower separation. Besides, hot oil and grease contaminated (from meal processing) in wastewater should be cooled within grease trap, then, they could be more solidified and easily separated from liquid bulk. Hence, short HRT in grease trap will hinder cooling step, which can double the adverse effect of short HRT on FOG removal efficiency. Therefore, the time for allowing oil and grease separated from wastewater was the key.

Moreover, Crites and Tchobanoglous [10] were mentioned that FOG concentration higher than 30 mg/l could cause problems with downstream wastewater collection and treatment. In this study, there were only some experiments that could produce the effluent FOG concentrations less than 30 mg/l. That is, the experiments with FOG concentration of 50 mg/l (every operating HRT, both with and without addition of dishwashing detergent), the ones with FOG of 200 mg/l and HRTs of 6 and 20 hours. In case of FOG concentration of 400 mg/l, only the experiments operated with HRTs of 6 and 20 hours and no addition of dishwashing detergent that could provide less than 30 mg/l effluents. Lastly, neither experiments with 600 mg/l FOG could provide less than 30 mg/l FOG effluent.

3.2 Part II: Effects of Daily Grease Trap Waste Withdrawing

Due to oil and grease separated from the water by floating and accumulating on the surface of water, this accumulated grease trap waste required regular removal to maintain the capability of the grease trap. This experimental part was fed with the FOG of 200 mg/l and conducted with operating HRT of 60 minutes. Two reactors were set up, one of which was acted as a control with no daily grease trap waste withdrawing (Reactor G1), while another

one with daily withdrawal (Reactor G2). Figure 4 illustrated profiles of the influents and effluents of FOG concentrations during seven–day operation.

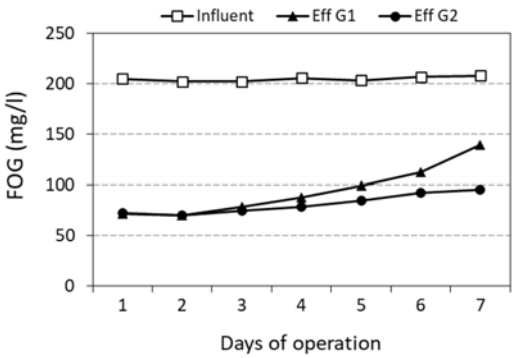

Fig. 4 Profiles of FOG concentrations

Effluent FOG concentrations of both reactors clearly increased after three days of operation. Then, effluent FOG concentrations in the control reactor (G1) gradually increased up to 139 mg/l on the last day of operation (day 7), resulting in FOG removal efficiency less than 40%. Figure 4 showed slower increase of effluent FOG in the reactor G2 (with daily withdrawing) than the reactor G1, resulting in its lower effluent FOG on the last day of 96 mg/l. It could be clearly seen that withdrawal of grease trap waste helped reduce accumulated FOG in the trap and prolong its capability before failure. With this FOG loadings (FOG concentration of 200 mg/l, HRT of 60 minutes and 4 hours operating), the control reactor (G1) lost its 50% efficiency since the fifth day of operation while daily withdrawing could maintain FOG removal efficiency over 50% after seven days of operation.

3.2.1 Mass balance of FOG

Due to operating HRT of 60 minutes and four hours of operation, sixty liters of the feed were used. Therefore, total FOG mass of around 12.3 g/day were calculated and total FOG mass fed into the trap after seven days was about 86 g. For the reactor G1, which there was no daily withdrawing of grease trap waste, those retained FOG mass of 8 g on the first day was the highest, then, they declined throughout the seven days of operation (Fig 5a). Totally, accumulated FOG mass after seven-day operation was about 47 g. If density of soybean at 23.9°C was 0.9193 g/ml [11], this 47 g of retained FOG should require volume of around 51 ml (0.34% of the trap volume of 15 liter).

In the reactor G2, the same seven days of operation was applied, but 0.5 liter of floated grease trap waste) was daily withdrawn. Grease trap waste mostly composed of water up to 86% [12]. The withdrawal was done in the first compartment of the grease trap (influent part). Total wasted FOG mass was about 20.3 g, considering as 23.6% of total influent FOG mass of 86 g. Apparently, daily withdrawing could help retard accumulation of retained FOG mass within the trap, resulting in less FOG mass discharged through the effluent ('mass out'). FOG removal efficiency was still higher than 50% on the last day of operation. The total accumulated FOG mass after seven-day operation was about 33 g, which was much less than those of the reactor G1 (47 g). Thus, no matter how effective grease trap was designed, lacking of proper maintenance could induce failure in FOG removal [2].

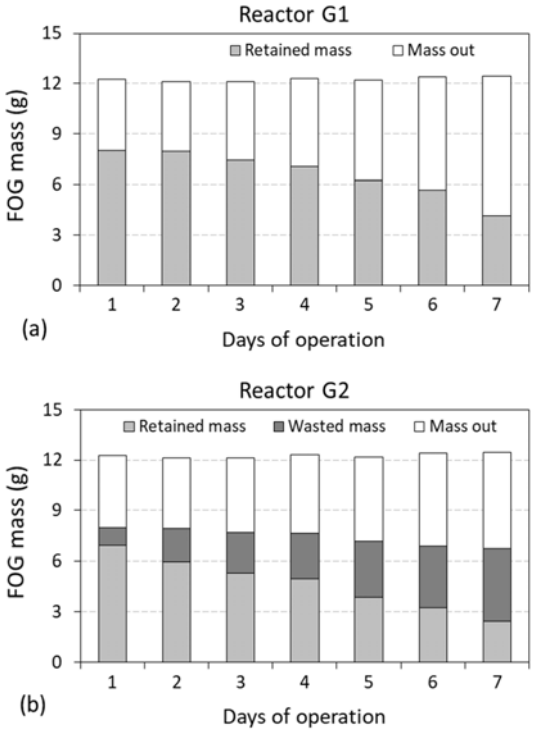

Fig. 5 Mass balance of FOG

3.2.2 Observational opinions in configuration of commercial package on-site grease trap

From this study, there are some observational opinions about the design of the package on-site grease trap to be mentioned. That is, the difference of the traps between two sizes (15 and 30 liters) was the enlargement of the second compartment, while the first compartment of both sizes was the same dimension. Therefore, the first compartment of 15–liter grease trap acting as an inlet compartment is comparatively larger than the latter compartment (oil separation chamber). The 30–liter grease trap seems to have more suitable dimension (larger oil separation part). Unfortunately, the first

compartment of 15–liter grease trap cannot be lessened because of those necessary inlet pipe and fittings. Moreover, they were also equipped with basket-shape screening for trapping food scrap or else as shown in Figure 6 [13]. Hence, the package on-site grease trap with a size as small as 15 liters would require more attention before implementation.

Fig. 6 Typical package on-site grease trap [13]

Besides, solid waste or food scrap contaminated in wastewater as in practice has not been included in this study. These solid wastes would be detained within the trap and deteriorate FOG removal efficiency by reducing effective volume of the trap. Also, the retained solid wastes could be further rotten and stinking within the trap faster than FOG. In practice, the small package on-site grease trap such as 15-liter type would not handle any solid wastes effectively. For this case, solid wastes or food scrap in wastewater must be removed well enough before entering the grease trap.

In consideration of HRT equation (HRT = V/Q; where V = required tank volume and Q = hydraulic flow), hydraulic flow should be carefully selected before calculation and selection the size of grease trap. Therefore, it is important that hydraulic flow passed into the very small trap (such as 15- or 30-liter) must be carefully concerned and managed.

4. CONCLUSION

The influent FOG concentrations varied between 50 to 600 mg/l did not make substantially difference in removal efficiency of the package on-site grease trap. The operating HRTs plays an important role in FOG removal. Several operating HRTs for the grease trap were recommended and published, but some confusion occurred to users. Especially, for household level, too small operating HRT of 15 minutes used to be advertised. In practice, the package on-site grease trap commercially marketed in Thailand are mostly too small for proper FOG removal. In addition, dishwashing detergent made oil and grease more soluble, then, more difficult to separate off water. Therefore, the operating HRTs of more than 6 hours (or up to 20 hours) were recommended for reliable FOG removal. However, maintenance program for grease trap, such as regular removal of floated FOG waste, should be applied to extend their capability and prevent failure of FOG removal.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] He X., de los Reyes F.L., Leming M.L., Dean L.O., Lappi S.E., Ducoste J.J., Mechanisms of Fat, Oil and Grease (FOG) deposit formation in sewer lines, Water Research, Vol. 47, 2013, pp. 4451–4459.

[2] Williams J.B., Clarkson C., Mant C., Drinkwater A. and May E., Fat, oil and grease deposits in sewers: Characterisation of deposits and formation mechanisms, Water Research, Vol. 46, 2012, pp. 6319–6328.

[3] Ashley R.M., Fraser A., Burrows R., Blanksby, J., The management of sediment in combined sewers, Urban Water, Vol. 2, Issue 4, 2000, pp. 263–275.

[4] Hussin M.S.F., Shamsuddin M.A., Jumaidin R., Zakaria A.A., Jenal N., Portable grease trap for wastewater management system: A conceptual design approach, Journal of Advanced Research in Fluid Mechanics and Thermal Sciences, Vol. 49, Issue 1, 2018, pp. 18–24.

[5] Wang H.X., Xu J.L., Sheng L.X., Study on the comprehensive utilization of city kitchen waste as a resource in China, Energy, Vol.173, 2019, pp. 263–277.

[6] Changmai M., Pasawan M., Purkait M.K., Treatment of oily wastewater from drilling site using electrocoagulation followed by microfiltration, Separation and Purification Technology, Vol.210, 2019, pp. 463–472.

[7] Pollution Control Department, On-site wastewater treatment manual for producers and designers [In Thai], Bangkok, Reunkaew Printing, 1994.

[8] APHA, AWWA, WEF. (2012). Standard methods for the examination of water and wastewater (22nd ed.). Washington, DC: American Water Works Association.

[9] Chu W. and Ng F.L., Upgrading the conventional grease trap using a tube settler, Environment International, Vol. 26, 2000, pp. 17–22.

[10] Crites R. and Tchobanoglous G. Small and Decentralized Wastewater Management System. McGraw-Hill Series in Water Resources and Environmental Engineering. Boston: WCB/McGraw-Hill, 1998.

[11] Noureddini H., Teoh B.C. and Clements L.D., Densities of Vegetable Oils and Fatty Acids, Papers in Biomaterials, 14, 1992, http://digitalcommons.unl.edu/chemeng_biomaterials/14.

[12] Tu Q. and McDonnell B.E., Monte Carlo analysis of life cycle energy consumption and greenhouse gas (GHG) emission for biodiesel production from trap grease. J. Clean. Prod. Vol.112 (Part 4), 2016, pp. 2674–2683.

[13] Pollution control department, Guidelines for Restaurant in Management of Oil and Grease from Grease Trap and Utilization [In Thai], Bangkok, TQP Co., Ltd., 2008.