Efficiency of Modified Grease Trap for Domestic Wastewater Treatment

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Abstract

The objective of study was to investigate the efficiency of modified grease trap for domestic wastewater treatment. The study was focused on a media arrangement (5 cm diameter of Mon brick: 1 cm diameter of gravel: 3 cm diameter of Mon brick) with the different media ratios (1:1:1, 1:1:2, 2:1:1, 1:2:1, 2:2:1, 2:1:2 and 1:2:2) in a modified grease trap. Also, it was focused on the optimal factors; flow rate (2-5 L/min) and hydraulic retention time (HRT) (4-10 hrs) on treatment efficiency of grease trap. The result revealed that modified grease trap (1:1:2) for domestic wastewater treatment was generated in the highest efficiency. Suspended solid (SS), fat oil and grease (FOG) and biochemical oxygen demand (BOD) removals were up to 80%. Moreover, it was found that the optimal flow rate and HRT for simple and modified grease (1:1:2) traps were at 2 L/min and 10 hrs. At the optimal condition; SS, BOD, and FOG removals were over 87, 70, and 87%, respectively. In a comparative study of treatment efficiency between simple and modified grease (1:1:2) traps, it showed that, under the same condition (2 L/min, HRT varied at 4, 6, 8 and 10 hrs), a modified grease trap generated the higher efficiency of SS, FOG and BOD removal than that of a simple grease trap.

Keywords : Modified grease trap, Media ratio, Flow rate, Hydraulic retention time

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1. Introduction

The problem of wastewater pollution is one of major problems in Thailand, particularly in domestic wastewater. The domestic wastewater or sewage is produced from community activities such as house cleaning and cooking in restaurants. Houses and restaurants generate sewage from washing activities such as cleaning dishes and containers. Usually, the sewage discharged into water body contains various contaminants which could adversely affect the creature in the water sources. Fat oil and grease (FOG) is one of main contaminants and can accumulate and float on the surface of water. It caused to block the oxygen transference between air and water and to prevent the biodegradation of organic matters. Moreover, FOG normally clogs the piping system of maintenance which is costly for concerning authority to solve the problem [1]. Therefore, the Ministry of Natural Resources and Environment, Thailand has emphasized the installation of grease traps to reduce the impact of FOG in wastewater before draining into public water sources. However, it has been found that the grease traps currently used in houses are not effectively reducing FOG before releasing to the public water sources [2]. Generally, the grease traps can dispose about 60% of FOG [3]. Hence, it is significant to study the factors that influence on the operational efficiency in FOG removal for maximum treatment of domestic wastewater and reduction of the impacts on water body and is environmental friendly.

The objectives of this research were to investigate the important factors; flow rate and hydraulic retention time (HRT) that affected wastewater treatment by grease trap and to investigate the media ratio in a modified grease trap for treatment efficiency of domestic wastewater.

2. Materials and methods

2.1 Domestic wastewater

Domestic wastewater from dishwashing activities of households was collected by a grab sampling method about 600 L for an experiment. Physical and chemical characteristics were analyzed for temperature, pH, suspended solid (SS), fat oil and grease (FOG), biochemical oxygen demand (BOD), and surfactant that are shown in Table 1.

2.2 Grease trap and media

There were two types of grease trap; a simple grease trap and a modified grease trap (Fig. 1). Simple grease trap made from plastic bucket was about 50 L of capacity. Holes of the plastic bucket were inserted with 2 inches diameter of PVC pipes for influent and effluent. The effluent pipe was connected to 15 cm height above the bucket bottom and the influent pipe was at 5 cm that is higher than effluent pipe (Fig. 1(a)). Modified grease trap was a simple grease trap that contained media layers for wastewater filtration. The media types used in a modified grease trap were Mon

brick (diameter of 3 cm and 5cm) and gravel (diameter of 1 cm) (Fig. 1(b)). Furthermore, the cost of a modified grease trap (60 L) is not expensive about 700 baht.

2.3 Experimental procedures

2.3.1 Optimal media ratio in a modified grease trap

Proportion of media in a modified grease trap was set from bottom to upper layers. The arrangement of media was 5 cm diameter of Mon brick, 1 cm diameter of gravel and 3 cm diameter of Mon brick, respectively. The arrangements of media ratio were 1:1:1, 1:1:2, 2:1:1, 1:2:1, 2:2:1, 2:1:2 and 1:2:2. The thickness of media arrangement (three layers) was calculated at 30% of the modified grease trap's height. A 600 L of domestic wastewater was filled into the modified grease trap which fixed with specific arrangement of media ratio. The flow rate was controlled at 2 L/min and 6 hrs of HRT. The experiment was conducted in triplicate for each arrangement of media ratio.

2.3.2 Factors affect the treatment efficiency of simple and modified grease traps

Domestic wastewater was filled in both of simple and modified grease (optimal media ratio) traps. The flow rates of wastewater (influent) were set at 2, 3, 4 and 5 L/min. Then, effluent was closed when the volume of wastewater reached to 45 L in order to set the HRT at 4, 6, 8, and 10 hrs, respectively. The experiment was conducted in the triplicate.

2.4 Analytical methods

Influent sample of 5 L and effluent sample of 5 L were collected from each grease trap to determine the temperature, SS, pH, FOG, BOD, and surfactant [4]. Treatment efficiencies of domestic wastewater from simple and modified grease traps were analyzed and calculated in the percentages. The contaminant removal in percentage was calculated by using an Equation 1 [5].

$$\% \text{ Removal} = \left[(C_{Inf} - C_{Eff})/C_{Inf}\right] \times 100 \qquad (1)$$

where C_{Inf} is a contaminant concentration in influent and C_{Eff} is a contaminant concentration in effluent.

3. Results and discussion

According to Table 1, when characteristics of influent quality were compared to the central wastewater treatment effluent standard and effluent standard of Ministerial Decree No. 51 (B.E. 2541) issued under the Building Control Act, B.E. 2522, they exceeded both standards [6]. Whereas comparing to the surface water quality standard, they showed that BOD exceeded this standard. However, SS, surfactant, and FOG values were not specified in the surface water quality standard.

3.1 Effect of media ratio on the treatment efficiency of domestic wastewater in a modified grease trap

Fig. 2 shows the treatment efficiencies of domestic wastewater in a modified grease trap with different arrangement ratios of media; 5 cm diameter of Mon brick: 1 cm diameter of gravel: 3 cm diameter of Mon brick, respectively. All media ratios affected the treatment efficiency of a modified grease trap, they showed that FOG removal was more than 75%, while pH removal was as little as 0.71 – 7.2%. Moreover, media ratio of 1:2:1 was the highest efficiency in FOG removal of 97.55%. However, with the same ratio of media, BOD removal was only 52%. At media ratio of 1:1:2, the efficiency of SS, BOD, and FOG removal was approximately 80% and given that it was the optimal media thickness for microorganism attachment that degraded the organic matters in wastewater. The results were consistent to other researches that studied various types of media used in wastewater treatment, i.e., plastic, gravel, sand, charcoal, and wood. However, most researchers preferred to use the crushed stone and gravel because they were readily available and inexpensive when were compared to the plastic filter [8].

Arrangement of media ratio in a modified grease trap could be reduced an impurity of organic compounds and removed the suspended solid and colloid [9]. The comparison of media characteristic resulted that media used was contaminated with dirt and grease, which might block the flow rate of wastewater. Therefore, the maintenance and cleaning of grease trap were required to extend a utility of media. The research is consistent with Chu and Ng (2000) [10] studied the performance improvement of grease trap by using tube settler. It was found that the treatment efficiencies of COD and FOG had increased. The results also showed that the treatment efficiencies of FOG were 79 - 87%. Wong et al. (2012) [11] conducted the experimental study by installing the filter in the 1,000 – 5,400 gallons of grease trap used in the restaurants in Malaysia and the treatment efficiency of SS was approximately 41 – 51% and the treatment efficiency of FOG was approximately 43 – 52%.

Another research installed two permanent grease traps at Bang Prarough community in Pathum Thani province, Thailand revealed that the best performance of grease trap had a capacity of 200 – 300 L/day which derived from 3 - 4 households. The grease trap tanks were made from cements and joined together with 200 L and then they were arranged with filters. The ratio of filter (½ bricks, 2 charcoal, ½ bricks, 1 stones and ½ bricks) was set in the grease trap, respectively. Then, effective microorganisms were added in purpose of biodegradation of organic matters and indicated that they had the treatment efficiency of FOG at 70 – 90 % [6].

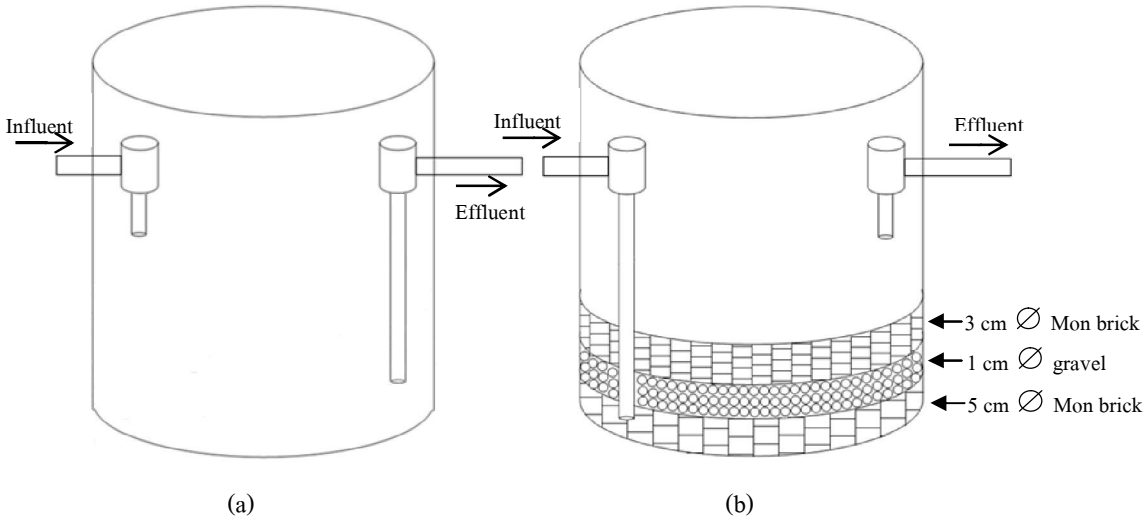

Fig. 1. Schematic diagrams of (a) simple grease trap and (b) modified grease trap of Mon brick and gravel.

Table 1 Characteristics of domestic wastewater.

Parameter	Domestic wastewater (Dishwashing)	Mean	Water quality standard		
			Central[1] wastewater treatment effluent standard	Ministerial Decree[2] No. 51 (B.E. 2541) issued under the Building Control Act, B.E. 2522	Surface[1] water quality standard
Temperature (^{0}C)	28 – 32	30	-	-	Natural
pH	6.71 – 7.67	7.26	5.5 – 9.0	5 – 9	Natural, 5 - 9
SS (mg/L)	70.6 – 499.2	221.54	20	30,40,50,50 and 60	-
BOD (mg/L)	90 – 290	154.86	30,50	20,30,40,50 and 200	Natural, 1.5, 2,4
FOG (mg/L)	42.05 – 260	102.26	5	20 and 100	-
Surfactant (µg/L)	0.192 - 10.6	2.94	-	-	-

[1]Pollution Control Department (2011) [6]

[2]Office of the council of state (2013) [7]

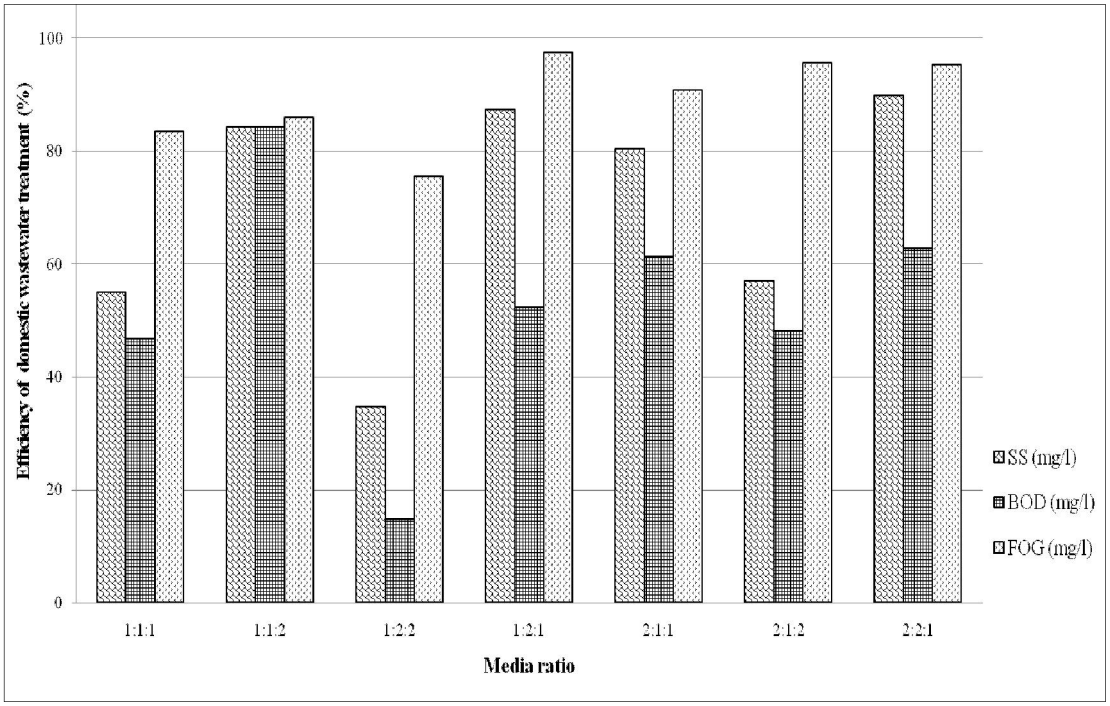

Fig. 2. Effect of media ratios on efficiency of modified grease trap treating domestic wastewater.

3.2 Effects of flow rate and hydraulic retention time on efficiency of grease traps for domestic wastewater treatment

Treatment efficiencies of domestic wastewater by using the simple and modified grease traps with flow rates of 2, 3, 4, and 5 L/min and HRT of 4, 6, 8 and 10 hrs showed that SS, BOD, and FOG removals of simple grease trap were in the ranges of 68 - 92%, 0.83 - 73%, and 76 - 98%, respectively. On the other hand, SS, BOD, and FOG removals of modified grease trap were in the ranges of 63 - 94%, 3.7 - 84.81%, and 80 - 97%, respectively. Treatment efficiencies of pH in the simple and modified grease traps were as little as 0.13 - 3.38% and 0.15 - 5.49%, respectively. The result revealed that flow rate of wastewater (influent) affected the SS removal whereas it was no effect on BOD and FOG removals. The high flow rate also reduced the SS removal. BOD removal of grease trap depended on the microorganism activities in the treatment tank [12]. The higher HRT increased the SS, BOD, and FOG removals. It was found that the optimal flow rate and HRT for the simple and modified grease traps were at 2 L/min and 10 hrs. At the optimal condition, the reductions of SS, BOD, and FOG were over 87, 70, and 87%, respectively, whereas there was no effect on the treatment of pH value. They were

inconsistent with previous study that HRT of grease trap should not be less than 24 hrs because result would be lower than 20 mg/L of FOG in effluent [13]. It might be occurred from the characteristics of wastewater from dishwashing and suitable design criteria of grease trap for treatment. Moreover, Sonune and Gahte (2004) [14] studied the characteristics of wastewater from primary treatment unit at California, USA. They revealed that BOD (influent) was 112 mg/L when it was treated by using a primary treatment unit and could provide up to 34.82% of removal as well as contained of SS 185 mg/L with efficiency for treatment up to 60%. It was consistent with the basic design of primary treatment in Thailand, which BOD and SS removals were 50 - 70% and 60%, respectively. This study also found that at 2 L/min of flow rate and 10 hrs of HRT resulted effluent having 7.01 and 6.7 of pH, 42.58 mg/L and 26.13 mg/L of SS, 45.83 mg/L and 34.17 mg/L of BOD, 12.3 mg/L and 5.95 mg/L FOG of simple and modified grease traps, respectively. However, the result in this experiment was found that the simple and modified grease traps could treat oil and grease less than 20 mg/L by applying a hydraulic retention time at 10 hrs which was the higher hydraulic retention time and the higher removal efficiency. The appropriate grease trap designed for wastewater treatment was related to the experimental results of varying 1, 2, 3 and 6 hrs of HRT for 140 L of grease trap, which treated wastewater generation from cafeteria, King Mongkut's University of Technology Thonburi, Thailand and made from cement ring, demonstrated 65 , 72 , 79 and 83 % of oil and grease removals at 1, 2, 3 and 6 hrs of HRT, respectively. Moreover, BOD removal for 1-3 hrs of HRT was in range of 40 – 50 % and SS removal for 3 hrs of HRT was 50 % [15].

3.3 Comparison between simple and modified grease traps for domestic wastewater treatment

From the comparison study of the wastewater treatment efficiency between simple and modified grease traps at 2 L/min and 10 hrs (HRT), it showed that treatment efficiencies of SS, BOD, and FOG in a modified grease trap were higher than that of simple grease trap as shown in Fig. 3. The effluent characteristics from simple grease trap were 42.58 mg/L (SS), 45.83 mg/L (BOD), and 12.3 mg/L (FOG). On the other hand, effluent characteristics from a modified grease trap were 26.13 mg/L (SS), 34.17 mg/L (BOD) and 5.95 mg/L (FOG).

The modified grease trap was able to reduce the concentrations of SS and FOG with more than 90% and was able to reduce the BOD concentration with more than 80%. The results were consistent with the report of U.S. EPA (2012) [16] which reported that the primary wastewater treatment unit was able to remove the pollutants in the ranges of 40 – 80% (SS), 26 – 65% (BOD), and 70 – 80% (FOG).

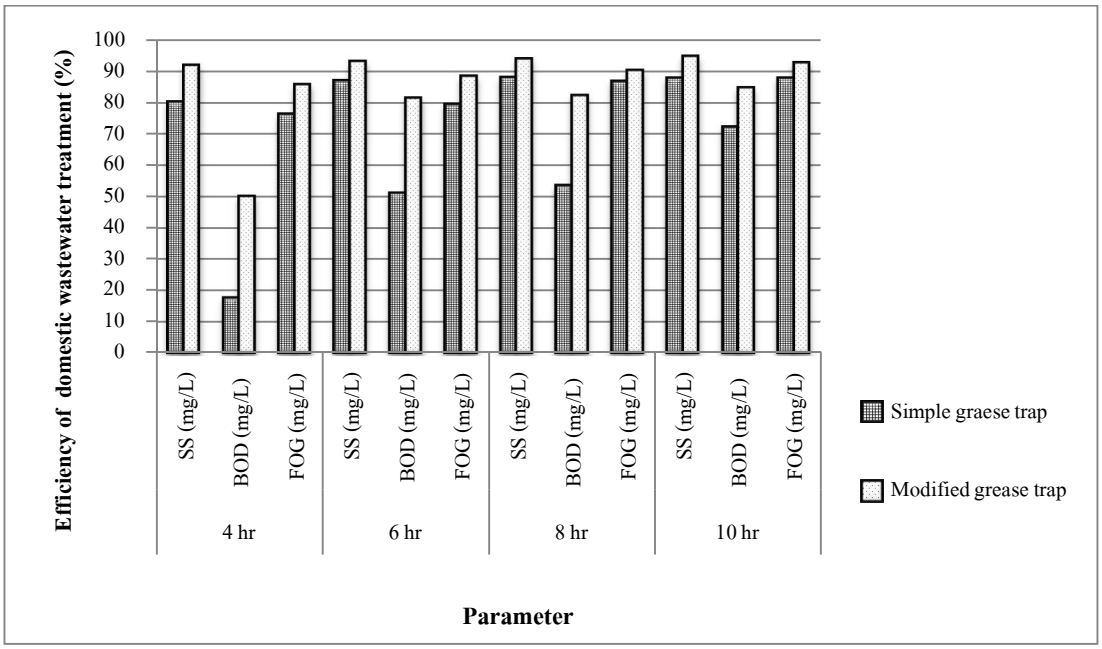

Fig. 3. Efficiency of simple and modified grease traps for domestic wastewater treatment (flow rate of 2 L/min, HRT varied between 4-10 hrs).

Comparing to the central wastewater effluent standard, the effluent did not meet the requirement. The effluents from both grease traps were still exceeded the central wastewater treatment effluent standards. However, when comparing to the standard from the Ministerial Decree No. 51 (B.E. 2541) issued under the Building Control Act, B.E. 2522, it was found that effluent from the modified grease trap had the SS value complied with the effluent standard of the class C buildings and had BOD value complied with the effluent standard of the class E buildings. For the effluent from the simple grease trap, it was found that the BOD value complied with the effluent standard of the class E buildings whereas the SS value exceeded the standard. The FOG values of effluent from both grease traps were complied with the effluent building standards. Many types of grease traps were used in household or restaurants. The various designs of grease trap were found to maximize the operation. The treatment efficiency of grease trap is shown in Table 2 which indicated that the grease trap without enzyme required 30 minutes - 24 hrs of HRT to give the 7-92.7% of FOG removal. If the grease trap was modified by adding the tube setter, aeration or making chamber, it would enhance the treatment efficiency around 70 - 80%. Furthermore, a clogging problem of media inside the modified grease trap may be occurred during operation due to the organic and FOG

overloading and surface biofilm formation of media [17]. Thus, the modified grease trap has to be often removed grease out at least once a week and cleaned up every six months. Moreover, the media inside a modified grease trap should be changed to the new one every month during operation and maintenance [18]. In case of grease trap with enzyme acquired longer HRT. Based on a research study, it was found that adding enzyme in the grease having 30-1,500 gallons of volume, it required one week for retention time and resulted 63% of FOG removal [19]. Moreover, adding enzyme in the compacted grease trap acquired 5 days and result was about 64.73 % of FOG removal [20]. Application of microorganism for wastewater treatment was termed as biological treatment. The microorganism would convert organic compounds to CO_2 and NH_3 gases that were the best method to degrade the organic matters in water sources. However, the biological treatment needs the suitable environment, which is linked amount of bacteria cell and time [21]. There are many species of microorganisms that those microbes could degrade organic pollutants consecutively till treated wastewater and could be reused in some purposes such as reuse in agriculture. Biological wastewater treatment required the suitable amount of microbe cells for the most efficiency for the treatment [6]. While given that the grease trap was a primary domestic treatment, the effluent was still contaminated with high organic loading [15]. Hence, the simple or modified grease trap should be applied for a primary treatment of kitchen wastewater at point source and needs to be joint other treatment processes for domestic wastewater treatment from household such as stabilization pond, activated sludge or oxidation ditch [22].

From the comparison study of the wastewater treatment between the simple and the modified grease traps, the results of modified grease trap were treatment efficiencies of SS and FOG at 90% and the treatment efficiency of BOD at 80%. They were better than that of the simple grease trap at a flow rate of wastewater of 2 L/min and a retention time of 10 hrs. Moreover, treatment efficiencies of SS and FOG were slightly higher than treatment efficiency of BOD. Regarding these results, they showed that treatment efficiencies of BOD and FOG from the grease traps were irrelative. One reason may be due to the characteristic of FOG is the one of organic matters composed of saturated and unsaturated fatty acids which are not soluble in water and are not easily biodegradable as well as are removed from wastewater by the floatation technique and proper HRT of grease trap [23]. Meanwhile, the characteristic of BOD is a measure of how much oxygen is required to biologically decompose organic matter by microorganism in the wastewater [4]. Thus, an organic matter in term of BOD in wastewater was not completely biodegraded by bacteria or microorganism in the grease trap and then BOD was still remained in an operation of this study [23]. It may be implied that

profile of BOD removal in wastewater was slowly biodegradable in both grease traps because this process required the suitable factors of aerobes, dissolved oxygen demand (DO) and HRT for operation [27]. They were consistent with previous researches [10, 27]. Treatment efficiencies of BOD and FOG were consistent with other researches in Table 2.

Table 2 Treatment efficiency of grease trap.

Type of grease trap	HRT	Treatment efficiency (%)		
		SS (mg/L)	FOG (mg/L)	BOD (mg/L)
Modified grease trap (1:1:2) (2 L/min) (5 cm diameter of Mon brick: 1 cm diameter of gravel: 3 cm diameter of Mon brick) (This study)	10 hrs	94.8	92.8	84.8
Grease trap made from 2 plastic tanks (18 L/tank) [24]	6 hrs	N/A	77.6	N/A
Grease trap tank (using in restaurant) [25]	1 - 3 hrs	N/A	7 – 65	12 – 46
Grease trap (using the tube setter and aeration) [10]	> 30 min	N/A	70 - 80	N/A
Grease trap tank [26]	8.5 hrs	N/A	16 – 69	N/A
Grease trap made from 2 water tank (15 L/tank) [27]	> 24 hrs	11.26	74.41	11.61
Grease trap tank [27]	> 24 hrs	34.56	74.21	12.81
Cement-ring grease trap (600 L) [28]	9 – 12 hrs	64.13	57.53	31.24
Grease trap added with enzyme [20]	5 days	N/A	64.73	N/A
Grease trap added with enzymes [19] (capacity of 30 – 1,500 gallons)	1 week	N/A	63	N/A

N/A = Not Available

The study results were consistent with the report from U.S. EPA (2012) [16] which reported that the primary wastewater treatment unit was able to remove the 26 – 65% of BOD, 40 – 80% of SS, and 70 – 80% of FOG. Results were also consistent with previous study of the upgrading the conventional grease trap using tube setter that was the development of the grease trap installed for restaurants and factories in Hong Kong to reduce the FOG before discharging into public sewers. Installation of the tube settler was into

the grease trap to improve the efficiency of wastewater treatment that resulted in the FOG removal of 80%. It also found that the efficiency of wastewater treatment increased as the hydraulic retention time increased [10].

4. Conclusion

This study demonstrated that flow rate of 2 L/min and HRT of 10 hrs (influent) was found to be the optimal condition for domestic wastewater treatment by using simple and modified grease traps. However, the modified grease trap was higher efficiency of SS, BOD, and FOG removal than the simple grease trap. Moreover, the modified grease trap that added arrangement media of 5 cm diameters Mon brick, 1 cm diameter gravel and 3 cm diameter Mon brick, respectively with the media ratio at 1:1:2 was the highest efficiency of SS, BOD, and FOG removal approximately 80%.

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6. Reference

[1] WaterWorld, “Fat oil and grease in pipelines and sewers cost billions in repairs”, Available: http://www.waterworld.com/, 12 March 2011.

[2] Resource Venture, “Fat oil and grease”, Available: http://www.resourceventure.org/, 12 March 2011.

[3] Pollution Control Department (PCD). “Domestic wastewater and treatment plant”, Kurusapa Ladprao Printing Press, Bangkok, Thailand. 2002.

[4] APHA/AWWA/WPCP. “Standard method for the examination of water and wastewater (21st ed.)”, Washington, D.C., USA. 2005.

[5] Department of Environmental Protection, “Percent removal”, Available: http://kyocp.wordpress.com/, 9 March 2011.

[6] Pollution Control Department, “Thai Environment Regulation”, Available: http://www.pcd.go.th/, 9 March 2011.

[7] Office of the council of state, “Effluent standard of Ministerial Decree No. 51 (B.E. 2541) issued under the Building Control Act, B.E. 2522”, Available: http://www.krisdika.go.th, 30 March 2013.

[8] V. Raman and A. Khan, “Unconventional low cost simplified sewage treatment by rotating biological contactor and anaerobic (upflow) filter system”, Available: http://wedc.lboro.ac.uk/, 10 August 2012.

[9] U. Charuratana, J. Woranisarakul and S. Sakchai, "Water supply and sanitary engineering", Bangkok: Ruen Kaew Press; 1999.

[10] W. Chu and F. Ng, "Upgrading the conventional grease trap a tube settler", Environment International Journal 26, 2000, pp. 17-22.

[11] N. Wong, P. Law P and S. Lai, "Field tests on grease trap effluent fitter", Available: http://www.bioline.org.br/, 25 October 2012.

[12] K. Somsai, "The study efficiency of wastewater treatment by using an aerobic submerged plastic bed reactor", Master Thesis, Environmental Technology Program, Mahidol University, Thailand. 1995.

[13] K. Samingwan, J. Khaowong, T. Lowrattana-chaiyong and P. Tura, "Characterization of dish-washing waste water and design criteria grease for trap", Bachelor degree, Environmental Engineering Program, King Mongkut's University of technology Thonburi, Thailand. 2000.

[14] A. Sonune and R. Ghate, "Developments in wastewater treatment methods", Desalination 167, 2004, pp. 55-63.

[15] U. Charuratana and J. Woranisarakul, "Guideline in design a grease trap", Report of conference King Mongkut's Institute of Technology Thonburi, Bangkok, Thailand, 1996, pp. 68 -77.

[16] United States Environmental Protection Agency (U.S.EPA), "Design Manual: Onsite wastewater treatment and disposal system" Available: http://cfpub.epa.gov/si/si_public_record_Report 20 January 2012.

[17] Pollution Control Department, "Manual for designers and manufacturers of the on-site wastewater treatment system", Bangkok: Religion Printing Press; 2001.

[18] Pollution Control Department, "Handbook of wastewater management for household", Available: http://wqm.pcd.go.th/, 19 January 2014.

[19] E. Gray and J. Sneddon, "Determination of the effects of enzymes in a grease trap", Microchemical Journal 61, 1999, pp. 53-57.

[20] S. Sadsopa, "Study on influencing factors oil and grease removal in grease trap", Bachelor degree, Environmental Health Program, Walailuk University, Thailand. 2009.

[21] Wastewater treatment, "Biological process", Available: http://www.il.mahidol.ac.th/emedia/ecology/chapter3/chapter3_water13.html, 25 October 2012.

[22] M. Hammer, "Water and wastewater technology (4th ed), Prentice Hall, Inc, New Jersey, USA. 2004.

[23] Pollution Control Department, "Domestic Wastewater and treatment plant", Bangkok: Kurusapa Ladprao Printing Press; 2002.

[24] B. Kaigate, S. Ungsoongnern, J. Kaewdam and P. Bunprom, "The efficiency of Grease trap made from recycled material as a wastewater treatment for homes and public vendors at soi soda community, Dusit District, Bangkok", Journal of environment management 1, 2001, pp. 30-42.

[25] P. Luangrungkiat, “KAP of food Establishment Owners and Factors Affect Grease Trap Efficiency in Bangkok”, Available: http://advisor.anamai.moph.go.th/, 10 January 2007.

[26] W. Chu and W. Hsu, “Pollution source identification and waste loading reduction at Chinese fast food resteraurants”, Environmental International Journal 25, 1999, pp. 97-107.

[27] P. Taweekun, “A comparative study of the grease traps tanks and modifies grease traps”, Bachelor degree, Science Program in Environmental Science, Chiangmai Rajabhat University, Thailand. 1998.

[28] K. Kuhirunyaratn, “The study of Onsite Anaerobic Filter system in wastewater treatment for restaurants”, Master Thesis, Department of civil engineering, Kasetsart University, Bangkok, Thailand. 1992.