Progress in Engineering Application and Technology Vol. 2 No. 1 (2021) 102–111

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN 2773-5303

Efficiency of Dual Functional Fat, Oil and Grease (FOG) Trap in Treating Kitchen Wastewater

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DOI: https://doi.org/10.30880/peat.2021.02.01.010
Received 13 January 2021; Accepted 01 March 2021; Available online 25 June 2021

Abstract: Direct drainage into the sewerage system of untreated kitchen wastewater created from the commercial restaurant leads to many adverse ecosystem effects due to disposal into the environment. FOG enters the sewer system from restaurants, residences, and food facilities in the industry. Its release into the sewer system results in a continuous build-up causing eventual sewer pipes blockage. These FOG blockages contribute to sanitary sewer overflows, flooding of property and water bodies polluted with sewage. As a type of renewable natural plant, kapok and coconut shell are abundant, biocompatible, and its full exploration and potential application have received increasing attention in both academic and industrial fields. Based on the structure and properties of kapok and coconut shell, this study shows they are compatible and good absorbent as additional filtration for raw kitchen wastewater pre-treatment process. This study was focused on the performance of the dual functional FOG trap in optimize the FOG contaminant removal process. Parameters measured to evaluate the efficiency of the process were concentration of FOG, pH, COD, BOD, turbidity and suspended solids. The findings show that the efficiency of FOG removal is higher than 50.00 %. The overall qualities of the wastewater improve significantly. In the treatment cycle, the FOG contaminants from the kitchen wastewater are absorbed by the dual functional FOG trap.

Keywords: FOG Trap, FOG Pollutants, Kitchen Wastewater, Sewage System

1. Introduction

Fat, oil and grease (FOG) is a growing concern for the environment. FOG is mainly produced in food service establishments (FSE) or other food preparation facilities. The by-products and waste from these FSE include deep-fried food, meat, cheeses, butter baked goods, sauces, dressings and gravy. When all these FOG released into collection systems, adhere to pipe walls, decreasing their capacity and may contribute to the build-up of FOG in the sewer system when it is discharged directly into the plumbing system of the facility [1]. In certain circumstances, these pipe occlusions tend to flood the sanitary overflows sewers (SSO) and thus discharging the untreated waste into the

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environment. SSO pose a risk to public health and the environment when they discharge untreated waste made up of high nutrient and pathogen loading [2].

FOG will reduce the sewer diameter and can entirely block pipes [3] causing floods or sewer overflows, particularly in combined systems. FOG is known to contribute to more than 50.00 % of these problems [4]. A subsequent release of wastewater accelerates water pollution and exposure to pathogens. FOG also attracts vermin such as rodents and sloughed deposits may affect the pumping stations operation and the waste treatment [5]. One undesirable health risk is illegally recycled "gutter oil" in China, where 10.00 % of food is believed to be cooked with FOG from sewers [6].

1.1 Objectives

Two objectives are going to be achieved as follows:

- To develop a FOG trap that acts as a dual functional in pre-treating the raw kitchen wastewater.
- To investigate the efficiency of kapok and coconut shell as filters in removing the FOG from raw kitchen wastewater.

2. Materials and Methods

2.1 Flow chart of the study

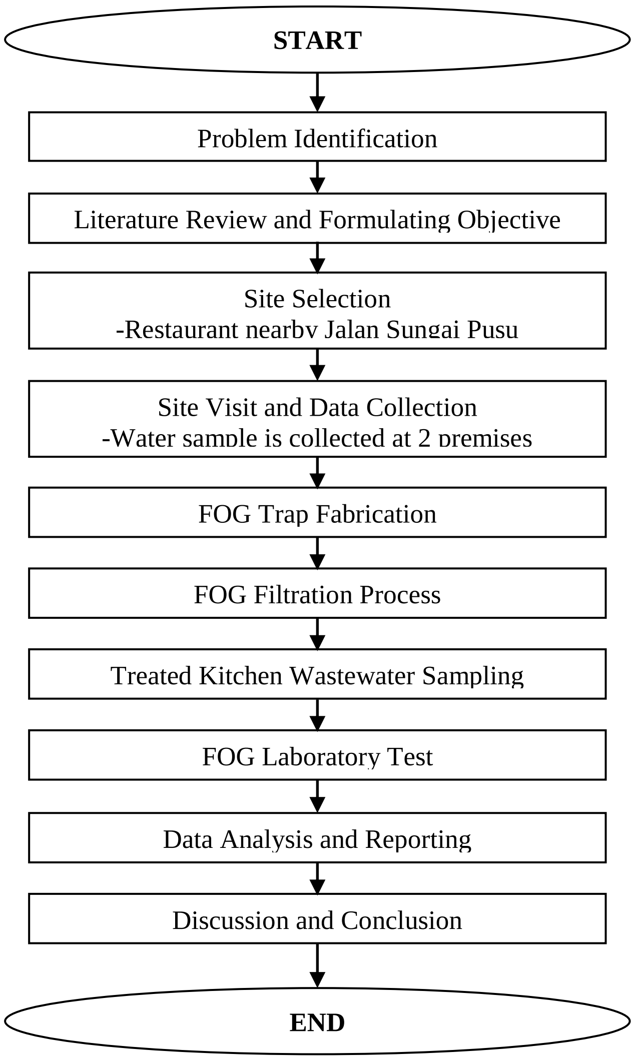

Figure 1: Study flow chart

2.2 FOG Model

The designed FOG trap made of a plastic tank with 25 L capacity while coconut shell and kapok being installed at the bottom of the tank as illustrated in Figure 2. The FOG trap installed at a level floor to ensure that the FOG trap works effectively.

Table 1: Volume capacity detail of the dual functional FOG trap

Notation	Compartment	Volume (L)
A	Screening	2.5
B	Primary Sedimentation	11.7
C	Secondary Sedimentation	5.1
D	FOG Separation Chamber	3.7
E	FOG Trap Capacity	1.5

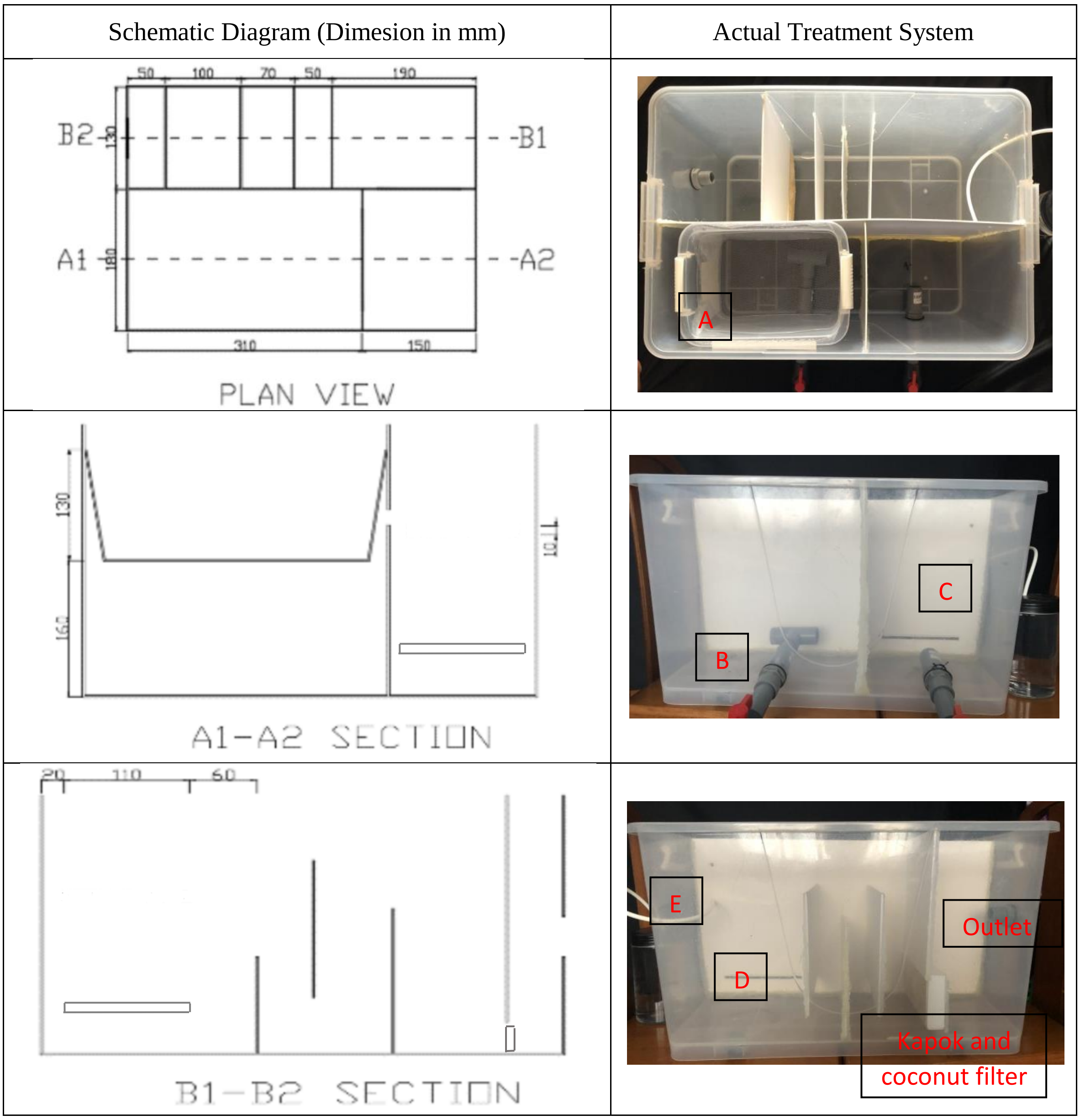

Figure 2: Schematic dual functional FOG trap detail drawing

2.2 Kitchen wastewater samples

Composite samples of kitchen wastewater were collected and tested. The samples are collected in between the evening 5.00 PM to 7.00 PM from the waste pipe in proportion to the kitchen wastewater flow as per wastewater sampling procedure by EPA (Environmental Protection Agency) at 2 different restaurant premises nearby the Jalan Sungai Pusu, Gombak which are Suntie Rose restaurant (Premise 1) and Tod's Western Street restaurant (Premise 2) nearby Kolej Vokasional Gombak.

2.3 Testing

2.3.1 FOG Concentration Test

The total FOG concentrations were measured by partition gravimetric method (No. 5520 B) adopted from The Standard Methods (APHA 1998). 1 litre of sample required to be acidified to a pH of 2. The sample is then extracted 3 times with hexane and those extracts are combined and dried. The collected extracts are distilled at 85 °C and weighed in order to determine the value. The extracts may also be filtered through silica gel to provide a total petroleum hydrocarbon (TPH) value as well at Geotechnical Engineering Technology Laboratory located at Faculty of Engineering Technology. The FOG trap removal efficiency of FOG was calculated by Equation 1 [7].

$$\text{Efficiency (\%)} = (A-B)/A \times 100\% \quad \textit{Eq. 1}$$

where A = untreated wastewater value and B = treated wastewater value.

2.3.2 pH Test

pH was determined using a portable Thermo-Orion probe like the Model 250 series in the Environment Engineering Technology Laboratory located at Faculty of Engineering Technology. pH meter should be calibrated before use then sensor of the probe dipped into the sample filled in a beaker. The tests will replicate three times per sample.

2.3.3 Chemical Oxygen Demand (COD), Suspended Solids (SS) Test

The COD and SS were analyzed [8] using respective Hach vials and DR6000 spectrophotometer in the Environment Engineering Technology Laboratory located at the Faculty of Engineering Technology. DR6000 offers high-speed wavelength scanning across the UV and Visible Spectrum and comes with over 250 pre-programmed methods. The sensor of the spectrometer being dipped into sample filled in a beaker. The tests will replicate three times per sample.

2.3.4 Turbidity

Turbidity was analyzed using TL2300 Turbidimeter in the Environment Engineering Technology Laboratory located at the Faculty of Engineering Technology. The TL2300 laboratory turbidimeter measures the scattered light from water samples to determine the turbidity value of the samples [9]. The sample is filled into the provided tube and tested. The tests will replicate three times per sample.

2.3.5 Biological Oxygen Demand (BOD) Test

BOD_5 solids were evaluated using standard methods like APHA 1998 [8] by using BOD incubator with respective Hach vials and DR6000 spectrophotometer in the Environment Engineering Technology Laboratory located at Faculty of Engineering Technology. BOD Incubator is used to maintain temperature for test tissue culture growth, storage of bacterial cultures and incubation where a high degree of constant temperature accuracy is required as needed to be followed in the electrode method. Preparation of BOD dilution water is 2.00 % of glucose-glutamic acid solution done before the BOD determination. The reading was taken before incubation and after 5 days in the incubator as the result being calculated by Equation 2. The tests will replicate three times per sample.

$$BOD_5 = (DO_0 - DO_5) \quad \textit{Eq. 2}$$

where DO_0 = dissolved oxygen value before incubation and DO_5 = dissolved oxygen value after 5 days in the incubator.

3. Results and Discussion

The expectation was to develop a FOG trap that acts as a dual functional in treating the raw kitchen wastewater. By achieving this aim, kitchen wastewater being released to drain will have higher quality hence lessening the pollution to the water body and pipe blocking. An analysis is done according to the parameter used in order to study the quality of kitchen wastewater while investigating the efficiency of kapok and coconut shell as a filter in removing the FOG from raw kitchen wastewater. The conditions for best adsorption process operation performed based on the results obtained from the testing done which revealed the possible way to optimize the FOG contaminant removal process. Moreover, the efficiency of kapok and coconut shell as a pre-treatment is evaluated to improve the wastewater quality. Thus the main purpose of this chapter is to achieve the research objectives of this study.

3.1 Raw kitchen wastewater sample from 2 different premises

Table 2: Parameters of raw kitchen wastewater samples

Parameter	Raw kitchen wastewater		Effluent Standard by the Environmental Quality Act 1974
	Premise 1	Premise 2	
pH	7.50	6.90	5.5-9.0
FOG (mg/L)	168.0	262.1	<10
BOD_5 (mg/L)	220.6	857.8	<50
COD (mg/L)	470.3	1840.4	<50
Turbidity (NTU)	11.3	19.5	<5
SS (mg/L)	210.5	375.1	<100

3.2 Percentage removal efficiency after pre-treatment of kitchen wastewater sample

Table 3: Percentage removal efficiency after pre-treatment of kitchen wastewater sample from premise 1

Parameters	Initial Reading	Effluent				Removal Efficiency (%)
		First Reading	Second Reading	Third Reading	Average Reading	
pH	7.30	7.15	7.08	7.13	7.12	-
FOG (mg/L)	168.0	56.3	55.7	56.0	56.0	66.67
BOD_5 (mg/L)	220.6	106.5	105.8	102.7	105.0	52.40
COD (mg/L)	470.3	162.6	159.1	157.1	159.6	66.06
Turbidity (NTU)	11.3	4.8	4.6	4.7	4.7	58.41
SS (mg/L)	210.5	43.7	42.5	43.5	43.2	79.47

Table 4: Percentage removal efficiency after pre-treatment of kitchen wastewater sample from premise 2

Parameters	Initial Reading	Effluent				Removal Efficiency (%)
		First Reading	Second Reading	Third Reading	Average Reading	
pH	6.90	7.10	7.06	7.01	7.06	-
FOG (mg/L)	262.1	109.4	109.4	108.8	109.2	58.35
BOD_5 (mg/L)	857.8	383.3	382.6	381.9	382.6	55.40
COD (mg/L)	1840.4	586.9	586.5	586.1	586.5	68.13
Turbidity (NTU)	19.5	8.4	8.3	8.3	8.3	57.44
SS (mg/L)	375.1	114.8	114.7	114.3	114.6	69.44

3.3 Result analysis

3.3.1 FOG Concentration Test

The data obtained from testing were analyzed to conclude the removal efficiency of the dual functional FOG trap in treating the raw kitchen wastewater. As mentioned in FOG trap Installation Guidelines [10] capable of reducing the quality to the maximum that is 50 mg/L before being channelled to the downstream. This follows with the limit set in Malaysian Sewerage Industry Guidelines (MSIG) by Suruhanjaya Perkhidmatan Air Negara (SPAN). Removal efficiency is 66.67 % for the sample from premise 1 while 58.35 % for the sample from premise 2 as shown in Table 3 and Table 4. It is resulting in 56.00 mg/L, effluent from premise 1 and 109.20 mg/L, effluent from premise 2 as shown in Figure 3. The FOG contaminant is partially being absorbed by the dual functional FOG trap in the pre-treatment cycle due to the kapok's hydrophobic-oleophilic characteristics as an oil sorbent as mentioned in [11], [12] study. However, [13], [14] kapok has higher removal efficiency that was 100.00 % and more than 99.40 %, respectively, which showed excellent performance of kapok in the removal of oils from oily.

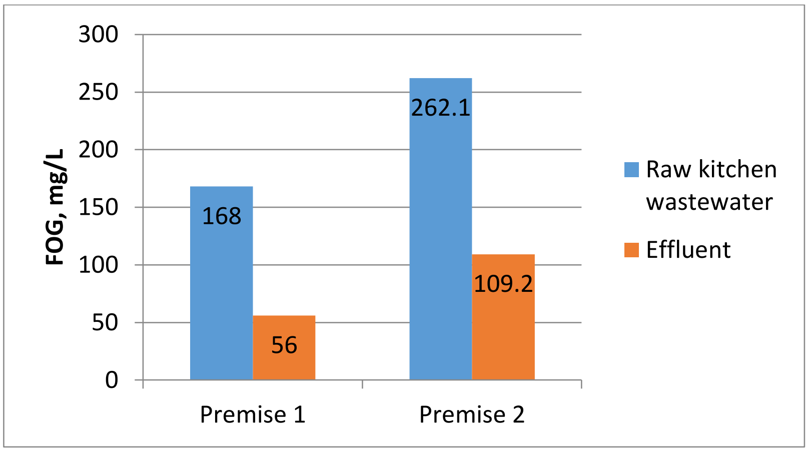

Figure 3: The initial reading and effluent reading of FOG in samples from premise 1 and 2

3.3.2 BOD_5 Test

The application of coconut shell and kapok provides sufficient microorganisms for the degradation of organic contaminants in kitchen wastewater. The concentration of BOD for raw kitchen wastewater from premise 1 was 220.6 mg/L filtered through the dual functional FOG trap and the BOD decreased to 105.00 mg/L. The removal efficiency of the sample from premise 1 is 52.40 %.

Premise 2 raw kitchen wastewater samples were 857.80 mg/L, resulting in 382.6 mg/L after the pre-treatment, resulting in a decrease of 58.35 %. as shown in Table 2, 3 and Figure 4. However, better performance was achieved in [15] study on wastewater treatment using filter material from bark, activated charcoal, foam and sand.

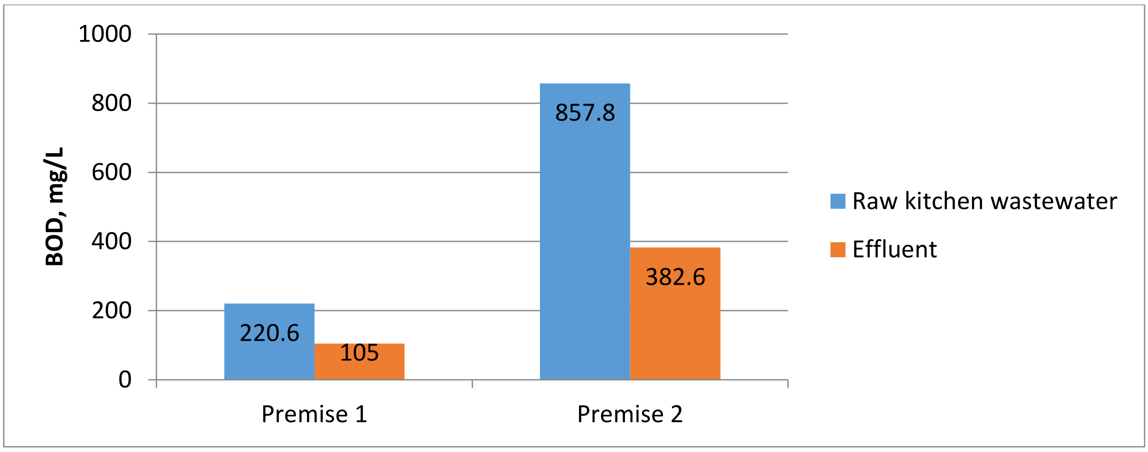

Figure 4: The initial reading and effluent reading of BOD in samples from premise 1 and 2

3.3.3 COD Test

COD removal efficiency in for raw and treated kitchen wastewater is shown in Table 2, 3 and 4. The sample from premise 1 has higher removal efficiency than the sample from premise 2 is may due to the pH value of samples from premise 1 is closer to 7 (neutral) than samples from premise 2. However, according to studies from Jordan [16], shows that the treated raw wastewater sample was removed 72.00 % of COD. The concentration of COD in raw kitchen wastewater for the sample from premise 1 is 470.30 mg/L whereas 1840.40 mg/L results in the sample from premise 2. According to [16] the COD was generally higher than BOD measure of a given sample by the number of refractory organics in the sample. After filtered with kapok and coconut shell in the dual functional FOG trap, COD concentration decreased significantly to 159.60 mg/L for the sample from premise 1 is whereas 586.50 mg/L result in the sample from premise 2.

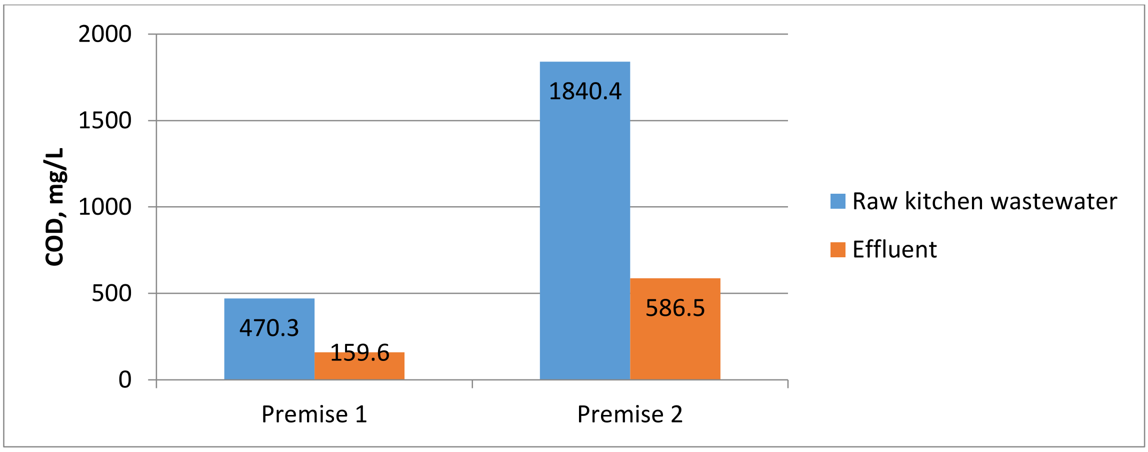

Figure 5: The initial reading and effluent reading of COD in samples from premise 1 and 2

3.3.4 Turbidity Test

The turbidity of raw kitchen wastewater from premise 1 was 11.3 NTU and 19.5 NTU for the sample from premise 2. The removal efficiency in turbidity is 58.41 % for the sample from premise 1 while 58.35 % for the sample from premise 2. Thus, the turbidity of the sample from premise 1 is resulting in 4.7 NTU and 8.3 NTU for effluent from premise 2. However, the better performance [7] study on wastewater treatment using peat as filter material. The turbidity removal is ranging from 35.00 % to 84.00 % of the results in treating raw kitchen wastewater. Its shows that the percentage efficiency removal both premises is higher than 35.00 % and can be considered as a good performance of pollutant removal process.

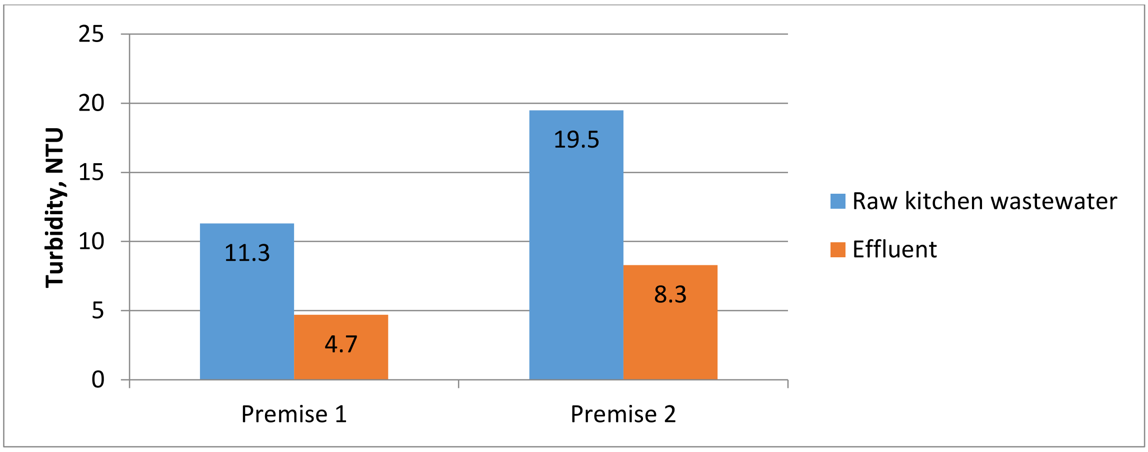

Figure 6: The initial reading and effluent reading of turbidity in samples from premise 1 and 2

3.3.4 Suspended Solid Test

The concentration of suspended solid of raw kitchen wastewater from premise 1 is 375.10 mg/L while 210.00 mg/L from premise 2. This shows both samples have a lot of solid pollutant drifting and floating in the water. The effluent suspended solid reading for the sample from premise 1 is 43.20 mg/L and 114.60 mg/L for the sample from premise 2. The result passed a little bit off the effluent limit in the [17] based on standard B. Suspended solid removal efficiency in the sample from premise 1 is 79.47 % while 69.44 % for the sample from premise 2. The removal efficiency of suspended solids is the highest among other parameters. The hollow structure of kapok filter contributed as it has a small internal diameter of 14.5 ± 2.4 µm hence contributed to lowering the suspended particle efficiently through the dual functional FOG trap pre-treatment cycle.

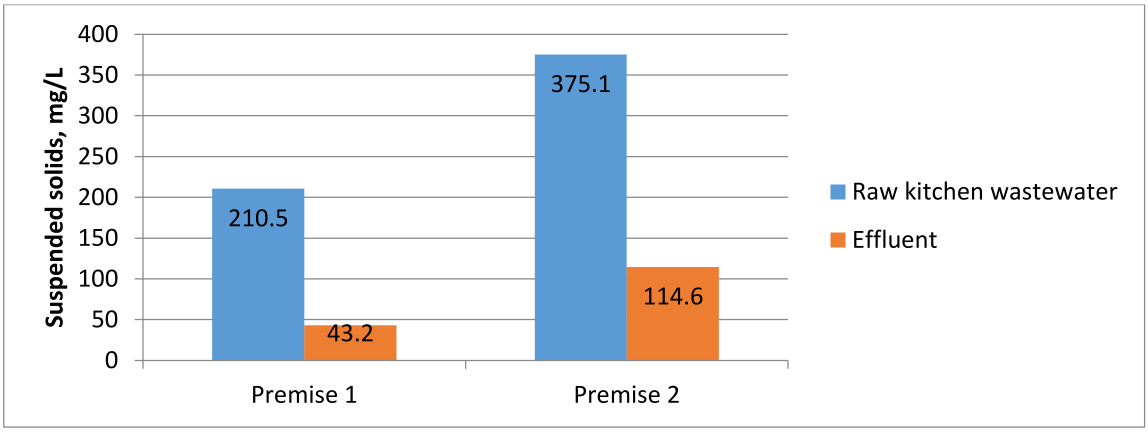

Figure 7: Removal efficiency of SS in samples from premise 1 and 2

4. Conclusion

In conclusion, the FOG concentration, BOD_5, COD, turbidity and SS were improved after going through pre-treatment in the dual functional FOG trap. In relation to objective 1, The removal efficiency of these parameters are ranging from 58.55 % - 66.67 % for FOG concentration, 52.40 %-55.40 % for BOD_5, 66.06 % -68.13 % for COD, 57.44 - 58.41 % for turbidity and 69.44 - 79.47 % for suspended solids. The raw kitchen wastewater has been pre-treated and the quality of it has improved more than 50.00 %. It proves that the FOG trap is acting as a dual functional in pre-treating the raw kitchen. As for the last objective, the kapok and coconut shell contributing to FOG samples due to their high efficiency in filtration characteristics as mentioned in literature. This is because of the result of the shows high in removal efficiency of FOG concentration that is 66.67 % sample from premise 1 while 58.35 % sample from premise 2 which make the effluent 56.00 mg/L and 109.20 mg/L. This did not meet the O&G standard discharge referred to in Environmental Quality Regulation 2009 that is limited to 1.00 mg/L for Standard A and 10.00 mg/L for Standard B [17]. However, results data has proved the efficiency of kapok and coconut shell as pre-treatment as the wastewater quality improved significantly. Recommendation for future research is to handle samples within the sample holding time to prevent error in result data and samples must be collected more if it is possible to increase accuracy. This recommendation can be used to achieve greater reliability in terms of future research.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for the support of this research.

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