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The Combination of a Previous Kitchen Waste Grease Trap for Fat, Oil, and Grease for Pre-Treatment

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Abstract: Fat, oil, and grease (FOG) contamination of wastewater is a significant problem for municipalities and operators of solid waste facilities. Restaurants and households are the higher contributions to the FOG entering the sewage system. Its discharge into the sewage system leads to a constant build-up that eventually causes sewer pipes to get clogged. Numerous scholars have examined FOG deposition concerning sewage conditions and local lifestyles. In addition, innovative technologies have been launched to the market that removes FOG from wastewater before its discharge into drainage and sewage systems. Grease interceptors, for example, are installed under certain restaurant kitchen sinks to collect grease from kitchen effluent. This technology is expensive, requires a lot of upkeep and space, and is often disregarded, resulting in odour discomfort. This research aims to modify a grease trap as the primary treatment method for untreated kitchen wastewater based on the gravity separation principle and to investigate the efficiency of grease trap physical treatment in a water treatment system used to filter oil and grease in the sink channel. Furthermore, when the outflow from the kitchen sink enters the grease trap, solid food particles sink into the grease trap while grease and oil float to the surface. The grease-free water goes into the septic system. Food particles in the waste food trap and floating oil and grease must be frequently removed. The optimization of the separation process was determined using a grease trap based on the flow rate of kitchen wastewater. The results revealed that the optimization removal of FOG was 99.54% with a 2.41 L/min of flow rate. Hence, this study shows the effectiveness of using grease traps could treat raw kitchen wastewater based on the gravity separation principle.

Keywords: FOG, kitchen wastewater, sewage system, grease trap

1. Introduction

Fat, oil, and grease (FOG), commonly known as a lipid, is a by-product of cooking. FOG is found in high concentrations in several Asian nations where large amounts of food are consumed [1]. The average Malaysian eats at least 78.3g of fat per day, which places the country in the top 10 nations in the world in average daily fat consumption [2]. Thus, it is projected that a large amount of FOG - containing kitchen trash will be generated. According to [3], it can be concluded that people in many developed countries, including Malaysia, tend to adopt western diets, which has produced an increase in the consumption of FOG due to urbanization and greater prosperity. This is one of the reasons why FOG consumption has grown. Thus, the resultant production of kitchen waste consisting of FOG is expected.

The high concentrations of FOG diminish the efficacy of the treatment process in the wastewater treatment system [4]. According to [5], before being discharged into the sewage system, kitchen waste should be exposed to a pretreatment procedure to minimize FOG. One of the successful pretreatment technologies for separating and removing

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FOG from kitchen wastewater is the trap. Nowadays, various FOG traps are available in the Malaysian market, including BioMicrobics' FOGHog, as described in prior research [5]. However, the present FOGs have several problems, including expensive installation, operating, and maintenance costs. Consequently, most of restaurants does not implemented this method to eliminate FOGs from wastewater prior to its ultimate discharge into the environment. Despite this, restaurants rely only on a screening procedure to separate big debris such as bone, food waste, and utensils and then release the liquid waste into the surrounding environment, resulting in a nasty smell in the restaurant's area.

Various pollutants are growing in our environment. The presence of oil and grease in water systems is one of the contaminants that might contribute to environmental issues. A high concentration of oil and grease inside the sewage system might clog as a by-product of the deposited oil and grease. The clogging may result in sewage overflow, which can cause water pollution such as pathogen exposure [6]. Numerous variables, including food processing enterprises, restaurants, farms and slaughterhouses, might contribute to the amount of oil and grease in wastewater. The rising use of oil in development and high-demand oil-processed goods (fast food enterprises, stalls) also contributes to the discharge of industrial or home oil into water drains. Oil may contaminate water in two distinct forms: emulsified oil and free oil [7]. Once oil wastewater is introduced into aquatic environments in high concentration and becomes toxic to the aquatic life and damages other ecology in water bodies.

Various studies reveal that to address this environmental concern, many innovative removal technologies have been developed for treatment recently that can reduce FOG from effluent before it can be released into sewerage and drainage systems. Grease interceptors for example, are installed under certain restaurant kitchen sinks to collect grease from kitchen effluent. However, this equipment is expensive, requires substantial maintenance, requires a great deal of space for installation, and is commonly overlooked, leading to irritation of odors [8].

The current work aimed to modify a grease trap for restaurant and domestic residential applications and test the efficiency of the grease trap. Therefore, the establishment of a grease trap creates opportunities for the potential manufacturer to expand their market in Malaysia and the international market due to the simplicity and effectiveness of FOG pre-treatment process.

2. Materials and Methods

The grease trap was made of a clear storage box with 38 L of capacity, as detailed in fig. 1 while the schematic FOG trap design detail drawing is presented in fig. 2. The transparent FOG allowed the user to monitor the operation of the kitchen wastewater and remove the sludge accumulated at the bottom of the FOG trap and the coarse filter screen. The FOG trap was installed at a level surface to ensure the FOG trap operates efficiently.

PVC and plastic storage boxes, both are low cost and easily accessible on the market, were used in the construction of the prototype. The mobility of this early version of a grease trap is the prototype's most notable strength. This simple design is easy to relocate to various locations and no lifting needed. The vast majority of passive grease traps which need to be moved to a different location will increase the maintenance and cleaning time/cost. The user will not benefit from it from an ergonomic point of view. After all the liquid in the container has been absorbed, the food left over may be removed.

Fig. 1 - prototype grease trap

2.1 Design Calculation

Calculations were carried out to determine the required size of the grease trap and reference from previous studies are needed to develop ideas for modifying the design. According to the calculation findings, the size of the grease trap should be reduced in terms of width and length. The reduction ratio for width is 1: 0.5, while the reduction ratio for length is 1: 0.8. The purpose of the size reduction is to ensure the grease trap is not too large for a standard sink. The depth ratio is 1: 2.3, this needs to be improved to understand the gravity of the isolation that will occur when the grease trap is located and installed based on water flow rate differences. This is done to understand the gravity of the separation that will occur when the grease trap is installed.

In addition, wastewater ran horizontally through the baffles in the grease pit to enable the oil and grease to float. The adsorption portion of the treatment process was continued for the wastewater until it had reached the grease trap drain, which was separated into two columns filled with various adsorbents. The variables in this investigation were the types and heights of the adsorbent media. The average heights of the adsorbents were 8 and 15 cm, as illustrated in fig. 2.

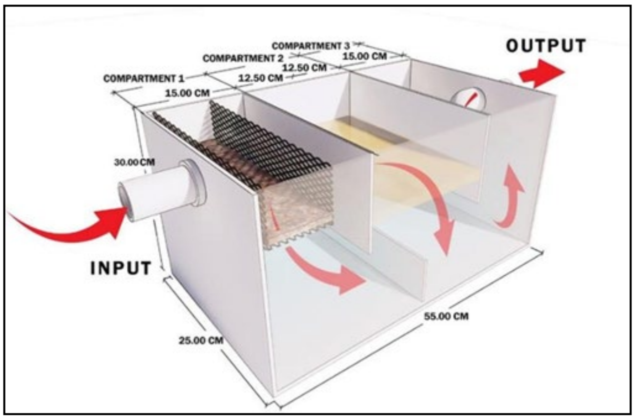

Fig. 2 - Schematic dimension diagram in cm

2.2 Grease and Oil Sampling

To investigate the effects of application grease traps on wastewater, oil and grease was extracted from waste oil that homeowners have filtered at Kampung Tualang Manir. In order to carry out the filtering procedure with FOG traps, 25L of wastewater sample were collected. A 1.25L plastic container was used to separate the oil residue and measure it accurately so that it could be used as an oil and grease sample.

2.3 Oil and Water Separation Measure

The result was measured after a 9.5L bottle was filled with oil wastewater flowing through a grease trap. When the oil wastewater bottle is full, the measurement process will be taken after one day. This purpose is to give oil and water that can be separated according to density so that it is easy to measure the amount of waste oil that can be separated using grease traps. The oil-water separation efficiency of the filters was examined by gravity filtration and suction pressure in combination with syringes (Fig. 3) [9]. The effectiveness of the filters in the separation of oil and water was evaluated using gravity filtration and suction pressure in conjunction with syringes.

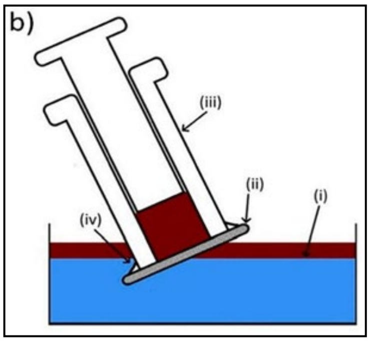

Fig. 3 - Illustration showing schematics for oil-water separation using a syringe device. The use of a syringe allows the collection of oils less dense than water. (i) oil-water mixture, (ii) porous superhydrophobic filter, (iii) syringe and (iv) PDMS adhesive [9]

2.3 FOG Filtration Process

An enclosed grease trap was where the operation for filtering out the FOG was carried out. The influents have been allowed to flow into the FOG trap chamber and preliminary screening has been performed to remove any medium-sized kitchen waste, such as waste from food that has been left over. The material that could float was seen floating on the surface of the water, while the smaller debris was seen collecting in the retention chamber. The baffle in the treatment system served as a flow adjuster, reducing the turbulent flow. Altering the overall retention duration allowed researchers to determine which retention period would be most beneficial for the pretreatment process.

As shown in fig. 4 and 5, when wastewater enters a grease trap, the flow rate was lowered to a level that allows the effluent to cool and separate into three layers, which is the desired result. The existence baffle mechanism and grease was rose and captured to the top of the interceptor. The solids was sunk to the bottom of the tank, and an outlet baffle ensures that only purified water can escape after separation. The presence of strainers in certain grease traps, which are used for collecting solid waste, contributes to a reduction in the amount of solid waste that accumulates at the grease trap's base over time. Solids and grease collect over time, and if they are allowed to accumulate for an extended period of time, they may begin to escape via the outlet, and in certain cases, they can back up through the inlet, causing flooding. As a result, the trap must be cleaned out on a regular basis to prevent clogging. The function of compartments are as in table 1.

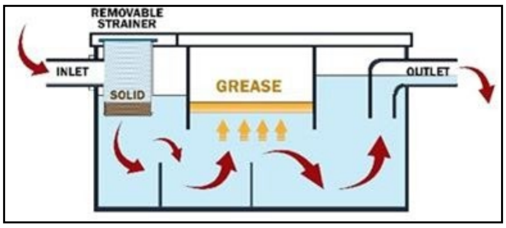

Fig. 4 - Schematic diagram of the research process

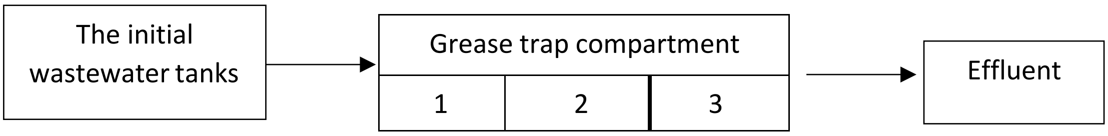

Fig. 5 - Schematic of the research process

Table 1 - Function of the compartment

Compartment 1	The first compartment has the function of collecting effluent produced by the previous compartment. The top of the box has been equipped with a filter so that grease and food scraps can be removed from the wastewater stream. After going through the filter, the wastewater gently moves into the second compartment via the bottom aperture of the bulkhead that separates the first and second compartments. At the same time, the oil grease floats to the top of the first compartment
Compartment 2	The second compartment has a second bulkhead in the middle, allowing flow-through from the top of the bulkhead but keeping grease and oil in the compartment. In addition, the waste flow is beginning to become apparent and is guided via the bottom aperture and towards the third bulkhead.
Compartment 3	It is intended that there will be no oil grease in compartment 3, which will ultimately exit the effluent through the outlet pipe after the oil grease has been removed from the first and second. This has been accomplished by removing oil grease from those compartments.

The flow rate of wastewater from kitchens was connected to the flow of tap water in Malaysia, which was used to determine the influent flow rate range, measured in litres per minute (L/min) and corresponded to the tap water flow rate in Malaysia. In a real-world setting, the FOG trap treatment system was used. The efficacy of the FOG trap in removing FOG was determined by equation (1).

$$\text{Efficiency (\%)} = \frac{A - B}{A} \times 100\% \qquad (1)$$

A = untreated wastewater value

B = treated wastewater value

3. Results and Discussion

3.1 Description

This idea originates from the gravitational law, which anything with a lower density tends to float above the water level when put in the same container as something with a greater density [10]. This notion was developed to explain why this occurs. If both the density of the fluid and the acceleration of gravity both stay the same, then the pressure exerted by a static fluid is proportional to the depth to which the fluid extends. As a result, the oil will continue to float on the water's surface and the water will be transmitted via the baffle situated in the lower portion of the container.

3.2 FOG Removal Efficiency

The FOG removal efficiency as a function of flow rate is illustrated in table 2. The results revealed that the highest FOG removal (99.54%) was recorded with 2.41 L/min of flow rate.

Table 2 - FOG removal efficiency

Flowrate L/min	Uuntreated wastewater, L	Treated wastewater, L	Oil trap in grease trap, L	Percentage removal oil, L	Percentage oil dissolve inwater, L	Removal efficiency, %
2.41	1.25	0.379	0.681	0.357	0.152	69.68
4.38	1.25	0.445	0.635	0.412	0.136	64.40
8.48	1.25	0.633	0.422	0.600	0.156	49.36

According to the findings, the flow rate plays an important role in the removal of FOG. In addition, the best operation for the removal efficiency % shifts depending on each component both on its own and when paired with the other factors. Studying the complete aspects that may impact the decrease of FOG content in water samples led to the selection of independent factors such as flow rate values ranging from 2.41 to 8.48 L/min and the sampling of 1.25 L of oil. These factors were included in the research. After the treatment procedure, the predicted coefficients for the elimination of FOG from kitchen wastewater can be found in table 2.

According to fig. 6, the impact of the flow rate factor is determined to be adequate, from 2.41 to 8.48 L/min for eliminating FOG from kitchen wastewater. This is because the amount of FOG removed from the wastewater is directly related to the volume of water that flows through the system. The amount of value that is created is adequate. Therefore, at a rate of 2.41 L/min, a flow rate that is slower than a quicker flow rate may filter more FOG. This is because, despite the modest flow rate, the gravitational principle of separation has adequate time to work in order to separate water and oil from one another [8]. In addition, in terms of the volume of treated wastewater, there is still a significant amount of oil waste that grease traps cannot properly filter out.

The efficacy of the grease trap in removing oil is shown in fig. 7, along with the flow rate it experiences while in operation. A positive value is created because the flow rate is directly related to the total percentage of FOG that is removed from the wastewater. According to the results of the FOG removal test, the efficiency with which the oil is removed decreases in proportion to the rate at which the wastewater is filtered. Because gravity separation takes time to function, it cannot be used to separate water and oil in a short amount of time. Because of this, gravity separation is not an option. Because gravity separation takes time to function, it cannot be used to separate water and oil in a short amount of time. Because of this, gravity separation is not an option.

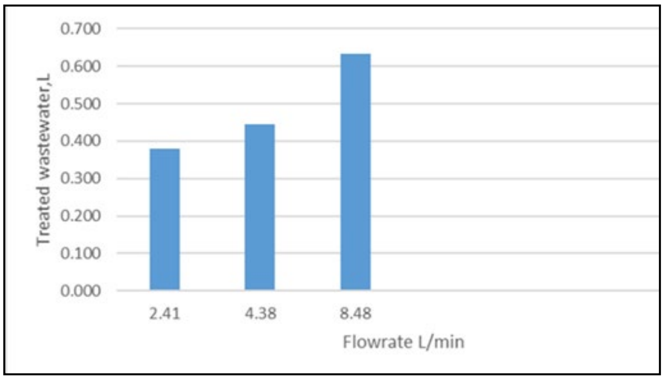

Fig. 6 - Graph of treated wastewater against flow rate

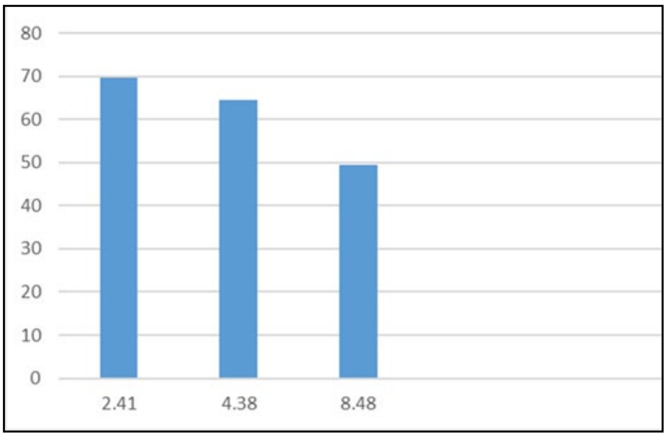

Fig. 7 - Graph of removal efficiency against flowrate

3.3 The Capacity of Gease trap

Throughout many cases, the elimination of oil levels takes place as a direct result of the physical process. This is because the conditions of the wastewater in each compartment go through significant changes without being accompanied by the production of any new substances; the oil level in the wastewater is the only component that is brought to the surface and separated from the water. Because water has a density of 1 g/cm^3, and oil has a density of 0.80 g/cm^3, it is possible to separate fat oil and water, as illustrated in Fig 8.

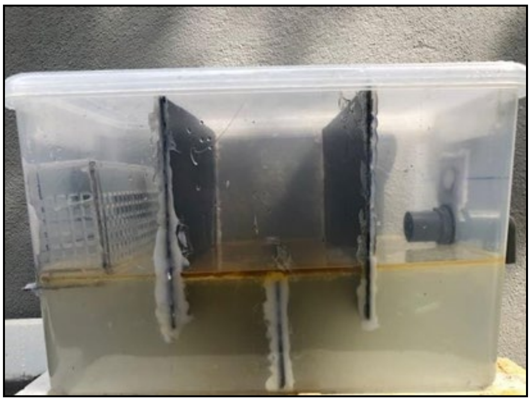

Fig. 8 - Oil and water separation process

This treatment demonstrates that 69.68 percent of the waste created by the trapping process is free of oil. However, most of the waste is still supplied via outlet pipes wastewater. As a result, the residual fat and oil found in wastewater make it more difficult for sunlight to reach the surface of water, limiting the amount of oxygen required by the water.

4. Conclusions

The outcomes of this research indicate that grease traps can provide the filter function necessary to remove oil from wastewater based on their physical isolation. Removal of FOG from kitchen wastewater using grease traps is possible via their installation. The results of the studies showed that the oil removal rate that could be achieved while optimising the treatment system was 0.379 L, according to the data collected. Furthermore, the grease trap performed at its highest possible level when the flow rate used was 2.41 L/min and the time used was 3.95 min. It can extract 0.379 L of grease when set up in this manner. Although this product has successfully separated the oil from the water compared to research done in the past, it has not been able to separate the oil itself.

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