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Portable Grease Trap for Wastewater Management System: A Conceptual Design Approach

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Research Article

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ABSTRACT

Water contamination is a result of people's careless attitude toward managing food waste, particularly in public sewers. During regular dishwashing, a lot of tiny solid particles like fat, oil, and grease (FOG) may still get past the sink filter and clog the piping system. The goal of this study was to create a conceptual design for a passive grease trap used in wastewater treatment systems. The best design was chosen using the Pugh technique, morphological chart, house of quality, and consumer survey. The finished design is lightweight and portable, measuring a respectable 300 x 430 x 300 mm and weighing around 7 kg. There are three divisions in the grease trap system. A solid filter is served by the first partition. Since water is denser than oil, the second partition serves as an oil filter. The last barrier serves to dump any leftover waste before water enters the public sewer. Because just PVC and mild steel are used, the suggested design is cost-effective.

Introduction
Wastewater discharge from homes and restaurants into public sewers has long been an issue, and it is becoming worse as more full-service and fast food establishments are constructed in both urban and rural areas [1–5]. These eateries usually release a lot of fat, oil, and grease, which over time would lower the capacity of public sewers. Food particles and other waste are trapped in the sewage lines by fats, oils, or grease (FOG), which cools, hardens, and adheres to the inner wall of the pipes. These powerful masses eventually continue to grow until they obstruct the waste water stream and push sewage downward. A grease trap, a mechanism installed on kitchen cleaning equipment such sinks, woks, and any other drains that collect grease, has become necessary as a result of this circumstance [6]. The substantial levels of food oil
Untreated sewage may be released into the environment when output in kitchens and restaurants overwhelms the septic tank or treatment facility. Cooking grease and high viscosity fats solidify as they cool, and they may mix with other disposed-of particles to clog drain systems. Before wastewater enters the sewage system, proper size, installation, use, and maintenance of an oil trap will ensure separation and upkeep of FOG from wastewater. In order to construct a grease trap system based on technical specifications and client requirements, this project focuses on idea creation and conceptual design. A grease trap is a mechanism that may be installed on kitchen cleaning equipment, such as sinks, woks, and other grease-collecting channels. Since many years ago, wastewater has been treated using a variety of methods, including coagulation, biological treatment, membrane separation technology, and others [7-9]. Grease traps, also known as grease interceptors, grease recuperation devices, or grease converters, are plumbing devices designed to capture the majority of oils and particles prior to their entry into waste water transfer systems. Grease traps come in a variety of forms. Hydromechanical is one of them. To separate the FOG from the waste water, these systems rely on gravity and temperature criteria. These modules are often composed of plastic or carbon steel. The water stream is managed using hydromechanical oil traps, allowing the heated water to cool. The FOG is captured by the mesh and retained inside the oil trap. These oil traps need to be routinely and manually cleaned. The hydromechanical unit estimates are provided in both pounds and gallons per minute (GPM). Passive

grease traps are the second kind. This kind of grease trap has two or more compartments, and the water within the trap is slowed down by the greater volume of water running through them. This makes it possible for FOG to split and become buoyant. 90% of FOG can be removed from the water thanks to the effectiveness of these grease traps. An Automatic Grease Removal Unit (AGRU) is the third. This kind of oil trap effectively skims FOG out of the water using mechanical and electrical components. Despite their modest size, these frameworks are quite effective. The majority of AGRU devices are capable of removing 99% of FOG from water.

A grease trap may encounter a few frequent issues that might stop it from working.efficiently. Clogged crossover is one of the issues. It happens when dirt or FOG accumulates in the line that separates the two chambers. The first compartment's liquid level will be too high and the second compartment's level will be normal if the crossover line is blocked. In the first chamber, the water can possibly be spilling. According to a research by Arthur & Blanc [6], FOG entering the wastewater system clogs the system by limiting capacity and destroying pipes, among other issues. This makes cleaning upkeep more expensive and time-consuming. Additionally, the FOG might reduce the amount of oxygen in incoming waters if it is not completely eliminated and cleansed. To deal with extra FOG entering the system, wastewater treatment facilities need more energy and capacity. Similarly, another typical issue that disrupts the flow is clogged outflow. The grease trap will begin to overflow in both compartments if there is a blockage in the grease trap interceptor's outgoing line. The outgoing line blockage has the potential to become very bad. Make careful to dispose of the wastewater on cycle since failing to do so will result in clogging. Another frequent issue with a grease trap is a clog in the incoming line. Therefore, the lowest plumbing fixture in the restaurant becomes backed up due to a blockage in the incoming line. The main cause of this problem is an excessive accumulation of FOG and debris in the line, which directs everything into the trap. The crossover, incoming, and outgoing lines will get clogged as a result. This allows you to use a pole to check the grease cap's depth; if it reaches the bottom, it's time to pump the grease. According to Shaffar [10], there are three types of obstruction "hot spots": sewer cleaning efficacy, design or structural problems, and grease loading.

Research Method

The project started by conducting customer's survey in defining customer's needs. The requirements received was generally in terms of maintenance, material, portability, ease to handle and function. The needs were compared to engineering characteristics in producing product design specification using House of Quality (HOQ). Concept generation was started by defining function analysis in the morphological chart. In morphological chart, ideas were generated by combining options to create new concept of product. In the end, the best concept was chosen from the analysis using Pugh Method [11-13].

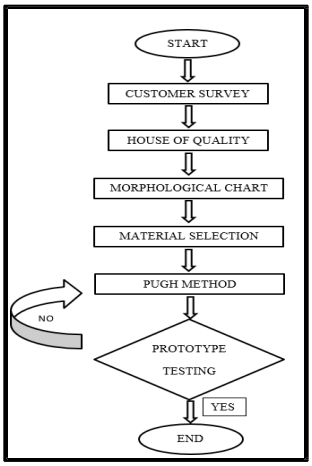
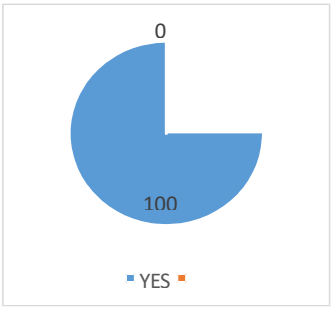
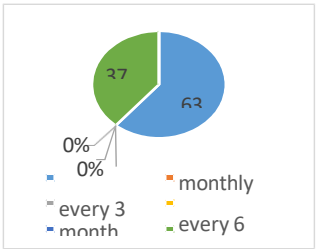


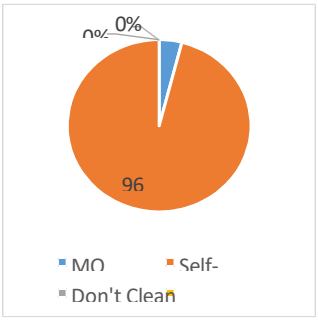
Fig. 1. Flowchart in developing portable grease trap system

Results and Discussion

Dispersion in the beginning, most important data are collected and then included into the project questionnaire. The questionnaire consisted of twenty questions that being gave to fifty one respondents which are the owners of the restaurant regarding their FOG disposal into the drainage, how frequent is the service to remove the blockage in sink pipeline and also the time took for services. After all the data were being compiled and gathered, it can determine the suitable concept in oil draining. The respondents of this questionnaire are from various restaurants at Klang, Shah Alam, Bandar Hilir, Ayer Keroh and Batu Berendam. Each question is analysed by the answer from respondent in percentage. The answers from the questionnaire are various, which is all based on their experiences and individual suggestion in this restaurant business. Figure 2 below shows that the every 51 restaurants that been surveyed use grease trap in their restaurants. This indicated that the role of a grease trap in restaurant is very important. Next on Figure 3, the survey shows that apart of using the grease trap heavily, it is also important to clean it accordingly. It shows that all owners clean the grease trap at least once a week. In Figure 4, the data shows that 96% of the respondents maintain the grease trap system by doing it themselves. Only 4% of them maintained the system using the waste hauler licensed by the ministry of environment.







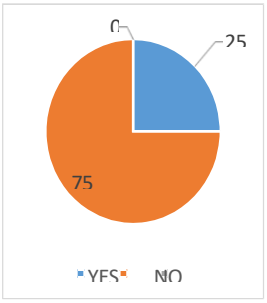
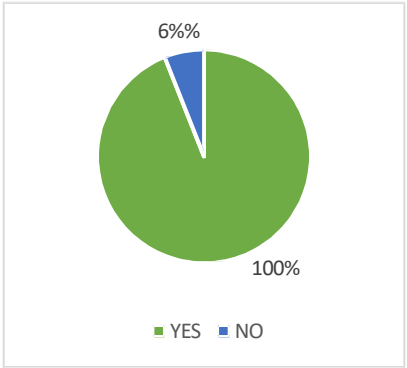


Fig. 2. Restaurants with grease trap system **Fig. 3.** Frequency of maintenance **Fig. 4.** Cleaning process **Fig. 5.** Experienced sewage blockage



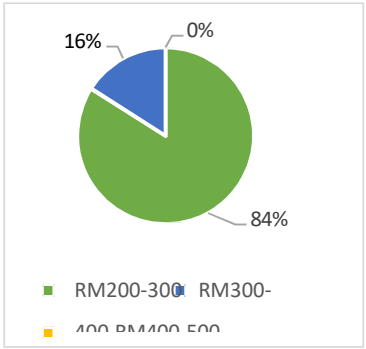
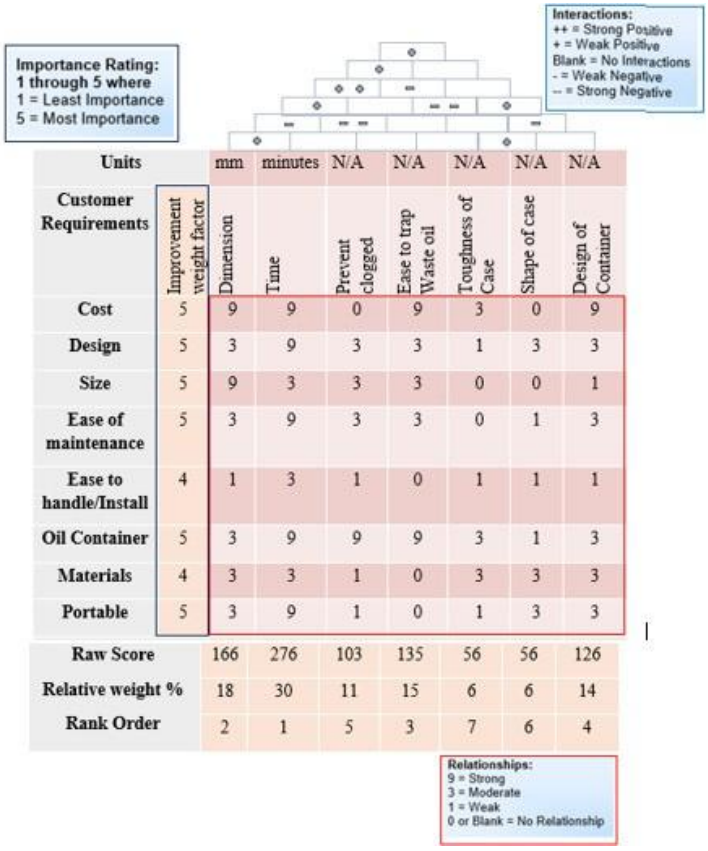


Fig. 6. Importance of oil separator **Fig. 7.** Acceptable price

In Figure 5, one fourth of the restaurants have experienced sewage blockage despite using grease trap system. This result shows that there is possibility of inefficiency among all the grease trap systems used by the restaurants owners. One of the most important components is the separation of fat oil and grease from each other in order to ensure smooth flow from the inlet to the outlet. In Figure 6, it shows that majority of the respondents, which is 94%, agree that the inclusion of oil separator is important as preventive maintenance. However, none of them are willing to spend more than MYR 400 to have the grease trap with oil separator as shown by Figure 7.



Units		mm	minutes	N/A	N/A	N/A	N/A	N/A
Customer Requirements	Improvement weight factor	Dimension	Time	Prevent clogged	Ease to trap Waste oil	Toughness of Case	Shape of case	Design of Container
Cost	5	9	9	0	9	3	0	9
Design	5	3	9	3	3	1	3	3
Size	5	9	3	3	3	0	0	1
Ease of maintenance	5	3	9	3	3	0	1	3
Ease to handle/Install	4	1	3	1	0	1	1	1
Oil Container	5	3	9	9	9	3	1	3
Materials	4	3	3	1	0	3	3	3
Portable	5	3	9	1	0	1	3	3
Raw Score		166	276	103	135	56	56	126
Relative weight %		18	30	11	15	6	6	14
Rank Order		2	1	5	3	7	6	4

Fig. 8. House of quality

All of the customer requirement are analysed using House of Quality to identify the most important engineering characteristics in fulfilling the customer's needs. Maintenance time, grease trap dimension and ease to trap the waste are rated the most important criteria to be realized. According to Morphological Chart, there are altogether 5 functions and 4 options to be matched in developing new concepts. From Table 1, there was three selected final concept from the morphological chart which are:

Table 1
Morphological chart in constructing concepts

	Option 1	Option 2	Option 3	Option 4
Weight of devices	5kg	7kg	9kg	11kg
Type of material	Stainless steel	Plastic	Mild steel	Aluminium
Maintenance	Once a week	Daily	Once a month	3 month
Baffle	Two	Three	One	Four
Shape of case	Square	Rectangle		

Place of device	Below sink	Near drain	In soil

Three concepts mentioned above was then evaluated and selected by using Pugh Method.
Compared to the datum and customer survey, one final concept has been developed into a parametric design for grease trap as shown in Figure 9.

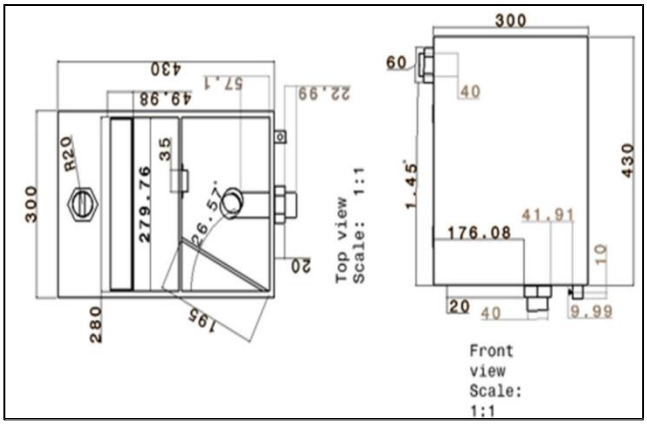


Fig. 9. Parametric design of selected concept

This concept was built based on gravitational law and Bernoulli law. Oil which has lower density tends to move above the water level if placed in the same container. The pressure of static fluid depends upon the depth of the fluid, given that fluid density and acceleration of gravity remain constant. Thus, oil will remain at the water surface and water will be transferred through the baffle located at the bottom part of the container. The newly developed prototype is considerably smaller compared to the previous design of Rahmiana *et al*.,[14] and Tarek *et al*., [15]. Moreover, the materials used for the prototype as shown in Figure 3 are mild steel and PVC that are easily available in the market and the prices are considerably low. The superiority of this grease trap prototype is portability. It can be moved easily to other places without lifting. Most of the passive grease trap must be lifted for maintenance and cleaning processes as well as to transfer it to another place. It is ergonomically not good for the user. The leftover foods can be moved once all the fluid in the container was flowing out.
Conclusion

This article offers a comprehensive analysis of a new grease trap system conceptual design that was created in accordance with client specifications. Combining the HOQ, Morphological Chart, and Pugh Method has resulted in a grease trap system prototype that is not only lightweight and portable but also user-friendly due to the simplicity of installation and the ease with which polluted water can be removed from the system by opening the nozzle.

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