UNIVERSITI PUTRA MALAYSIA

GENERATION AND MANAGEMENT OF FATS, OIL AND GREASE IN FOOD WASTE AMONG RESIDENTS IN PRECINCT 14, PUTRAJAYA, MALAYSIA

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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Fats, Oil and Grease (FOG) is a result of cooking and can always be found in daily domestic food waste. The improper management of domestic FOG waste causes many environmental problems as a result of pipe blockage and sewage overflow. Thus this study focused on gaining knowledge on the management of domestic FOG waste among the households in the residential area of Precinct 14, Putrajaya. This study had been structured with three objectives. The first objective of this study was to assess the level of awareness, attitude and practices towards domestic FOG waste among households in Precinct 14, Putrajaya. The first objective was achieved using the questionnaire survey method. A total of 453 respondents from Precinct 14, Putrajaya were involved in the survey. The result showed that households in Precinct 14, Putrajaya have a high level of awareness and attitude but a modest level of practice towards domestic FOG waste management. The second objective of this study was to determine the generation rate and composition of FOG waste from food waste of households in Precinct 14, Putrajaya. There were seven households involved in this second objective, where lab analysis with the involvement of Soxhlet Extraction Method was used to obtain the results. The result of the analysis showed that the total collected food waste was 18.983kg over a period of seven days. The range of FOG composition in every gram of food waste generated per household in Precinct 14, Putrajaya was found to be between 4.80% and 38.60%. The total FOG generation for seven selected households in seven days was approximately 0.955kg. The third objective of this study was to identify the factors contributing towards domestic FOG waste generation. A linear regression analysis was used to achieve this third objective. The results from the linear regression analysis revealed that the factors influencing the FOG waste generation were attitude, practice, age, level of education and the number of family members. This study had managed to reveal the actual composition of FOG waste in the daily food waste generated by the households in Precinct 14, Putrajaya.

The rate of FOG composition and generation can be controlled with a better attitude and practice on food waste management. Practicing proper food waste management is also able to improve the quality of the environment. Proper management practices of FOG waste can be instilled through good environmental education.

Keywords: fats, oil and grease (FOG), food waste, FOG waste generation, FOG waste management, awareness, attitude, practice

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENJANAAN DAN PENGURUSAN LEMAK, MINYAK DAN GRIS DALAM SISA MAKANAN DI KALANGAN PENDUDUK PRESINT 14, PUTRAJAYA, MALAYSIA

Oleh

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Lemak, Minyak dan Gris (LMG) adalah hasil masakan dan selalu ditemui dalam sisa makanan harian. Pengurusan sisa LMG yang tidak terurus boleh menyebabkan masalah alam sekitar seperti paip tersumbat dan limpahan sisa kumbahan. Oleh itu, kajian ini fokus kepada mengkaji pengetahuan isirumah terhadap pengurusan sisa domestik LMG di kawasan perumahan Presint 14, Putrajaya. Kajian ini dijalankan berdasarkan tiga objektif. Objektif pertama adalah untuk mengetahui tahap kesedaran, sikap dan amalan terhadap pengurusan sisa domestic LMG di kawasan perumahan Presint 14, Putrajaya. Objektif pertama dicapai dengan menggunakan kaedah kaji selidik. Seramai 453 responden dari Presint 14, Putrajaya terlibat di dalam kaji selidik ini. Keputusan kaji selidik menunjukkan isi rumah di Presint 14, Putrajaya mempunyai tahap kesedaran dan sikap yang tinggi tetapi mempunyai tahap amalan ditahap sederhana terhadap pengurusan sisa domestic LMG. Objektif kedua kajian ini adalah untuk menentukan kadar penjanaan dan komposisi sisa LMG dari sisa makanan isirumah di Presint 14, Putrajaya. Terdapat tujuh buah isirumah terlibat di dalam objektif kedua ini, di mana analisis makmal dengan penglibatan Kaedah Pengekstrakan Soxhlet digunakan untuk mendapatkan keputusan. Keputusan analisis menunjukkan bahawa jumlah sisa makanan terkumpul adalah 18.983kg untuk tujuh hari. Komposisi LMG di dalam setiap gram sisa makanan untuk sebuah rumah adalah di dalam lingkungan 4.80% dan 38.60%. Jumlah keseluruhan LMG dijana seminggu adalah 0.955kg. Objektif ketiga adalah untuk mengenalpasti faktor menyumbang terhadap penjanaan sisa domestic LMG. Analisis regresi linear digunakan untuk mencapai objektif ketiga. Keputusan dari analisis linear regresi menunjukkan bahawa faktor mempengaruhi kadar penjanaan sisa LMG adalah sikap, amalan, umur, tahap pendidikan dan bilangan ahli keluarga. Kajian ini telah berjaya mendedahkan komposisi sebenar sisa LMG di dalam sisa makanan harian oleh sisarumah di Presint 14, Putrajaya. Kadar penjanaan dan komposisi LMG boleh dikawal dengan sikap dan

amalan yang lebih baik terhadap pengurusan sisa makanan. Selain itu, amalan pengurusan sisa makanan yang lebih baik akan meningkatkan kualiti alam sekitar. Amalan pengurusan sisa LMG yang lebih baik akan dapat terlaksana dengan pendidikan alam sekitar sejak dari kecil.

Kata kunci: sisa lemak, sisa minyak dan sisa gris, sisa makanan, penjanaan sisa LMG, tingkah laku, amalan, kesedaran

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Thank You.

I certify that a Thesis Examination Committee has met on 19 September 2017 to conduct the final examination of Lili Mastura binti Che Wil on her thesis entitled "Generation and Management of Fats, Oil and Grease in Food Waste among Residents in Precinct 14, Putrajaya, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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LIST OF ABBREVIATIONS

FOG	Fats, Oil and Grease
WCO	Waste Cooking Oil
MSW	Municipal Solid Waste
IWK	Indah Water Konsortium
HSW	Household Solid Waste
JKR	Jabatan Kerja Raya
BPH	Bahagian Pengurusan Hartanah
SSOs	Sanitary Sewer Overflows
STPs	Sewage Treatment Plants
WHO	World Health Organization
BOD	Biochemical Oxygen Demand

CHAPTER 1

INTRODUCTION

Chapter 1 presents the introduction of the study, statement of the problem, research objectives, significance, scope and limitations, assumptions, and operational definitions of terms utilized in this study.

1.1 Background

Food waste, as a major constituent of solid municipal waste to most countries, has become a burden to environmental management with various serious environmental and economic issues.

It was estimated that 1.3 billion tonnes of food waste is generated annually in the world, which is equivalent to approximately USD750 billion (FAO, 2013). In Malaysia, the generation of food waste has increased tremendously, as from 4.4 million tonnes in 2005 to approximately 5.5 million tonnes in 2013, and the number estimated may reach up to 6.5 million tonnes in 2020 (Hamid et al., 2012; Papargyropoulou et al., 2014). It was reported that half of every 31,000 tonnes of waste produced daily consisted of organic kitchen waste (Yasin et al., 2013).

As waste management is known as one of the major concerns affecting environmental problems faced by most municipalities, the increasing generation of food waste has not made waste management easy (Agamuthu and Fauziah, 2011). Improper food waste management may lead to many environmental problems, which in turn brings about a series of serious complications to the environmental condition and public health. Odour, decay, vermin attraction, groundwater contamination and greenhouse gas emission problems results from the poor management of food waste. Recently, popular discourse in conferences or research papers has related food waste, which consists of Fats, Oil and Grease (FOG), to the growing number of environmental problems (Williams et al., 2012; Chan, 2010) .

FOG, generally known as lipid, is a by-product of cooking. In certain Asian countries, FOG is known to be present in high quantities of food consumption (Stabnikova et al., 2005). An average Malaysian consumes at least 78.3g of fat per day, which qualifies Malaysia to be among the top 10 countries that consumes a high average amount of fat each day (Ferdman, 2015). It is deduced that people in many developed countries including Malaysia tend to move to western diets, which caused a rise in the consumption of FOG due to urbanization and increased affluence (Williams et al.,

2012; Mirnalini et al., 2008). Thus, the resultant production of kitchen waste consisting of FOG is expected.

However, FOG is not supposed to be found in wastewater (Gonzalez et al., 2008; Williams et al., 2012). Thus, any discovery of FOG concentration in untreated domestic wastewater actually demonstrates poor practices of kitchen management by the household (Roya, 2014; Williams et al., 2012). Several researchers had named domestic kitchen waste as among the largest contributors to FOG problems to the environment (O.Alade, et al., 2011; Hafid et al., 2011; Yin et al., 2013). When FOG is found in untreated wastewater, the main source is always kitchen water. This is due to the fact that households are inclined to discard food scraps containing FOG, especially the disposal waste cooking oil (WCO) into the sink as an easier way for disposal (Awang et al., 2015). FOG also may come in residual emulsions, which are directly released from household dishwashers (Roya, 2014).

The consequences of improper management of FOG waste may cause many environmental problems. The most common problem that is widely discussed is pipe blockage (O.Alade, et al., 2011; Hafid et al., 2011; Yin et al., 2013; Williams et al., 2012; Gonzalez et al., 2008). As FOG ends up in the sink either deliberately or as a result of ignorance, the washed down FOG that passes through the kitchen sink or drain naturally tends to stick to the insides of sewer pipes. The cool internal surfaces and the presence of water in sewer lines provide ideal locations for the formation of FOG deposits (He et al., 2013). These FOG deposits will eventually reduce the diameter of the sewer line until it will completely block the pipes, resulting in flooding or sewage overflow.

Cases of flooding or sewage overflow not only pose a risk to people's health, but also results in destruction of the environment and high costs of maintenance. The sewage overflow also exposes the surrounding population to pathogens and attracts vermin (Gonzalez et al., 2008; Williams et al., 2012). When the oily wastewater flows into the drains, it is later discharged directly into the watercourses, contaminating water resources and leading to a series of other problems. If the untreated sewage reaches the ocean, the risks or dangers that we would then face are coastal contamination, beach closures, and associated potential human health risks (Shaffer et al., 2003).

Several conferences and researches that have discussed FOG have shown that the problem is not only limited to certain countries (Williams et al., 2012). In the USA the accumulation of hardened and insoluble FOG deposits have been found to be the cause of pipe blockages, contributing to 40 to 50% of a total of 138 000 annual cases of sanitary sewer overflows (SSOs) (Keener et al., 2007). The excessive build-up of FOG has also been identified as the main reason behind more than 60% of sewer blockages that occurred in the year 2000 in Hong Kong (Chan, 2010) and 21% of all sewer blockages in Australia (Mattsson et al., 2014).

In Malaysia, FOG has been a challenge in environmental management, especially in an urban city such as Putrajaya. Up to approximately 70% of the sanitary sewer overflows (SSOs) that have occurred in Malaysia has been related to FOG accumulation (Husain et al., 2014). Indah Water Konsortium (IWK), a Malaysian national sewerage company, reported that in 2010, IWK received approximately 22,184 public complaints on blockage and manhole overflows. Based on IWK's report, the major contributors towards these blockages was indeed FOG build-up in the sewer pipes (Nair, 2011; IWK, 2011). FOG that is poured down into the sink might not have to travel far through the pipes before they begin to form FOG deposits and cause complete blockages (Roya, 2014). The cause of these blockages by FOG seems related to poorhousehold waste management and the reality of sewage treatment plants in Malaysia, which has not been designed to handle lipid deposition (Rasit et al., 2015). Thus, problems associated with FOG continue to occur and reoccur in every state.

1.2 Problem Statement

The residents in Putrajaya generate approximately 27.6 tonnes of food waste per day, which is 69% of a total of 40 tonnes of waste generated per day. This figure makes Putrajaya the state with the highest amount of food waste compared to other states in Malaysia (Sheikh Abd. Rahim, 2009). However, from this amount, only approximately 95% to 97% of the total waste generated reported was successfully sent to landfills for disposal (Desa et al., 2012). The remaining 2 to 5% is an alarming figure and can be considered an environmental issue, one of which is created by the FOG derived from food wastes. According to Alam Flora Sdn. Bhd, in one year, more than 130 tonnes of FOG from generated food waste were disposed into drains (Daniel, 2016). These FOG waste became hardened formations and adheres strongly to pipe walls, blocking the piping system and causing Sanitary Sewer Overflows (SSOs) (Williams et al., 2012). In addition, the cleaning of massive networks of drains in the city cannot be done frequently, thus resulting in gunk build-up, producing nasty smells and clogging the drains (Daniel, 2016).

FOG waste issues need to be tackled from the waste management side as waste problems should be addressed from the source (Tchobanoglous et al., 1996). Although most municipalities have targeted restaurants and the food industry as the major sources of FOG discharge, residential areas are playing a more significant role in FOG waste production. Roya (2014) reported that residential areas, especially those with high population densities, produced shocking results of FOG waste production. Furthermore, household habits and routine have been found to affect the environment significantly (Stern, 2000). In residential areas, households choose easier ways to dispose FOG waste, which is usually by using the kitchen piping channels during cleaning, which is a common practice resulting from ignorance. Poor kitchen practice is the reason why despite public information and campaigns, significant quantities of FOG are still found entering the sewers (Williams et al., 2012). Household attitudes and current practices in discharging domestic FOG, have given rise to the FOG

problem in the municipal sewer systems and the environment as a whole (Kamilah et al., 2013). Thus, good practice of FOG waste management is needed, as research has proven that this can minimize the contribution of oil and grease to the collection system, which may reduce the risk of sewer line blockages and other mentioned problems by up to 50% (Dodd and Roger, 2002).

The lack of household awareness and knowledge about waste management has contributed to the FOG waste problem (Kamilah et al., 2013; Papargyropoulou et al., 2014). Furthermore, households tend to ignore the after-effects, which has definitely worsened the problem (Desa et al., 2011). The study conducted by Agamuthu and Fauziah (2011) proved that waste management in Malaysia is still in a poor state. The lack of study on the household awareness, attitude and practice on the management of FOG waste has created difficulties for the researcher in finding the solution to the problem (Aminrad and Zakariya, 2013). This study therefore sought to understand the problem from the perspective of the household itself with Precinct 14, Putrajaya being selected as the study area for this study. In order to better understand and provide a clearer picture on the FOG problem, this study has also measured the generation and composition of daily FOG produced by the household.

Domestic FOG waste management issue has been a common occurrence, however its existence has not been as popular as other municipal waste. Prevention of the problem is the most suitable solution to avoid any incurred cost. The first step to prevent the problem from occurring was to identify the factors that influenced the problem. Thus, this study had investigated household awareness, attitude and practice towards FOG waste management through a set of survey questionnaire distributed among the households. In order to better understand the issue of domestic FOG waste management, this study had further investigated the FOG produced by households. In this study, the actual amount of FOG waste produced by the household everyday was verified using laboratory tests on food samples that were collected from the participants in Precinct 14, Putrajaya.

The study on the awareness, attitude and practice of households on FOG waste management was relevant, as preventing FOG waste from entering our drains proved to be difficult. The reason was because although installation of “grease traps” or “grease interceptors” is highly recommended in retaining lipids or reducing the impact of FOG in wastewater before draining into public water sources, the installation of these equipment is not cheap, and therefore is not something that everyone is able to afford (He et al., 2013). FOG limits in sewer systems was only 100 mg/L in most municipalities but this limit can vary depending on several factors, such as the type of sewers, slope of sewers, flow in sewers, operation and maintenance of the sewers, and history of grease-related clogs (Deparment of Public Work, 2013). However, previous researches have found that even when grease interceptors were installed, effluent FOG concentrations could still peak at well over 1000 mg/L, meaning that these equipment were not working as effectively as they should be (Williams et al., 2012). This proved that good management attitudes and practices were cheaper and more relevant

solutions, which was the main focus of this study. Furthermore, the attention that has been given to the matter is still greatly lacking despite the fact that domestic FOG waste management problems do exist in this country. As most of the research attention has focused on larger scales such as municipal solid waste or industrial waste discharges, FOG waste has become a neglected environmental problem (Parizeau et al., 2014; Kamilah et al., 2013; Ashraf at al., 2010; Dodd and Roger, 2002). Although there have been many researches from other countries, their experiences cannot be generalized since the food patterns and/or sewer system characteristics may differ (Mattsson et al., 2014). A new research on FOG specifically will be an effort in helping to better understand the matter. This study was conducted based on questions that have arises, such as those shown below:

1. What are the levels of awareness, attitude and practices in the management of domestic kitchen waste among the residential households in Precinct 14, Putrajaya?
2. What is the FOG waste generation rate and the composition percentage in kitchen waste of selected residential area in Precinct 14, Putrajaya?
3. What are the factors contributing towards domestic FOG waste generation?

1.3 Research Objectives

With the above views in mind the study will be undertaken with the following objectives:

1. To assess the level of awareness, attitude and practice in the management of domestic FOG waste in the residential area of Precinct 14, Putrajaya.
2. To determine the generation rate and composition of FOG in kitchen waste of Precinct 14, Putrajaya.
3. To identify the factors contributing towards domestic FOG waste generation.

1.4 Significance of Study

This study focused on gaining knowledge on domestic FOG waste management among the households in the residential area of Precinct 14, Putrajaya. By conducting this study, a clear view on the actual behavioral practices in the management of domestic FOG waste in the residential area of Precinct 14, Putrajaya can be observed. This information was beneficial in further understanding the issue in order to solve the problems related to food waste generally and FOG waste specifically. Furthermore, this study identified the major factors that contributed to FOG waste management problems. The factors can be further used to develop any effective and efficient domestic kitchen waste management plan or model to counterfeit the problems faced by the community. The data of the composition and generation rate of FOG from

domestic kitchen waste provided important information on FOG components in Malaysia's domestic kitchen waste and the consumption profile of the oil and fatty foods among Malaysians. This study will help to increase public awareness and understanding towards the importance of domestic kitchen waste management. The education value brought by this study may reduce public complaints on sewer systems, as well as costs for sewer operations and maintenance (this study area supported by Bahagian Pengurusan Hartanah (BPH), Putrajaya), besides reducing the environmental impact caused by ignorance on the issue. Lastly, it is hoped that this study could contribute in reducing environmental problems, as Pongrácz et al., (2002) wrote; "*waste management is an urgent problem for society and every contribution is important*".

1.5 Scope of Study

The focus of the study was on practices on the management of FOG from domestic kitchen waste, solely in the focus area, which was Putrajaya. The questionnaire survey conducted in this study focused on the awareness, attitude and practices of the residential community of an area in Putrajaya towards behavioral practices in the management of domestic FOG waste. Meanwhile, the laboratory analysis used in this study focused on measuring the generation rate and composition of FOG in domestic kitchen waste from Precinct 14, Putrajaya. Both of the findings led the study to identify major factors contributing to FOG waste management problems.

1.6 Limitations

As this study area was the residential of Precinct 14, Putrajaya, the finding will be applied to this area only and cannot be generalized to other parts of Malaysia. This study focused solely on the management of domestic FOG waste, thus, the result applies to FOG waste produced by households only and is not applicable to any other sources.

1.7 Thesis Organization

This thesis is organized into five chapters as follows.

Chapter 2 gave a review on previous research that is relevant to this study. The overall concept of this study was discussed, where the conceptual framework was presented.

Chapter 3 described the methodology used in this study. In this chapter, all the methods learned from previous research that were suitable to complete this study were explained in detail.

Chapter 4 discussed the result of this research. The results were based on the objectives of the study and represented graphically with Table and Graph charts.

Finally, Chapter 5 summarized and concluded the findings of this study, besides providing recommendations. It is hoped that these findings and recommendations would help to provide more information about FOG waste problems among the community in Precinct 14, Putrajaya.

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