THE PERFORMANCE OF TAKAKURA COMPOSTING USING FOOD WASTE FROM MAKANAN RINGAN MAS INDUSTRY

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"Special dedicated with much love and affection to my beloved parents,
Azhari bin Abdullah, Sabariah binti Sulaiman,
and beloved siblings,
Nurfatin Aida, Fathul Aqil, Nur Athirah

Also my current supervisor ASSOC PROF DR. Aeslina binti Abdul Kadir
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Thank you for always being there for me.
Without your support this would mean nothing

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In the name of Allah, Most Gracious, Most Merciful

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ABSTRACT

Food waste is the easily biodegradable waste. Without proper management, the waste could create several environment problems. Management of food waste reduces or eliminates adverse impacts on land, contamination of the atmosphere, soil and water. The aim of this study was to investigate the performance of takakura composting methods by utilizing waste generated by Makanan Ringan Mas Industry. Two types of takakura composts were prepared with different decomposing mediums and fermentation liquids. Each reactor was then left to stable for up to 22 weeks and the final product content was determined to evaluate the level of decomposition. Physical, chemical and biological parameters were examined to observe the effectiveness of each reactor. In terms of physical parameters, a maximum temperature of 44 °C was observed in reactor processed food waste. The pH values fluctuated between 6 to 8.5 whereas the moisture content between 40% to 55% in all reactors throughout the composting process. As for chemical parameters except reactor of raw food waste was not achieved satisfactory values. In addition, biological parameters demonstrated the microbial activity during the decomposing process. After a composting period of 22 weeks, slight difference demonstrated between the best values of total kjedahl nitrogen, phosphorus and potassium obtained by research compost in reactor processed food waste were 6300 ppm, 10.57 ppm, 726.07 ppm, respectively while for commercial compost 8400 ppm, 15.45 ppm and 727.81 ppm respectively. In contrast, raw food waste had the lowest total kjedahl nitrogen, phosphorous and potassium values. Nevertheless, all the results obtained indicate that all the composted food wastes along with the decomposing mediums and fermentation liquids were suitable to be used as both soil amendment and organic compost.

ABSTRAK

Sisa makanan adalah sisa mudah terurai. Tanpa pengurusan yang sewajarnya, sisa makanan ini boleh mewujudkan beberapa masalah persekitaran. Pengurusan sisa makanan sama ada dengan mengurangkan atau menghapuskan kesan buruk ke atas tanah, pencemaran alam sekitar, tanah dan air. Tujuan kajian ini adalah untuk menyiasat prestasi kaedah kompos Takakura dengan menggunakan sisa makanan yang dihasilkan oleh Makanan Ringan Mas Industri. Dua jenis kompos takakura telah disediakan dengan media pengkomposan berbeza dan cecair penapaian. Setiap reaktor dibiarkan stabil pada minggu ke 22 dan kandungan produk akhir ditentukan untuk menilai tahap penguraian. Parameter fizikal, kimia dan biologi diperiksa untuk melihat keberkesanan setiap reaktor. Dari segi parameter fizikal, suhu maksimum 44 °C direkodkan pada reaktor. sisa makanan yang diproses. Nilai pH berubah-ubah antara 6 hingga 8.5 manakala kandungan lembapan antara 40% hingga 55% dalam semua reaktor sepanjang proses pengkomposan. Bagi parameter kimia kecuali reaktor sisa makanan mentah tidak mencapai nilai memuaskan. Di samping itu, parameter biologi menunjukkan aktiviti mikrob semasa proses penguraian. Selepas tempoh pengkomposan selama 22 minggu, sedikit perbezaan yang ditunjukkan antara nilai terbaik jumlah kjedahl nitrogen, fosforus dan kalium yang diperolehi oleh kompos penyelidikan dalam sisa makanan yang diproses reaktor ialah 6300 ppm, 10.57 ppm, 726.07 ppm, sementara untuk kompos komersil 8400 ppm, 15.45 ppm dan 727.81 ppm masing-masing. Sebaliknya, sisa makanan mentah mempunyai nilai terendah jumlah kjedahl nitrogen, fosforus dan potassium terendah. Walau bagaimanapun, semua keputusan yang diperoleh menunjukkan bahawa semua sisa makanan kompos bersama-sama dengan medium-decomposing dan cecair penapaian adalah sesuai untuk digunakan sebagai pindaan tanah dan kompos organik.

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LIST OF ABBREVIATIONS

%	-	Percentage
A	-	Pore pressure parameter
AAS	-	Atomic Absorption Spectroscopy
AS	-	Arsenic
C:TKN		Carbon to Total Kjedahl Nitrogen
Cd	-	Cadmium
CH_4	-	Methane
CO_2	-	Carbon Dioxide
Cr	-	Chromium
Cu	-	Copper
HM	-	Heavy Metal
ICPMS		Inductively Coupled Plasma Mass Spectrometry
K		Potassium
kg		kilogram
m^2	-	meter square
m^3	-	Cubic metre
mg		miligram
mg/l	-	milligram per litre
mL	-	miliLitre
MPRC		Micropollutant Research Centre
MRMi		Makanan Ringan Mas Industry
MSW		Municipal Solid Waste
N		Nitrogen
Ni		Nickel
P		Phosphorus
Pb		Lead

ppm		part per million
TKN		Total Kjedahl Nitrogen
TOC		Total Organic Carbon
UTHM		Universiti Tun Hussein Onn Malaysia
w	-	Moisture content
Zn		Zinc

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Rapid development is demonstrated through industrialization, urbanization as well as population growth. These activities will increase the generation rate as well as the characteristics of municipal solid waste (Samsudin & Don, 2013; Dhokhikah & Trihadiningrum, 2012). According to Masirin *et al.*, (2008), the increase in waste generation in Malaysia is due to the urbanization process, increase in per capita income as well as changes in consumption patterns, economic activities and population growth (Ismail & Manaf, 2013).

In terms of classification, according to the United Nations Environment Programme (UNEP), there are four categories of waste which are municipal solid waste (MSW), industrial waste, agricultural waste and hazardous waste. MSW is also a category of diverse waste and is generated from different sources such as residential households, offices, hotels, schools and institutions.

In general, the MSW composition in Malaysia consists of organic waste, paper, plastic, textile or rubber, wood, metal, glass, ash, and others (Dhokhikah & Trihadiningrum, 2012; Fauziah & Agamuthu, 2012). Food, paper, and plastic waste constitute were found to be the major components of MSW, which comprise 80% of the overall waste in Malaysia (Samsudin & Don, 2013). According to Saipul *et al.*, (2017), the main component of solid waste in Malaysia is decomposable organic waste which makes up 44.5%, followed by plastic at 13.2%, 12% disposable diapers, paper and garden waste at 5.8%.

Currently, Malaysia is facing issues in solid waste management (Moh & Manaf 2017) due to the lack of funds and expertise to carry out sufficient and efficient waste treatment methods. Furthermore, the lack of waste collection encourages open dumping as the final method of disposal and this can lead to negative impacts on the environment and human health (Rakib *et al.*, 2014; Dhokhikah & Trihadiningrum, 2012). In addition, decomposable organic waste was highly biodegradable and it has a high moisture content of 55.01% (Samsudin & Don, 2013; Dhokhikah & Trihadiningrum, 2012; Manaf *et al.*, 2009). Therefore, current practices of organic waste disposal a serious problem on the environment and health.

Landfills and open dumping are the most common disposal methods in Malaysia. Waste is often disposed of without being pre-treated and this leads to a major impact on the environment (Ismail & Manaf, 2013; Othman, 2012). Furthermore, according to Chua *et al.,* (2011), most solid waste is disposed in landfills or dumpsites and only a small amount is incinerated. Organic waste will cause contamination when it is disposed in landfills due to the breakdown of organic matter without oxygen which produces acids and creates toxic leachates. These leachates will seep into groundwater and contribute to groundwater pollution.

From previous studies, landfilling of mixed wastes is the worst solution as the degradation process can lead to harmful gas emissions and leachates (Abdul Hamid *et al.*, 2012). Another option for MSW is incineration. Although this method has become popular nowadays because it can reduce the amount of waste for sanitary landfilling, it produce harmful gases, particles, and ash (Chua *et al.*, 2011). According to Masirin *et al.,* (2008), the incineration process can reduce the volume of waste by about 90%, it incurs high operational costs and but the resulting ash contains high levels of heavy metals. In addition, the high moisture and organic content in MSW contribute to the failure of the incineration process (Ismail & Manaf, 2013). Thus, the best method to manage food waste efficiently, according to Dhokhikah and Trihadiningrum (2012), is by composting solid waste. This method is more suitable for treating organic waste in developing countries.

Composting is also a sustainable alternative for managing and recycling organic solid waste because it can produce compost which can be useful for

agriculture (Pagans *et al.*, 2006). By composting, the amount of greenhouse gas emissions formed from decomposing organic material in landfills decreases (Mustapha, 2013, Chien, 2012). According to Masirin *et al.*, (2008), composting solid waste can significantly reduce solid waste volume, especially in countries where organic waste and yard waste are predominant. In addition, Saheri *et al.,* (2009) contended that composting organic material that has been diverted from landfills prevents the production of methane and leachates in landfills, increases the lifespan of landfills, and reduces land use. Thus, composting is considered the best alternative method for food waste disposal as it is environmentally safe, cost effective and hygienic.

Nevertheless, the composting medium and fermentation liquid can affect the degradation process of food waste. Composting is a natural process that generates heat and moisture which allow food waste to decompose. Therefore, the availability and sustainability of the composting medium and fermentation liquid are important to ensure an effective composting process. Thus, in this research, available food waste will be composted using feasible, sustainable and economical composting mediums and fermentation liquids that are locally available.

1.2 Problem Statement

In this study, the focus is on food waste production by small and medium industries around Parit Raja, Batu Pahat, Johor, as the amount of food waste produced is high. In general, this industry operates 24 hours a day as the production depends on customer needs, especially during festive periods and school holidays. Makanan Ringan Mas Industry (MRMi) at Parit Kuari Darat is one of the medium scale industries that focuses on food production such as chips and coconut candy. The food waste produced by MRMi includes grated coconut, tamarind husks, banana peel and tapioca peel.

Improper waste management such as open dumping and open burning has been practised in this industry. There are several factors that contribute to improper waste management, which include the lack of collection coverage and transportation of waste generated as the area is far from the main road. Thus, improper solid waste

management is being implemented without any collection and disposal facilities. From the observations made, most of the neighbourhoods have yet to consider improper waste management as an environmental threat. Most of the wastes are dumped into rivers and some of the wastes are partially burned in the backyard of their homes

Secondly, in terms of road networks, some roads were found to be accessible for trucks and buses while others are only accessible by motorcycles. Due to this, industries in Parit Kuari Darat need different types of waste transportation methods or temporary dumpsters for waste collection.

Thirdly, improper waste management can be attributed to social conditions. Open dumping and open burning has long been practised in this industry. Sometimes, the industries choose to burn garbage in the backyard because it is easier to just throw and burn garbage instead of managing it properly. In addition, there is also no community cleaning activity that is usually held weekly or monthly by the local authorities.

The study utilises avoidable and unavoidable food waste generated by MRMi. Avoidable food waste refers to products that are still good for human consumption at the point of disposal or products that would been edible if they had been eaten in time while unavoidable food waste are not suitable for human consumption.

In conclusion, environmental conditions, road networks and social conditions have affected the management of solid waste in Parit Kuari Darat. It is important to manage solid waste, starting from the process of waste generation, waste treatment to waste disposal especially because food waste is easily biodegradable.

Therefore, the composting method could be an alternative disposal method for managing waste in a proper manner, especially for organic waste. This method is simple, affordable and easy to carry out. It could also benefit the community in terms of improving recycling activities, hygienic conditions and environmental awareness.

Composting is a good alternative for managing food waste as it is capable of producing compost with adequate nutrients such as nitrogen, phosphorus and potassium which constitute a good source of macronutrients and micronutrients for soil which can further be used as fertiliser or soil amendment to replace chemical

fertilisers. Therefore, this study utilises all the food waste produced by MRMi to produce compost along with low-cost composting mediums and fermentation liquids.

1.3 Research Objectives

The main objective of this research is to provide an alternative disposal method for food waste generated by Makanan Ringan Mas Industry (MRMi) at Parit Kuari Darat, Johor.

The specific objectives of the study are:

i. To identify the amount of waste generation, including the composition and classification of food waste at Makanan Ringan Mas Industry (MRMi).

ii. To determine the physical, chemical and biological parameters of research compost and commercial compost.

iii. To determine the final product of total kjedahl nitrogen, phosphorus, potassium and heavy metal concentration between research compost and commercial compost

1.4 Scope of Research

This study is limited to food waste produced by Makanan Ringan Mas Industry (MRMi), Parit Kuari Darat, Johor. For composting purposes, the first part of the study involved the collection of all food waste generated by MRMi. The food waste was collected weekly from the industry, which is located about 13.5 km from UTHM. In situ separation of food waste was carried out to determine the amount of food waste generated, its composition and the classification of food waste. The waste was collected and weighed during a 12-month period. The waste was tested in the Geotechnics Laboratory to determine its physical characteristics which are moisture content and density.

In the second stage of the study, the characterization of the compounds in the fermentation liquid and decomposing medium was carried out. Two types of fermentation liquids which are research fermentation liquid and commercial

fermentation liquid were prepared and underwent a bacteria count test. On the other hand, the composting medium was chosen based on its carbon-total kjedahl nitrogen ratio, C:TKN.

At the third stage of this research, the testing of the parameters of each compost was conducted in triplicate (n=3) and lasted for a period of 22 weeks which was equivalent to the composting period (22 weeks). The physical, chemical, and biological parameters were tested. The physical parameters tested included temperature, moisture content and pH while the chemical parameters included total kjedahl nitrogen content (TKN), total organic carbon (TOC), carbon and total kjedahl nitrogen ratio (C:TKN), phosphorus (P), potassium (K) and heavy metals (cadmium, chromium, copper, lead, nickel, zinc, arsenic).

At the final stage, total kjedahl nitrogen, phosphorus, potassium as well heavy metal concentrations between the research compost and the commercial compost were compared.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In Malaysia, solid waste management is relatively poor. Dumping waste in open fields and rivers is a common practice till today. According to Yatima and Arshad (2010), Malaysian solid waste contains a very high concentration of organic waste especially food waste, followed by plastics and paper. Malaysia is looking towards innovative solutions to solve these problems (Abas & Wee, 2014).

2.2 Solid Waste

Solid waste is defined as any garbage, refuse or sludge from wastewater treatment plants, water supply treatment plants or air pollution control facilities. It also includes discarded materials including solids, liquids, semi-solids or gaseous materials resulting from industrial, commercial, mining and agricultural operations, as well as community activities. However, it does not include solid or dissolved materials in domestic sewage or solids or dissolved materials in irrigation return flows or industrial discharges.

Essentially, according to the Environmental Quality Act 1974, waste includes any matter prescribed to be scheduled waste or any matter in solid, semi-solid or liquid form. It can also come in the form of gas or vapor that is emitted, discharged or deposited in the environment in a way that causes pollution. In addition, Mishra *et al.,* (2014) defined waste as any substance or object disposed of by humans or animal activity that is not possible to use again or has no value in economic terms. On the

other hand, Ismail and Manaf (2013) define solid waste as waste arising from human activities which is, usually in the form of solid, liquid or gas and has no use.

Furthermore, according to Gaurav *et al.,* (2014), solid waste results from a variety of sources such as residential areas, commercial areas, municipal services, agriculture and industries that produce various types of solid waste. Improper management can cause susceptibility to various diseases in reproductive animals and threaten human health and the environment. Accordingly, solid waste has to be managed appropriately according to the amount of waste generated (Ismail & Manaf, 2013). In conclusion, solid waste refers to any substance or object that is disposed of, cannot be used again, has no economic value, and caused by human or animal activity.

2.2.1 Municipal Solid Waste Disposal

In Malaysia, the generation of municipal solid waste (MSW) has increased due to population growth, rapid urbanization, economic growth, and its multicultural society that celebrates various festivals (Chua *et al.*, 2011). The composition of MSW for a developing country and that of an industrialized country is different (Norbu, 2002). The higher the economic development and urbanization, the greater the amount of solid waste produced (Ismail & Manaf, 2013). Meanwhile, according to Abas and Wee (2014), the generation of municipal solid waste varies in terms of residential, commercial, institutional, industrial and city centre areas.

According to Samsudin and Don (2013), MSW has increased more by than 91%. Dangi *et al.*, (2011) found that the composition of solid waste in Kathmandu, Nepal consists of 71% organic material, 12% plastics, 7.5% paper, 5% construction waste and 1% hazardous waste. On the other hand, it was found that the household waste generated in Tulsipur is made up of 46% organic waste, 11% construction debris, 10% plastics, 7% glass, 6% paper, 5% metals, and 5% rubber and leather (Dangi *et al.*, 2013). Meanwhile, a study in China showed that solid waste comprises 57% organic waste (Chen *et al.*, 2010). In addition, Forouhar and Hristovski (2012) who studied waste generation in Kabul, Afghanistan, also found that about 70% of waste generated comprised organic materials. Food waste can be defined as any food or inedible parts of food that are removed from the food supply chain to be recovered

or disposed. Food waste is unavoidable waste which is mostly generated from residences and commercial establishments such as households and restaurants, grocery stores, hotels, institutional cafeterias and kitchens, and other commercial and industrial sources including employee lunchrooms and others.

Furthermore, which Malaysia is not exempted. In Kuala Lumpur, the capital city of Malaysia, the waste generation rate is growing every year. Budhiarta *et al.* (2012) reported that among the solid waste generated in Kuala Lumpur in 2010, the highest amount generated was food waste, followed by plastic, paper, mixed organic waste, wood and others at percentages of 74%, 21%, 1%, 1%, 1%, and 2%, while according to Aja and Kayiem (2016) reported that, Malaysian solid waste generates high in food waste, followed by plastic, paper materials and others waste components (metal, wood, glass) as shown in Figure 2.1.

The high amount of food waste generated is the main cause to most issues. The challenge to overcome the generation of MSW involves the location and treatment of waste. Landfills and open dumping are the main forms of disposal in Malaysia. This poor management of solid waste causes environmental pollution, such as leachates (Ismail & Manaf, 2013; Samsudin & Don, 2013).

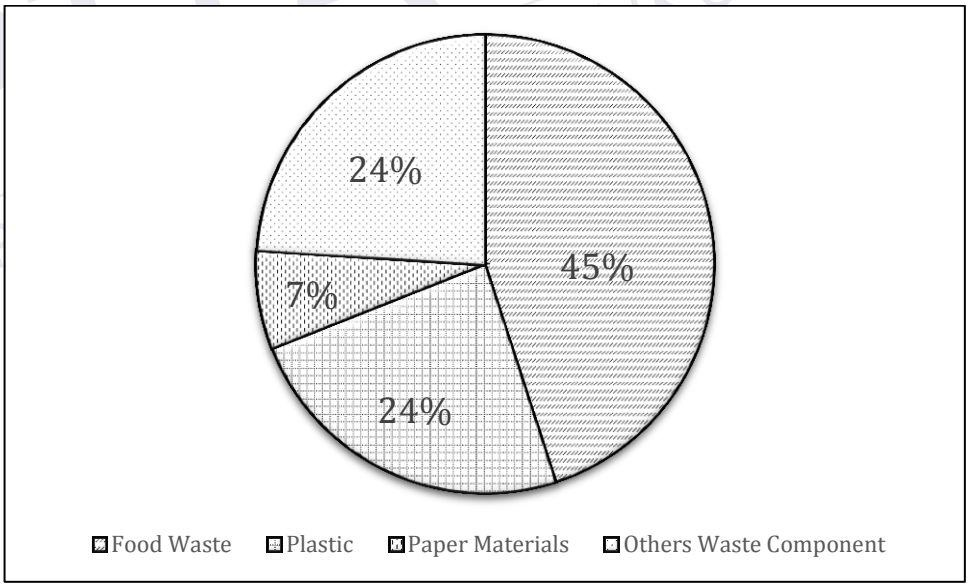

Figure 2.1: Waste composition in Malaysia
(Source: Aja & Kayiem, 2016)

In Malaysia, there are three (3) main methods of solid waste disposal including landfills, incineration, recycling and composting (Tweib *et al.*, 2012; Chua *et al.*, 2011; Ali, 2008). Other methods include land reclamation and wet oxidation. Many

of the studies on solid waste management in Malaysia reported that dumping and landfilling are the main forms of waste disposal (Ismail & Manaf, 2013; Alkassasbeh *et al.,* 2009).

Sanitary landfill is an important method for waste disposal in Malaysia (Tweib *et al.,* 2012). Landfill refers to land that has been purposely excavated for the disposal of trash. This method is simpler and cheaper. In Malaysia 70% to 90% of municipal solid waste is disposed of in landfills without being pre-treated. However, the disadvantages of landfilling are environmental pollution caused by leachate (Ismail & Manaf, 2013). According to Chua *et al.,* (2011), landfills containing solid waste is an anaerobic process without oxygen that can produce landfill gases such as carbon dioxide (CO_2), methane (CH_4), hydrogen sulphide (H_2S), ammonia (NH_3) and others. Landfilling is not an ideal option and presents a major challenge in Malaysia due to the increase in waste generation, economic growth, and population growth (Abdul Rahman, 2013; Ismail & Manaf, 2013; Badgie *et al.,* 2012; Behzad *et al.,* 2011).

During the incineration process, materials are burnt at high temperature (Habib *et al.,* 2008). According to Chua *et al.,* (2011), there are four incinerators in Malaysia located at Pulau Pangkor, Pulau Langkawi, Pulau Tioman and Cameron Highlands. Although the disposal of solid waste by incineration does not produce greenhouse gas (GHG), it produces other harmful gases, particles and ashes. According to Abdul Rahman (2013), the toxic contaminants emitted during incineration affect those working in incinerators as well as the community. However, due to the high moisture content (55%) of the organic compounds in MSW, incineration failure is common in Malaysia. This results in additional operating costs to cover auxiliary fuel during the burning process (Ismail & Manaf, 2013; Kathirvale *et al.,* 2004).

According to Abdul Hamid *et al.,* (2012), food waste is disposed of in landfills with other types of waste without being treated or separated. According to Ismail and Manaf (2013), the landfilling of mixed waste is the worst solution of all in terms of biological, chemical and physical degradation processes. The high amount of food waste in landfill contributes to foul odour, toxic leachates, emission of greenhouse gasses, and vermin infestation (Abdul Hamid *et al.,* 2012). In addition, according to an article written by Priya (2017) argued that, food waste which decomposes under low oxygen conditions typically encountered in landfills produces

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