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ASSESSING THE POTENTIAL USED OF EFFECTIVE MICROORGANISM (EM) IN FOOD WASTE COMPOSTING AND IT'S CONTRIBUTION TO REDUCE THE RISK ON HUMAN HEALTH

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BY

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ABSTRACT

ASSESSING THE POTENTIAL USED OF EFFECTIVE MICROORGANISM (EM) IN FOOD WASTE COMPOSTING AND IT'S CONTRIBUTION TO REDUCE THE RISK ON HUMAN HEALTH

NURUL FARAH NADIRAH BINTI ZAINAL

Introduction: Food waste composting with effective microorganism (EM) helps to accelerate the composting process and reduce the unpleasant by-product or the production of residual sludge. **Objectives:** To evaluate the effect of homemade and commercial Effective Microorganism™ (EM) for the home scale co-composting and to measure the nutrient content of the compost as organic fertilizer that has less risk to human health. **Methodology:** Food waste was composed using commercial EM and homemade EM to identify the potential use of EM in composting method and the quality of compost in term of the nutrient content. The experiment was conducted for 8 weeks in dark and covered plastics bin to maintain the heat that produce from degradation process. Temperature, pH and moisture content were measured throughout the experiment. The colour and smell were observed once a week. For nutrient content, Potassium (K) and Phosphorus (P) were determined using Auto Analyzer and Atomic Absorption Spectroscopy, while Nitrogen (N) was measured using Carbon/Nitrogen/Sulphur Analyzer (TruMac CNS Analyzer). **Result:** The pH changes in the homemade EM were more stable compared to the commercial EM compost. After 8 weeks of the composting process, both composts were matured at the pH values of 6.00-8.00. Both composts have similar ranged of moisture content (72%) and temperature (20°C) at the end of experiment. Both of composts produced were well matured within 8 weeks. Compost with homemade EM showed significantly higher N content (3.12%) than the commercial EM (2.26 %). However, both composts have low phosphorus (0.001–0.002%) and potassium (0.004%) content. The sum of NPK content in the compost with homemade EM (3.13%) was higher than the commercial EM (2.27%), thus suggested the positive effect of EM to enhance the NPK of compost (>3%) to exert the fertilizing effect. **Conclusion:** EM application in composting has reduced the duration of composting process to 8 weeks and the compost product is potential to be used as organic fertilizer which is less risk to human health.

Keywords: Effective Microorganism (EM), Food Waste, Composting

ABSTRAK

MENGKAJI KEBERKESANAN PENGGUNAAN EFEKTIF MIKROORGANISMA (EM) DIDALAM PENGKOMPOSAN SISA MAKANAN DAN SUMBANGAN DALAM MENGURANGKAN RISIKO TERHADAP KESIHATAN MANUSIA

NURUL FARAH NADIRAH BINTI ZAINAL

Pendahuluan: Pengkomposan sisa makanan dengan pengunaan Efektif Mikrooganisma (EM) dapat membantu mempercepatkan proses pengkomposan dan mengurangkan penghasilan produk sampingan yang tidak menyenangkan atau penghasilan enap cemar. **Objektif:** Untuk mengkaji keberkesanan penggunaan pembuatan sendiri Efektif Mikroorganisma dan komersial Efektif Mikroorganisma untuk skala kompos rumah dan untuk mengukur kandungan nutrisi kompos sebagai baja organik yang kurang berisiko untuk kesihatan manusia. **Metodologi:** Sisa makanan dikompos mengunakan komersial EM dan buatan sendiri EM untuk mengenal pasti potensi penggunaan EM dalam kaedah pengkomposan dan kualiti kompos dari segi kandungan nutrisi. Eksperimen ini dijalankan selama 8 minggu dalam tangki plastik yang gelap dan tertutup untuk mengekalkan haba yang dihasilkan daripada proses degradasi. Suhu, pH dan kandungan kelembapan diukur sepanjang eksperimen. Warna dan bau diperhatikan sekali semimggu. Untuk kandungan nutrien, Potassium (K) dan Phosphorus (P) ditentukan dengan menggunakan Auto Analyzer dan Spectroscopy Penyerapan Atom, manakala Nitrogen (N) diukur menggunakan Carbon / Nitrogen / Sulfur Analyzer (TruMac CNS Analyzer). **Keputusan:** Perubahan pH dalam EM buatan sendiri lebih stabil berbanding kompos EM komersial. Selepas 8 minggu proses pengkomposan, kedua-dua kompos telah matang pada nilai pH 6.00-8.00. Kedua-dua kompos ini mempunyai kandungan kelembapan yang sama (72%) dan suhu (20ºC) pada akhir percubaan. Kedua-dua kompos yang dihasilkan matang dalam tempoh 8 minggu. Kompos dengan EM buatan sendiri menunjukkan kandungan N yang lebih tinggi (3.12%) daripada EM komersial (2.26%). Walau bagaimanapun, kedua-dua kompos mempunyai kandungan Phosphorus rendah (0.001-0.002%) dan Potassium (0.004%) kandungan. Jumlah NPK dalam kompos dengan EM buatan sendiri (3.13%) adalah lebih tinggi daripada EM komersil (2.27%), mencadangkan kesan positif EM untuk meningkatkan kompos (> 3%) NPK kompos. **Kesimpulan:** Hasil menunjukkan kesan positif aplikasi EM dalam mengurangkan masa proses pengkomposan hingga 8 minggu dan produk kompos berpotensi untuk digunakan sebagai baja organik yang kurang berisiko kepada kesihatan manusia.

Kata Kunci : Efektif Mikroorganisma (EM), Sisa Makanan, Kompos

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Food waste is defined as a discarding or alternative (non-food) use of a food that is give a benefit for human consumption start from primary production until the end of consumer level (FAO, 2017). Food waste also can be described as all the food materials that left uneaten or throw away which is was produced for human consumption (Ghafar, 2017). Food waste is not only occurs at the end of the consumers level, but it start from initial agricultural process to the final use of consumer. Armi & Khairul (2017) stated that Malaysia has been throwing 15 000 tonnes of food waste per day from 38 000 tonnes of total municipal solid in 2015 (Solid Waste and Public Cleansing Management Corporation (SW Corp), 2016). In another study reported 930 tons of unconsumed food were thrown away by Malaysian for each days (Jereme, et.al, 2016) and 60% of the municipal solid waste in Malaysia are comes from food waste and estimated to increase to 6.54 million tons in 2020 (Hamid, et.al, 2012).

Lim et al, (2016) divide food waste into three groups which is food losses, unavoidable food waste and avoidable food waste. There are 6 stages of food wastage which is start from the farm, before shipment, in the truck, supermarket and restaurants, in the fridge and the last stage at the consumer. For example, for fruits and vegetables, it's easy to damage and its will through gradation's process before it will deliver to consumer. At this stage, almost 17% of agriculture product will be throwing because do not fulfil the standards of marketing (Ghafar, 2017).

A collaboration project between the Ministry of Housing and Local Government Malaysia (MHLG) and Ministry of the Environment Japan (MOEJ) have developed a National Strategic Plan for Food Waste Management in Malaysia (National Solid Waste Management Department, 2013). Few strategies was finalized including government support in data collection, regulations set up for food waste management and incentives for the implementation of the strategies, establish more centralized facilities for food waste treatment with active participations, appropriate final disposal and a proper treatment to turn food waste into resources at source.

According to Manaf, Samah, & Zukki, (2009), most common disposal method in Malaysia are landfilling, where most of the landfill site are open dumping areas, which will cause serious environmental and social threats. Malaysia facing a problem such as urban solid waste management problem as landfills are rapidly overload, while the amount of waste generate become increase day by day, the lack of disposal sites, resulting of serious environmental and human health effects problem (Mahmood, 2009). Besides that, landfills also produce leachate which is contains a toxic substances and cause an emissions of greenhouse gasses (GHG) to the atmosphere.

Due this condition, people are encouraged to practicing composting. Li et.al (2013) defined composting as a biochemical process converting various components in organic waste into relatively stable humus-like substances that can be used as a soil amendments or organic fertilizer. Other than that, Kadir et al (2016) defined composting as a natural process that turns food waste into compost which is rich with the nutrient that goods for soil. There are several benefits of composting which is reduce the volume of food waste disposed in landfill, produce new organic fertilizer, improve soil structure and fertilizer and reduce the groundwater contamination, air pollution and greenhouses gas (GHG) releasing (Li et.al, 2013).

But, due to some disadvantages of composting such as time consuming to produce matured compost and it also produce smelly odour during the process (Fan et al, 2017), less people are practicing composting at home. Then, the researchers used Effective Microorganism (EM) in composting.

According toKathrick and Kirithiga, (2010), Effective Microorganism is a mixture of microorganism such as lactic acid bacteria, yeast, photosynthetic bacteria, fermenting fungi and actinomycetes. There are several benefits of EM such as helps to reduce the duration of composting. Other than that, it also helps to reduce the production of smelly odour during the composting process and helps to increase the number of nutrient in compost product.

1.2 Problem Statement

Municipal solid waste generation is increased with the growth of population especially in the urban area. According to the Global Environment Centre (2017), Malaysia had produced almost 23,000 tonnes of waste and the volume is expected to increase to 30,000 tonnes by year 2020 with the increased of human population and development, and only of 17% of the waste is being recycled (SWM Corporation, 2017).

The statistic has shown solid waste in Malaysia consists of 50% food waste at source and 70% of the food waste disposed through landfills (National Solid Waste Management Department, 2013) Disposal of food waste in landfill is considered as low cost and easy to be managed compared to other type of disposal method such as incineration.

However, excessive disposal of food waste in landfill may cause excessive organic material decomposition in the landfill and the disposed waste undergo infiltration from precipitation and produce leachate (waste water). Leachate content toxic elements that accumulate at the bottom of landfill and absorbed through the soil and groundwater and further pollute the ecosystem and human (Nagarajan, Thirumalaisamy & Lakshumanan (2012). These pollutants give an adverse effects on aquatic population, ecology and food chain, which can indirectly effects human health such as carcinogenic effects, acute toxicity and genotoxicity after consumed from that affected sources (Aminah et al., 2016; Ghafar, 2017). Previous study by

Tengku Nilam, Zalina & Faridah (2016), estimates the leachate generation in landfills in Selangor as 7175 m^3/ year. The volume of leachate produce was influenced by the annual rainfall pattern.

Furthermore, landfill also generates greenhouse gas (GHG) emissions such as Methane (50-55%) and Carbon dioxide (40-45%) from the biodegradation process that contribute to climate change and global warming. The atmospheric methane concentration reported increasing at the rate of 1% per year and the most common sources of methane emission comes from landfills, coal mining and the production and distribution of natural gas (Thorneloe & Peer, 2015). The aggregate methane discharge and those from waste management represent 14.3% and 2.8% individually of the world wide greenhouse gasses (GHG) outflows in 2004. Bo-Feng et al.,(2014) stated in their study that the methane emission from waste management shared 4% of the worldwide aggregate greenhouse gasses (GHG) discharge in 2010 with about half both from civil strong waste (MSW) landfill and waste water treatment.

One way of controlling the effects of landfill pollution from food waste decomposition was through composting technique. Composting can reduce the volume of food waste from entering the landfill and also minimize the impact to the environment. A study by Li et al., (2013), indicate, composting as a biochemical process changing over different segments in natural waste into moderately stable humus-like substances that can be utilized as soil alteration or natural manure. Through composting, environmental pollution such as groundwater contamination, air pollution, greenhouse gas (GHG) releasing can be reduced and beneficial by-products will be produced. It also produces new organic fertilizer and improves the soil structure and fertility.

However, composting has been reviewed as not efficient and less viable technique because of it slow process, take a lot of space, produce unpleasant odour and produce different product or quality of compost depending on several factors that influence compost maturity (Kadir et.al, 2016). Therefore, Effective Microorganism or effective microbe (EM) as a catalyst to speed up the process of composting, increase the number of nutrient in compost and reduce the unpleasant odours has been introduced by several researchers to be applied on food waste composting as a more environmental friendly method (Aminah et al., 2016; Lokman et.al, 2013; Lokare,et.al, 2007). Szymanski & Patterson (2003) also reported EM can turn carbon dioxide and methane and utilize it for development and multiplication to reduce the unpleasant by-product or the residual sludge. EM also was reported able to enhance the soil fertility to increase the crop fields and crop quality. It also helps to correct nutritional and physiological crop disorder, and minimize the disease of plants.

EM is a non-genetic modifications organism, not pathogenic, not harmful and not chemically synthesized which is safe to be use in environment (Zakaria, Gairola, & Shariff, 2010). The principle of EM is to convert of harmful microorganisms to useful and safe microorganisms which are commonly designed for agriculture and environmental management.

Limited studies found exploring the effectiveness of EM use in accelerating the composting process. A recent study conducted by Fan et al., (2017) has suggested the positive effect provided by EM was notably in odour control and humification in the home scale co-composting of food waste, rice bran and dried leaves. Home scale composting was carried out with and without EM (control) to identify the roles of EM and the results showed the composting parameters for both trials were in similar trend of changes during the decomposition. However, the function of EM to facilitate the composting process is depending on the type of waste to be managed as well as the aims of using it. It was also highlighted that EM is less significant in enhancing the composting performance when the waste consists mainly of food waste where the microbial population is readily available in abundance.

Therefore, this study was designed to assess the potential used of home-made EM in enhancing the composting process in comparable to commercial EM and its contribution to produce organic fertilizer that can reduce health risk. A general information on this is lacking regarding the efficiency of the home-made EM in inoculation composting. The final products of compost can be used for organic farming as an organic fertilizer as it has high nutrient content of Nitrogen, Potassium and Phosphorus for plant and this practice can help to reduce the contamination of soil with the using of inorganic fertilizer and protect the food chain and human health (Kadir et.al, (2016). The functions of Nitrogen in fertilizer are important for the plant growth, physiology and carbohydrate content. Phosphorus is most important element which is to energy transfer and storage, while Potassium is to maintain the osmotic balance, phloem transport and photosynthesis in plants (Hasmah et.al, 2015).

1.3 Study Justification

According to Kadir et.al, (2016), Malaysia commonly used landfills as a main method disposal of solid waste and 50% landfill containing with food waste. There are various sources that generate food waste such as agriculture, household, commercial, institutions and industries. Increasing numbers of landfill will produce another problem such as increasing emission of greenhouse gases (GHG) which is emitted to the atmosphere during the process and producing of leachates in landfills.

Composting is an alternative ways that can be used to dispose food waste in developing countries such as Malaysia due to cost-effectiveness, environmental sustainability and well known among consumers. Unfortunately, the study of home scale composting are less been studied a broadly as compared to the industrial scale composting. Lack of knowledge and technique to manage home scale composting is the main course of less practice composting at home (Fan et al., 2017). Besides that, our community would rather pay higher prices for waste management to authorities compared deal or manage the waste by themselves.

Another issues is composting will take a long time to produce mature compost, takes a lots of space and will produce earthy smelly during the process. Because of these issues, Effective Microorganism (EM) was used as a technology in compost method. EM is a mixture group of microorganism such as lactic acid bacteria, photosynthetic bacteria, yeasts, actinomycetes and fermenting fungi that reviving action on humans, animals and the natural environmental ad also as a multi-culture of co-existing anaerobic beneficial microorganism (Sekeran, Balaji, & Pushpa, 2005).

There are lots of advantages of EM in composting process such as reduce odour, increase the decomposition rate, producing compost with higher nutrient, useful additive when microorganisms are compatible with the characteristics of the waste to be composed, increase enzymatic activities, promote biodegradation of organic matter, accelerate the composting process and degrade waste satisfactorily given the optimum environmental conditions (Fan et al., 2017).

The nutrient content (Nitrogen, Phosphorus and Potassium) in food waste compost had been analysed to make sure all the nutrient content do not exceed or less than the standard. Besides that, the analysis was been done to avoid any affects to human health and to control the excess flow of nutrient content into ground water and water system (Hogarh et.al, 2008).

Next, it hopes that all the results and information obtained from this study can be used as reference in Malaysia, especially in home food wastage composting process. Besides that, the findings of this study can also be used to educate and increase the awareness among human population about the potentially harmful effects of solid waste on environment and human.

1.4 Objectives

1.4.1 General Objectives

To assess the potential use of Effective Microorganism (EM) in food waste composting and its risk on human health.

1.4.2 Specific Objectives

1. To produce homemade Effective Microorganism (EM) from collected fruits waste.

2. To compost the food waste using homemade Effective Microorganism (EM) and commercial Effective Microorganism (EM).

3. To compare the pH, temperature, moisture content, smell and colour of homemade EM compost and commercial EM compost by weeks (i.e. 8 weeks).

4. To compare the maturity of homemade EM compost and commercial EM compost by weeks (i.e. 8 weeks)

5. To compare the nutrient content (Nitrogen, Phosphorus and Potassium) of the homemade EM compost, commercial EM compost

6. To compare the nutrient content of the homemade EM compost, commercial EM compost with the typical ranges of fertilizer for agricultural.

7. To determine the relationship between the pH, moisture content and temperature of compost.

8. To determine the relationship between pH, moisture content and temperature with the NPK concentration of compost.

1.5 Hypothesis

1. The compost become more matured when at slightly alkaline of pH level.
2. The faster the compost achieves and maintain at the ambient temperature, the matured of the compost.
3. The higher of moisture content of compost, the more quality of the compost.
4. The faster of the colour change to dark brown and no smell, the more matured of the compost.
5. The higher level of nutrient content is more suitable for agricultural use.
6. The higher the temperature, the higher the pH and moisture content.
7. The high the concentration of nutrient content, the higher of pH, moisture content and temperature.

1.6 Definition of Terms

1.6.1 Conceptual Definition

i. Food Waste

Food waste was described as all suitable and safe food materials produce for human consumption but left uneaten, either throw away or discarded throughout the food supply chain, from farm to consumer's table. Food waste discharged from various sources such as agriculture, household, commercial, institutional and industries (Ghafar, 2017). "Food Loss and Food Waste | FAO | Food and Agriculture Organization of the United Nations," (2017) refer food waste to the decrease of food in subsequent stages of the food supply chain intended for human consumption. Food is lost or wasted throughout the supply chain, from initial production down to final household consumption.

ii. Composting

Composting is a biochemical process converting various components in organic waste relatively stable humus-like substances that can be used as a soil amendment or organic fertilizer (Li et al., 2013). In additional, composting is the process of biological decomposition of organic material through the generation of heat and stabilized the product to the point that it is beneficial to plant growth (The US Composting Council, 2001).

iii. Effective Microorganism (EM)

Effective Microorganisms (EM) is a mixture of a organisms that has a reviving action on human, animals, and the natural environment (Higa 1995) which is also described as a multi-culture of 'co-existing anaerobic and aerobic beneficial microorganisms (Szymanski & Patterson, 2003).

1.6.2 Operational Definition

i. Food Waste

Food waste is leftover of food or uneaten food such as rice, chicken, fish, sauce, oil, salt, fruits and vegetables that collected from cafeteria of Faculty of Medicine and Health Science, Universiti Putra Malaysia, Serdang, Selangor.

ii. Composting

Composting of converting food waste such as rice, chicken, fish, sauce, oil, salt, fruits and vegetables to produce compost product which was measured by pH, temperature, moisture content, stability, maturity, colour, odour and nutrient content in composting using homemade EM, commercial EM and without EM.

iii. Effective Microorganism (EM)

Mixture of effective microorganism that been used as a catalyst in composting process. The homemade Effective Microorganism (EM) was made from mixture of fruit waste (papaya and apple), molasses from brown sugar, rice and water. While, commercial Effective Microorganism was purchase from EMRO Sdn. Bhd, Malaysia.

1.7 Conceptual Framework

Figure 1.3 shows the conceptual framework of this study. There are three independent variables in this study which is composting using the homemade Effective Microorganism (EM), composting using the commercial Effective Microorganism (EM) and composting without using Effective Microorganism (EM). The dependent variables are physicochemical properties (pH, temperature, colour, odour and moisture content), stability and maturity, and nutrient content (Nitrogen, Phosphorus and Potassium).

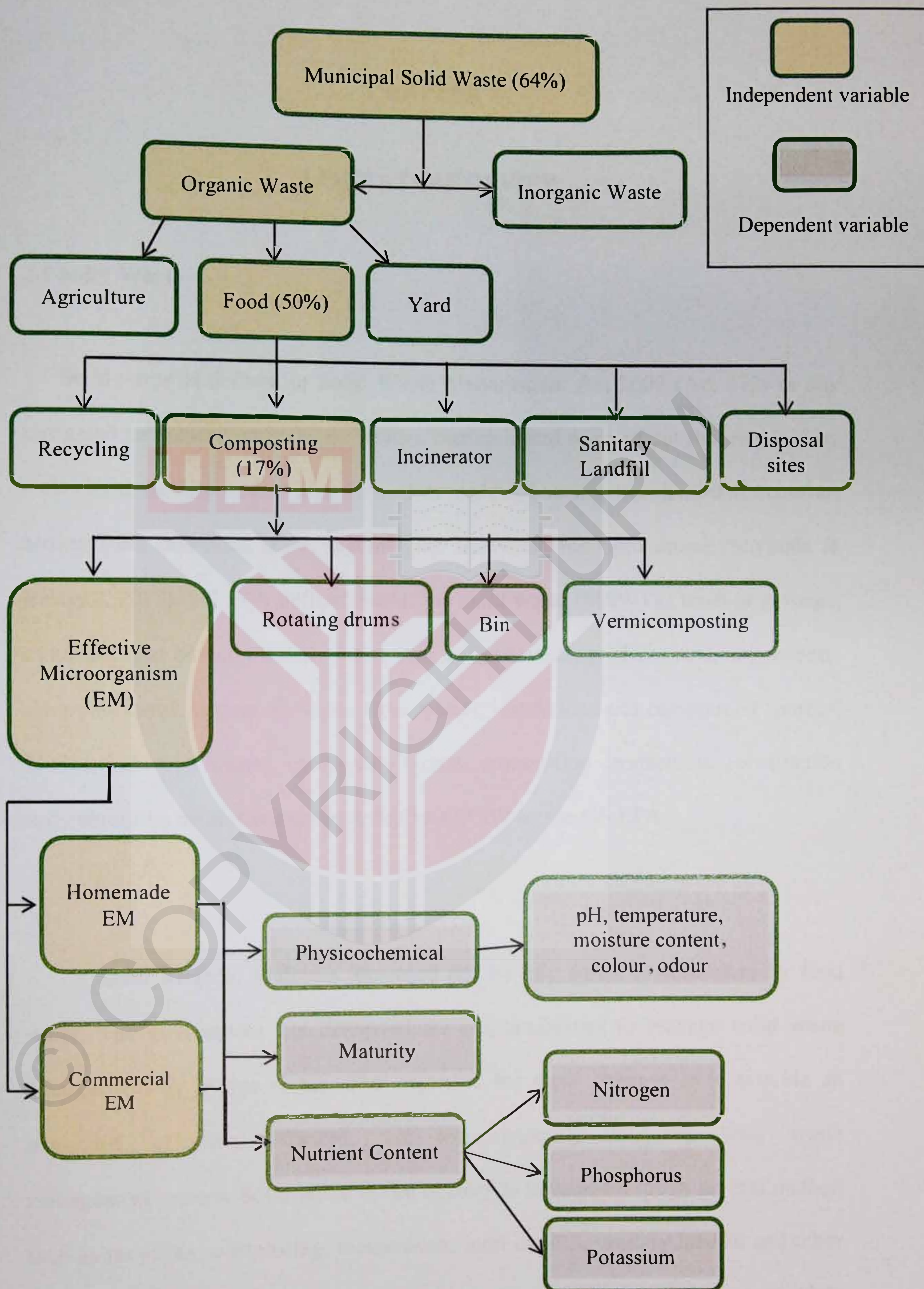


Figure 1.1: Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Solid Waste

Solid waste is defined in Solid Waste Management Act 2007 (Act 672) as any unwanted substances, material or broken, contaminated or worn out that required by authority to be disposed. It also defined as useless, unwanted or discarded materials arising from domestic, trade, commercial, industrial and agricultural (Shymala & Belagali, 2012). US EPA defined municipal solid waste (MSW) as trash or garbage, as a waste that contains a daily items such as food waste, garden waste, newspapers, electronic items, commonly come from homes, institutions and commercial sources. Sludge, industrial wastes, automobile wastes, combustion products, or construction and demolition decries are not included as a MSW by the US EPA.

Solid waste in Malaysia increased day by day which is dominated by food waste. The government has delegated the responsibilities to manage solid waste management to private sector. The objective for these changes is to provide an integrated, effective, efficient, and technologically advanced solid waste management system. Solid waste in the country is managed through several method such as recycling, composting, incineration, inert landfill, sanitary landfill and other disposal sites (Ghafar, 2017). The government also provides a lot of efforts to adapt proper planning, management, and project or programme to manage the food waste and to increase the awareness among Malaysian consumer such as Separation at Source's programme.

In 11th Malaysia Plan (2016-2020) stated the strategy for managing waste holistically which want to increasing coordination on waste management, encourage habits of reuse, reduce and recycle (3R) and increasing investment in waste as a resources. There are several methods that can be used to disposed food waste which is sanitary landfill, incinerator and composting (Kadir,et.al, 2016).

In the study of Manaf, Samah, & Zukki, (2009), solid waste in Malaysia are categorized into three major categories which is Municipal solid waste, schedule or hazardous waste and clinical waste. These three major categories of solid waste were managed by different government department. For example, Municipal solid waste under the responsibility of Ministry of Housing and Local Government (MHLG), Schedule or hazardous waste under Department of Environment (DOE) and Clinical waste under Ministry of Health (MOH).

As the population in the country increase from 23.49 to 30.65 million between 2000 and 2015 had caused waste generation increased (Abdul Samad, Jamin, & Saleh, 2017). The total daily of Municipal Solid Waste generate are between 29,711 tonne/day in 2012 and by 2020, their estimates that the overall of MSW will becomes 36,165 tonne/day. Solid wastes in one of the big problems because it was produce every second and every time and it will give an impact to us especially environmental and human health if not properly manages. It consists of organic and inorganic waste, which is organic waste mainly consists of food waste and inorganic waste consists of recyclable materials (Armi & Khairul, 2017).

According to Manaf, Samah, & Zukki, (2009), the increasing numbers of solid waste in Malaysia also encourage by rapid economic development and population growth, lack of adequate infrastructure and expertise, and land scarcity. The per capita generation rate of solid waste is around 0.5 – 0.8 kg/individual/day in which domestic are the primary source. Economic and geographical status of the certain area also influenced the amount of waste generation. For example, an urban city such as Kuala Lumpur generates 1.5kg/person/day of municipal solid waste as compared to the rural areas generate only ranging from 0.5 kg to 0.8 kg (Kadir & Abidin, 2016).

2.2 Solid Waste Generation in Malaysia

The overall waste type generated in Malaysia is municipal solid waste (MSW) (64%), industrial waste (25%), commercial waste (8%) and construction waste (3%) (Moh & Manaf, 2014). Malaysia produces almost 33,000 tonnes of solid waste per day and will exceed the limit of production of 30,000 tonnes by 2020 (Ghafar. S, 2017). Table 2.1 shows the trends of solid waste generation in major urban area in Peninsular Malaysia from 2002-2010 by Fauziah & Agamuthi (2010). The total of solid waste generation in all state has increased, especially in urbanized area such as Kuala Lumpur and Klang.

Table 2. 1.: Generation of solid waste in urban areas in Peninsular Malaysia (2002-2010), (Fauziah & Agamuthu, 2012)

Urban areas	Solid waste generation (tonnes/day)		
	2002	2006	2010
Kuala Lumpur	2754	3100	3489
Johor Bahru	215	242	272
Ipoh	208	234	264
Georgetown	221	249	280
Klang	478	538	606
Kuala Terengganu	137	154	173
Kota Bahru	129.5	146	165
Kuantan	174	196	220
Seremban	165	186	209
Melaka	562	632	712

2.3 Waste Composition

The waste composition of municipal solid waste in Malaysia can be categorized in to 6 groups which is; organic waste, platics, paper, metal, glass and others (Armi Abu Samah et al, 2013). Figure 2.1 shows the waste composition in Peninsular Malaysia consist of organic waste such as food waste (45%) as the highest, followed by plastics waste (24%), glass (18%), paper (7%) and metal (6%). The waste composition is related to human or community activities such as commercial, institutional, industial and markets (Armi Abu Samah et al, 2013).

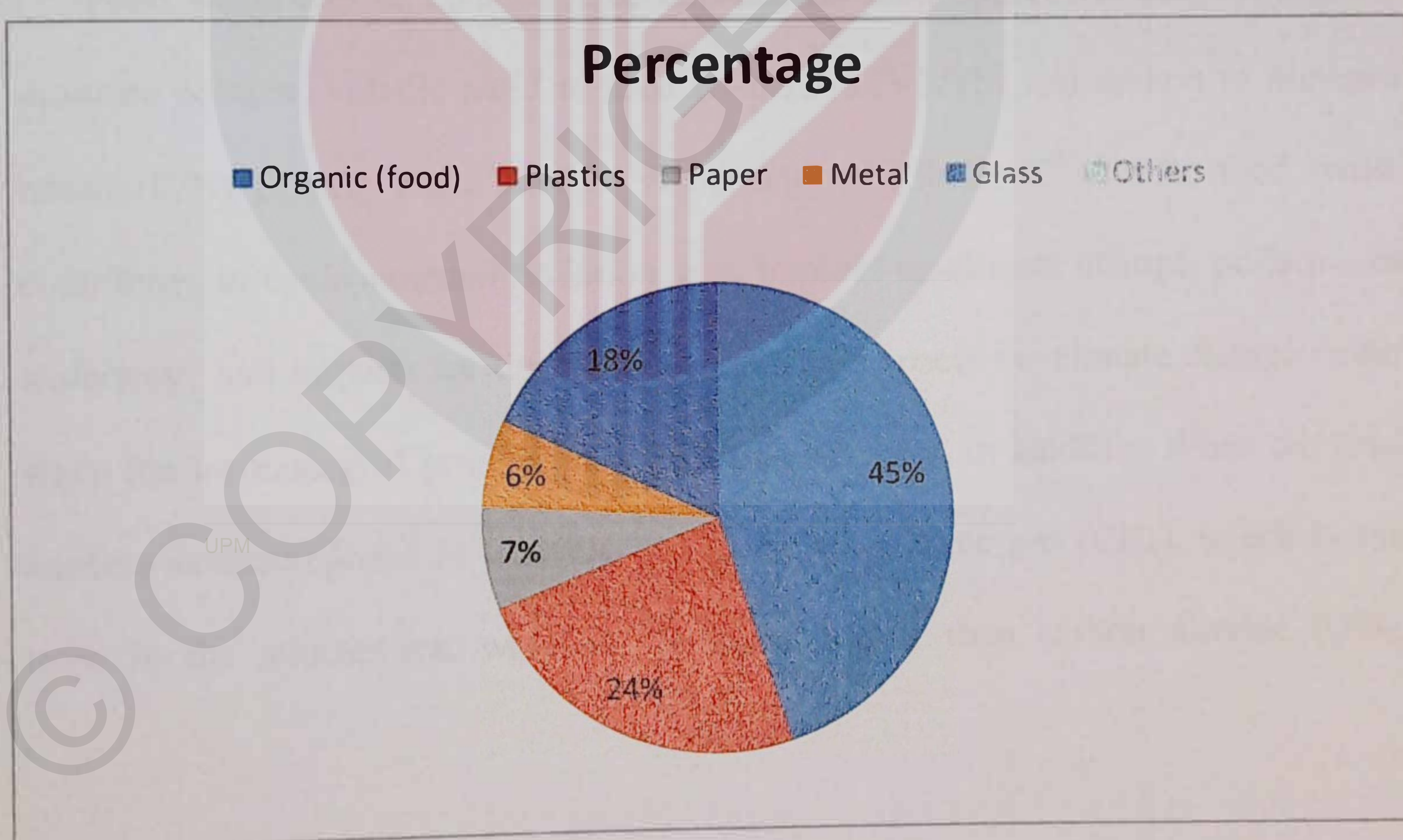


Figure 2. 1: Waste composition generated per day in Peninsular Malaysia (Zainu, Z. A., & Songip, A. R., 2017)

2.4 Food Waste

Municipal solid waste in Malaysia consists of 45% of food waste and almost 70% of food waste was disposed in landfill. In 2015, the food waste production in Malaysia had reached 15,000 tonnes per day Ghafar (2017). Menteri Alam Eko (M) Sdn. Bhd ("MAEKO - The Food Waste Specialist," 2018) stated that the 15,000 tonnes of food waste that produce by Malaysian daily is enough to feed almost 2.2 million people in this country.

Food waste can be characterized depends on their sources of content such as moisture content, volatile solid to total solid ratio (VS/TS) and carbon to nitrogen ration (C/N) (Zhang et.al, 2007). According to Kibria, G. (2017), food waste contributes to environmental pollution such impacts on climate change, pollution of waterways and impacts on water resources. The impacts on climate change occur when the increasing of greenhouse gas (GHG) emission in landfills. When the food waste was decomposed in landfills, it will emits methane gas (CH_4), which is can traps in the atmosphere, which is 21 times higher than carbon dioxide (CO_2).

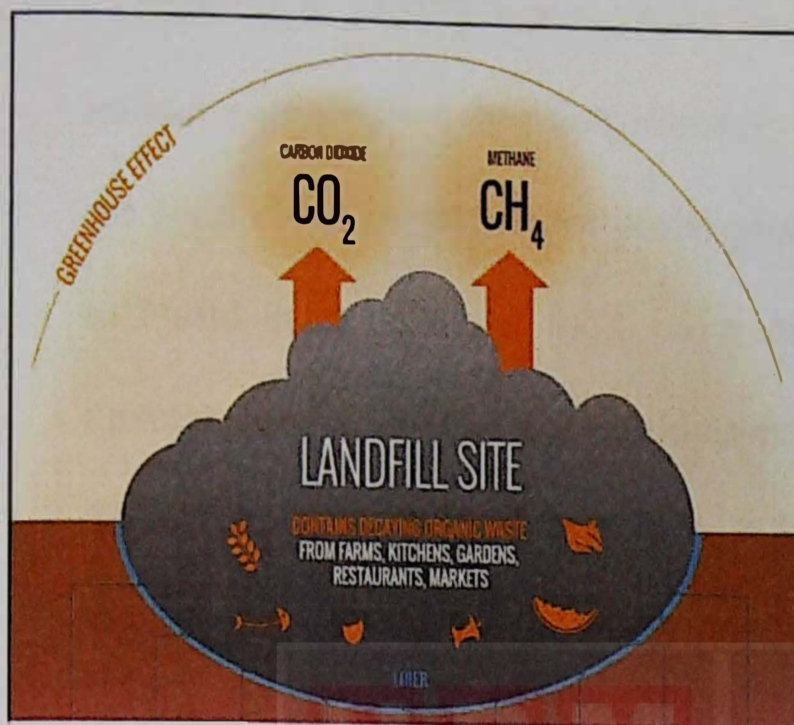


Figure 2. 3: Process formation of methane (CH4) and carbon dioxide (CO2)

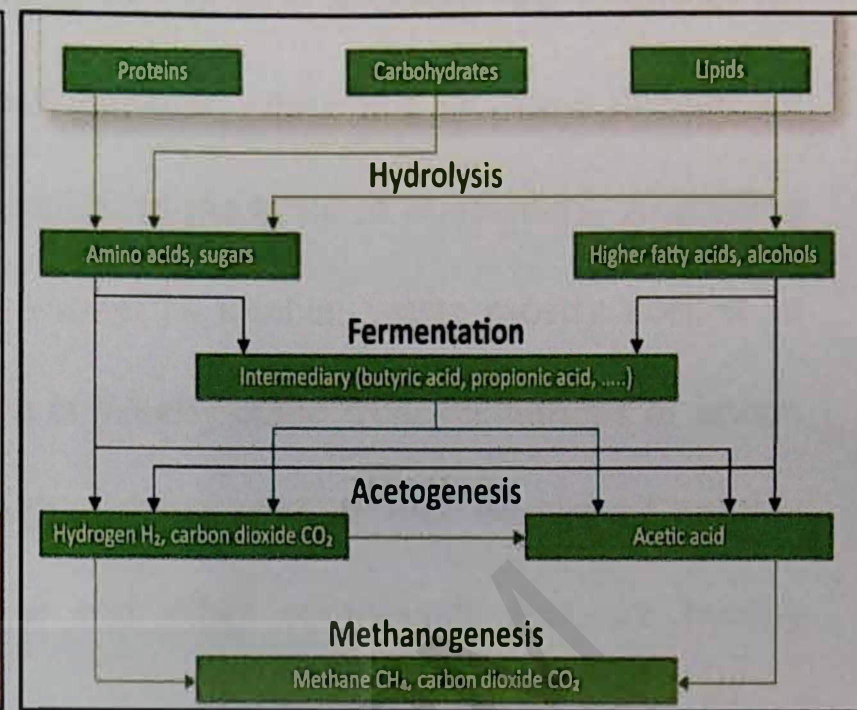


Figure 2. 2: Chemical Process of Methane (CH_4) and Carbon dioxide (CO_2)

Food waste also made up from carbohydrates, proteins and lipids. This components will undergoes the process of hydrolysis which is protein and carbohydrates will break up into amino acids and sugar, while lipids will break up into fatty acids and alcohols. This substances continued to undergoes fermentation process and produces intermediary substances such as butyric acid, propionic acid and so on. After that, process of acetogenesis will occurs. The last process is methanogenesis which is will produce methane and carbon dioxide.

Food waste also cause the pollution to waterways through leachate which is can contaminate the groundwater that causing impacts in land and aquatic life. Besides that, the impacts of landfill towards water resources is it will drain out the toxic substances to water resources and will effected human health (Kibria G, 2017).

Ghafar, S. (2017), defined food waste as all safe food materials that produced for human consumption but unfortunately left uneaten, either lost or throw throughout the food chain supply, from initial production to the table of consumers. According to Hafid et al., (2010), food waste or known as kitchen waste mostly consist of uneaten food and food preparation which is usually come from restaurants or home. The characteristic of food waste is high organic content that consist of soluble sugars, starch, lipids, protein, cellulose and other compounds that are readily biodegradable which is can inhibit bacteria. In additional, almost one-third of food that produces for human consumption is lost globally which is about 1.3 billion tonnes per year.

Fan et al., (2017) stated in their study that food waste is categorized as active waste which contains low carbon-to-nitrogen where this condition leads the production of odour by emission of ammonia. Besides that, food waste contains high moisture content which reduces the movement of oxygen and can lead to an anaerobic condition that can cause the production of unpleasant odour.

The increasing number of Malaysia's population contributes to the increase the number of food waste because of the economic development, population growth and urbanization which is to fulfil the demand among the population. The reasons of the issues become worse are because of the improvement or changes of eating habits according to the improvement of living standards, where nowadays everyone can afford more food products than a few years back and the rapid of human population and urbanisation (Lim et al., 2016a). Malaysia Solid Waste and Public Cleansing

Management Act 2007 (Act 672) categorised food waste disposal under disposal of solid waste.

2.5 Solid Waste Management

In Malaysia, landfills are the common methods that being used to food waste disposal including solid waste disposal. According to (Moh & Manaf, 2014), landfill methods are the general and acceptable method to managing food waste because of the cost effective and simple to manage. The difficulties of food waste management in landfills comes when it reach the capacity. 95% of Malaysian waste was disposed at 165 disposal site in Malaysia (Fauziah & Agamuthu, 2010).

Landfills are widely used as waste management method as it low cost and easy to manage. There two types of landfill in the country which is the sanitary landfill (fully equipped landfill with environmental protection measures) and non-sanitary landfill (less environmental control measures). Most of the landfills in Malaysia is a non-sanitary landfill (Johari et al, 2012).

According to Ministry or Urban Wellbeing, Housing and Local Government (2015), the government has made the Separation at Source as a mandatory for consumer to separate solid waste at source start from 1 September 2015 under the regulation Solid Waste and Public Cleansing Management Act 2007 (Act 672). The stated such as the Federal Territories: Kuala Lumpur, Putrajaya, Johor, Melaka, Negeri Sembilan, Pahang, Kedah and Perlis have implemented this act. The main objective for the Act is due to lack of food recovery, low awareness among the consumer and the low demand for product to be recycled from food waste (Armi & Khairul, 2017).

Composting is the best of alternative method that can be used to retreat the food waste produce and from entering the landfills to dispose but still have a lacking in this method. Aminah, Norkhadijah, & Praveena, (2016) stated that composting takes a time to make it matured and ready to be used as an organic fertilizer to builds soil structure, enable soil to retain the nutrient contents, water and air; helps to maintain a neutral pH and protects plants from diseases. Besides that, the process of composting also produce unpleasant odour because of the content of organic compounds.

The proper disposal management needs to conduct according to the current situation where the totals of waste generation almost increase year by year. The proper disposal management was very important because it will affect the sanitation and the health of community.

According to Fauziah & Agamuthu (2012), landfills needs to be manage effectively and must be sustainable landfill to reduce the impacts to the environments and community. The current landfill in Malaysia consists of 2 types which is non-sanitary landfills and sanitary landfill. The differences between non-sanitary landfill and sanitary landfill are the non-sanitary landfills were constructed without the proper engineering plan compared to sanitary landfill.

Figure 2.2 shows the location of landfill sites in Peninsular Malaysia which is 165 of landfill that operate to manage waste in our country. Some of the landfill are closed due to over capacity of waste.

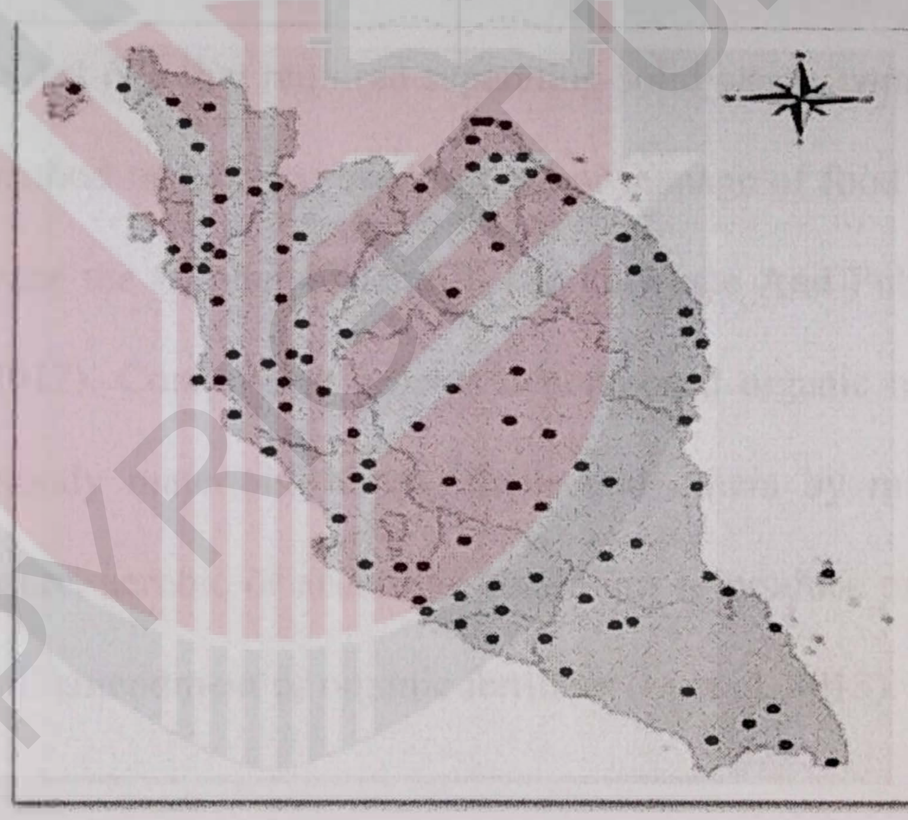


Figure 2. 4: The location of existing and closed landfills sites in Peninsular Malaysia, which is almost 80% of landfills, was almost reached full capacity (Zainu, Z. A., & Songip, A. R., 2017)

In Malaysia, the new technology or second method being used for waste management is an incinerator. Incinerators are good to manage various type of waste. This technology used a combustion- based process to treat the waste but without the proper effective control it will cause harmful pollution (Zainu, Z. A., & Songip, A. R., 2017)

2.6 Food Waste Management

In Malaysia, the solid waste management waste conducted by private sector such as Alam Flora Sdn. Bhd, Northen Waste Industries Sdn. Bhd, Eastern Waste Management Sdn. Bhd and Southern Waste Management Sdn. Bhd (Fauziah & Agamuthu, 2010), which is to achieve and provide integrated, effective, efficient and technologically advanced of waste management (Ghafar,S. 2017).

According to Act 672 that required separating solid waste, composting is the best of alternative method that can be used to treat or manage of food waste instead of build up or increase the number of landfill (Solid Waste And Public Cleansing Management Act, 2017). Composting process decomposed organic matter such as meat, vegetables, woody materials, bones, shells and others by microorganisms under standard moisture, aerobic or anaerobic conditions to produce products which is can be used as a soil amendment or organic fertilizer (Li et al, 2013).

According to Lim et.al (2016), the management of food waste in Malaysia are less efficient because of the limited budget. However, the National Strategic Plan for Food Waste Management in Malaysia with the collaboration of Japan government's Ministry of Environment was planned in 2010 to encourage people in practising a good habit of food waste disposal such as separating food waste from the others waste . However, our food wastes still being disposed in landfill.

According to Domingo & Nadal, (2008), there are three ways that compost can be effect to human health. First, through the ingestion of soil treated with the contaminated compost, these usually occur at children stage. Second, contamination through the food chains by consumption of product that applying compost on the soil. Lastly, the emission of atmospheric dust of compost which is can have toxic microorganism and toxic substances that can be inhaled by human. The final products of composting usually are used as an organic fertilizer. In study of Hogarh et al, (2008), in urban and peri-urban area in Ghana, they usually produced a compost to be applied to agricultural production of vegetables. But, the compost that locally produced by the population was applied without the knowledge about the nutrient compost which is they do not know whether it safe or can affected to human health. The over use of compost may lead to excess nutrient loading into the water sources.

Jasmin & Norizan (2017) stated that the most suitable methods for treating the biodegradable waste such as food waste are through composting method. This is because, composting helps to reduce the significant amount of greenhouse gasses (GHG) emitted to the atmosphere. The example of gasses emission are methane, carbon dioxide, nitrous oxide and other type greenhouse gasses (Zainu, Z. A., & Songip, A. R., 2017). The emission of these gasses can cause negative effects to environment and will affects to human health.

The production of food at different stages has considered as a contributor to the global warming and give an environmental impact due to loss of natural resources was used to produce the food and emitted the greenhouse gasses (GHG) during the production and disposal of food waste. Food waste contribute to environmental issues because of the improper separation of municipal solid waste and it also cause the production of greenhouse gasses and leachate in landfills (Moh & Manaf, 2014).

According to study of Aminah, Norkhadijah, & Praveena, (2016), leachate was produced from the decomposition process of organic substances in food waste. The leachate produce in landfills contains of toxic elements such as aromatic compounds, halogenated compounds, phenols, pesticides, heavy metals and ammonium. This products will give a negative impacts to aquatic life forms, environment and also to food chains which is can lead to various of problems in public health.

35% of carbon dioxide emission from industries, 47% of methane emission by landfills and 60% of nitrous oxide emission from agricultural soils, start from production to disposal of food waste. The emission of greenhouse gasses (GHG) can cause the negative effects to human, animal and others such as climate changes, which is can cause global warming (Thi, et.al, 2015).

In study of Zainu, Z. A., & Songip, A. R., (2017), in 2010, Malaysia produced 42.2% more of Methane, 25.5% more Carbon Dioxide, 10.4% more Nitrous Oxide and 99.9% of other type of greenhouse gasses (GHG) compared than previous years between 1990-2010 by World Bank statistics.

In United States, approximately 15.4 % of human-related methane emission produces in 2015. There are several human sources of methane which is come from fossil fuel production, distribution and use, livestock farming, landfills and waste, biomass burning, rice agriculture and biofuels. The most important of human source of methane emissions is come from landfills and waste which is generated by the decomposition of solid waste. Other studies states that 55 million tons of methane gases were produce per year. The process of production of methane gases in landfills occurs when the organic mattes in landfills which is contain of organic matters such as food waste, newspapers, dry leaves was trapped in conditions where there is no oxygen. This is excellent conditions to produce microbes to break down the waste. During the breakdown of the waste, methane gases were produces (U.S. Environmental Protection Agency, 2017)

According to (World Health Organization, 2017), lifetime of methane in atmosphere is much shorter than carbon dioxide but methane is more efficient at trapping radiation compared to carbon dioxide. Methane do not give an direct human health but the impact of methane is more than 25 times greater than carbon dioxide over a 100-year period. Methane is precursor to ozone which is ozone itself is a greenhouse gases.

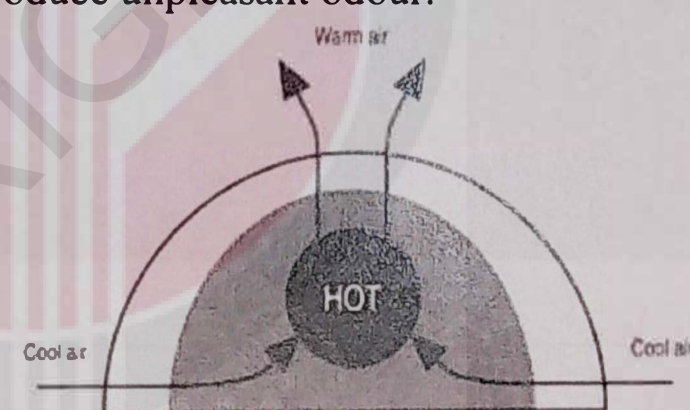
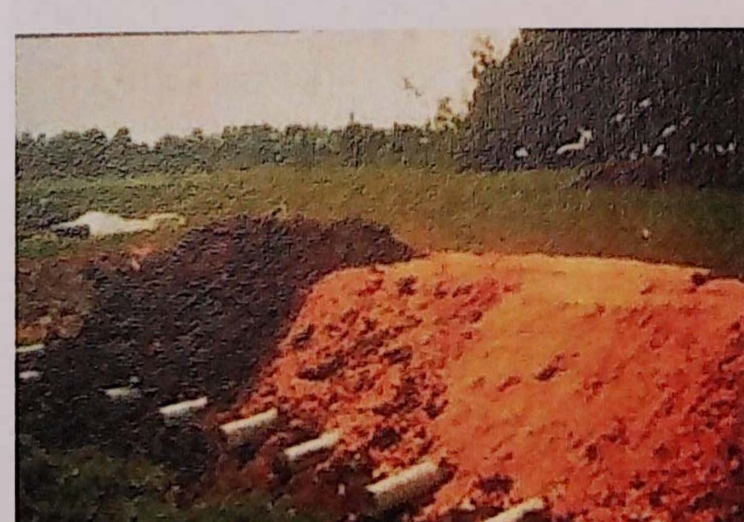
2.6.1 Food waste Composting

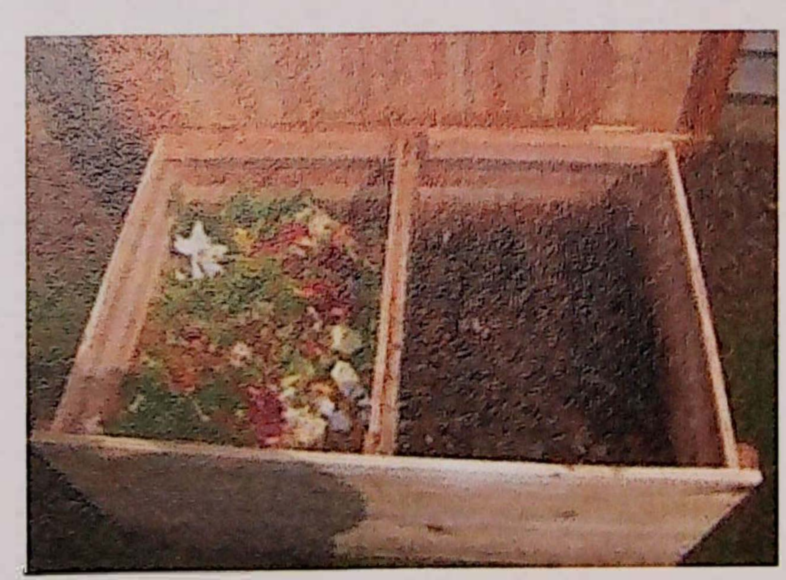
Composting was defined as a process decomposed of organic matter by several microorganisms under certain moisture, aerobic or anaerobic conditions to produce compost's products which a stable, low in moisture and free from pathogen. In additional, composting is sustainable method in managing food waste as it cost effectively, environmental friendly which is the most important is can reduce the pollution and also can provide an income for the products (Aminah et al., 2016).

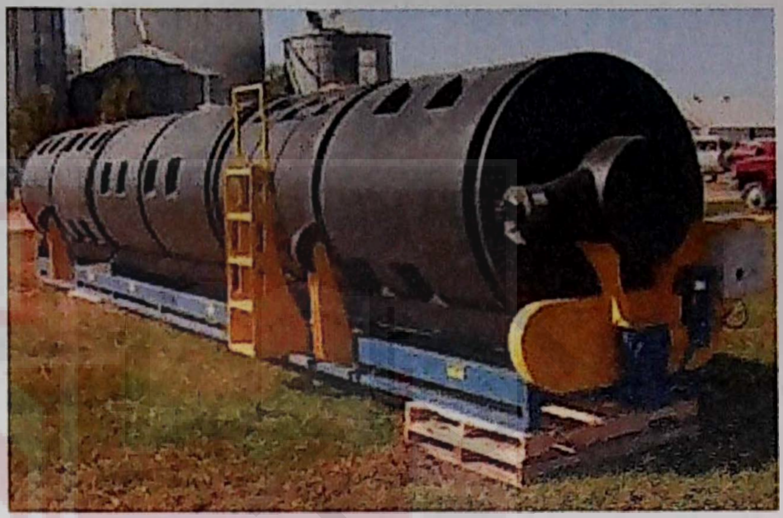
There are two main types of composting technique which is aerobic and anaerobic composting. The characteristics of aerobic composting are process which occurs with the presence of oxygen, produce stable organic end product with Carbon dioxide, ammonia, water, heat and humus. It also has less risk of phytotoxicity. The heat that generate by aerobic composting helps to accelerate in breakdown of organic matter but the nutrients from the organic matter will be lost during this process. The duration for this process is within 4 months. The anaerobic composting process occurs with absent of oxygen. It produce strong odor and has risk of phytotoxicity. There is low temperature process and the most important the nutrient does not lost during the process but need to take a long duration to produce mature compost compared to aerobic process (Aminah et al., 2016),

Risse & Faucette, 2013 reported several food waste method includes passive composting or piling, aerated static piles, windrows method, bins method, in-vessel systems, and vermicomposting (Table 2.2). Other method of composting includes shredding and frequent turnings, use of cellulolytic cultures, aerated static pile composting, rectangular agitated beds, silos, use of mineral nitrogen activator and use of effective microorganisms (EM) (Siti Aminah et al, 2016). For example, technique of vermicomposting used red worms to eat all the organic material during the composting process, while technique using of mineral Nitrogen Activator are adding the nitrogen fertilizer into the compost.

Table 2. 2: The food waste composting method (Risse & Faucette, 2013)

Food Waste Composting	**Description**
Passive composting or piling	• The simple process which is involves stacking the materials and let the process naturally occur. • Involves low cost of process. • Take a long time to process. • Produce unpleasant odour. 
Aerated static piles	• Involves air to the stacked pile using perforated pipes and blower. • No need to turning the compost. 

Windrows method	• Long, narrow piles that need to be turned when have requirements such as temperature and oxygen requirement. • Produce uniform product. • Used large volumes where these methods need a large of space. • Produce odour and leachate. 
Bins	• Simple in-vessel method. • Low cost of method. • Used for small amount of food waste. 

In-vessel systems	• Use perforated barrels, drums or container. • Simple to use. • Easy to turning the material. • Not sensitive to weather. 
Vermicomposting	• Use worms to eat the organic material during the process. • Use container, bins or greenhouses. 

2.6.2 Factors that influence compost process

There are few factors that affecting the composting process such as temperature, moisture content, pH level, aeration level, carbon : nitrogen ration, particle size and nutrient content which are their interact with each other. The role of temperature is to reduce the pathogen activity during the thermophilic period while pH level and aeration rate is contributed during the microbial growth and ammonia emission. The physical and chemicals properties of raw materials affected by moisture content, and carbon:nitrogen ratio is significant to microbial growth (Li, Z., et.al, 2013).

Tweib, Rahman, & Kalil,(2011), describe the phases that involved in composting process which is classified by temperature and heat out (Figure 2.3). The first phase is mesophilic phase which occurs at 24-48 hours where the temperature gradually increasing to 40-50^{0}C. In this phase, sugar and easily biodegradable substances was metabolized by fungi and bacteria. The second phase is thermophilic phase, the temperature between 45-65^{0}C, where the cellulose and other difficult biodegradable substances are destroyed at this phase. Plant pathogen, weed seed and bio-control agents are killed during the high temperature phase. The concentrations of materials were decrease during the third phase. This study states that the characteristic of matured composts are dark colour, contain largely of lignin, humus and biomass; and has earthy odour.

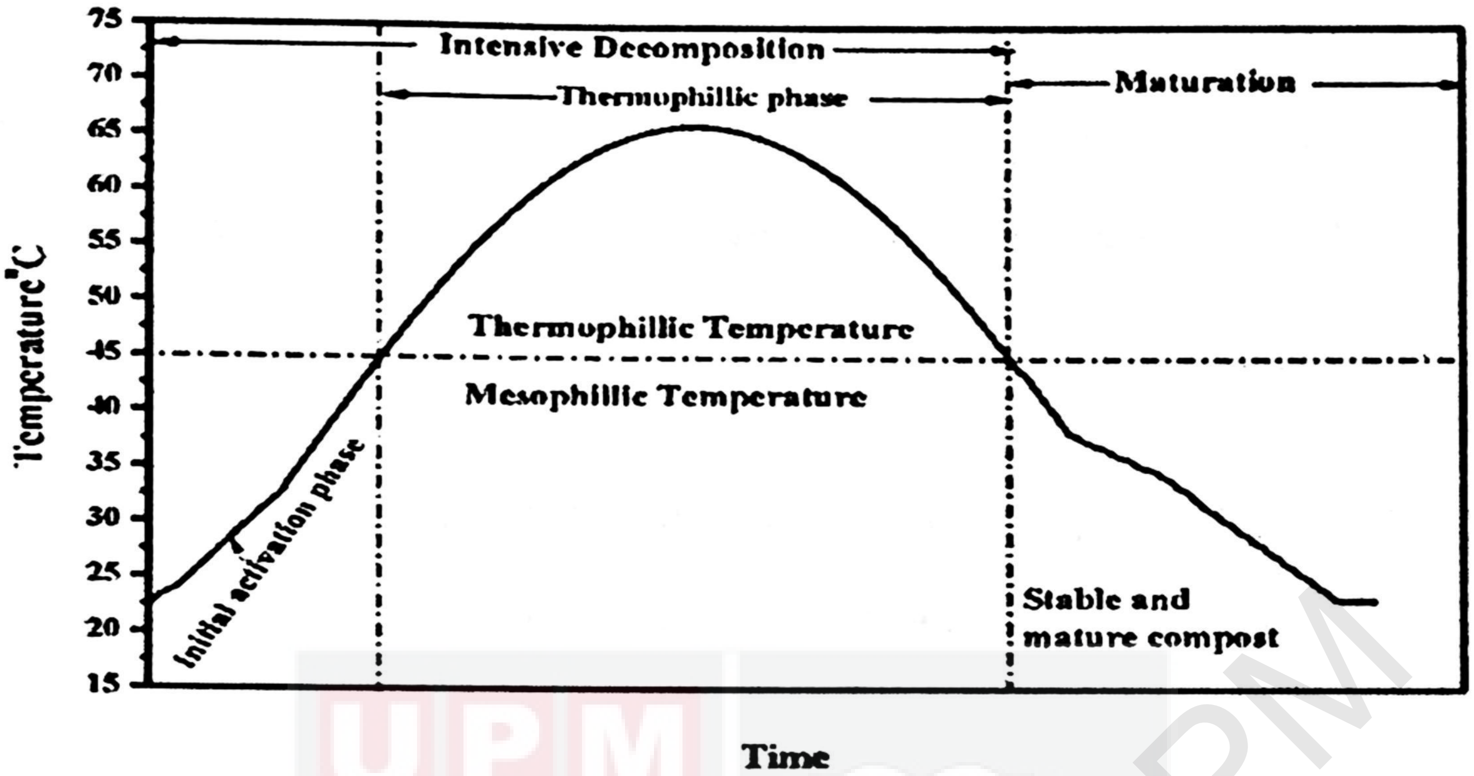


Figure 2. 5: The composting phase

Temperature is an indicator of microbial activities, which is influence of the population of the microbiological and the type and the rate of decomposition. Temperature is a convenient and direct parameter that can be used to determine the status of the composting process. According to Risse & Faucette, (2013), the low temperature will slow down the composting process, while the high temperature will speed up the process. But, too high temperature will kill the seed weed and kill the pathogen in the process. The optimum temperature for mesophillic phase are between 40-50°C, while the suitable temperature for thermophillic phase are between 45-65°C. Compost will be the matured compost when it achieve and maintained at ambient temperature.

Next, moisture content in composting process is an important for transporting the dissolved nutrients that are need by the microorganisms for physical and metabolic activity. 60% of moisture content in compost are suitable for organism to breakdown the compost, while more than 70% of moisture content will slow down the composting process and can produce unpleasant smell, The suitable of moisture content for food waste compost are between 80-90% (Risse & Faucette, 2013).

According to Fan et al., (2017), the rapid change of pH at the initial stage of composting will produce the unpleasant smell. The acidic of pH at the initial phase will increase the level of microorganism, which is the decomposing process will be more efficient. The suitable pHs for matured compost are between 6-8.

Another factor is aeration level, which are important factors for microbial growth and gas emission. Aeration or oxygen are very important for microorganism to breakdown effectively the composting material (Risse & Faucette, 2013)

Carbon-to-nitrogen ratio factors show the efficiency of composting process, where a lot of previous study shows that low of C/N ratio in food waste composting is good for the process. This factor was very important for bacteria starts the process of organic matter breakdown (Risse & Faucette, 2013)

The particle size also gives an impact during the composting process because the small size of particle will increase the surface area for microbial activity, besides fastening the process of composting (Risse & Faucette, 2013)

Nutrient content are also important especially as sources for microbial activity. The examples of nitrogen content are Nitrogen, Phosphorus and Potassium. According to Fan et al., (2017), the content of Nitrogen that being used for agriculture must have range between 3% and 4% to exert fertilizing capabilities. Phosphorus are important for root growth and plant metabolism. The typical ranges of Phosphorus are between 0.2-2.0%. While, Potassium are acts as regulator of water content in plant cell and also so important for the formation of protein and carbohydrates and the typical range of Potassium are between 1% and above.

2.7 Effective Microorganism (EM)

The use of Effective Microorganism (EM) in composting process that can help to enhance the composting process (Sivasubramanian, Namasivayam, 2013). Effective Microorganism (EM) was originally developed by Dr. Higa in 1992 which is the mixture of the solution contain of microbial inoculant such as lactic acid bacteria, filamentous fungi, yeast, Streptomyces and photosynthesis bacteria (EM Research Organization (EMRO) , 2014).

The function of microorganisms in Effective Microorganism (EM) which is Lactic acid bacteria work as the accelerator of decomposition and fermentation and suppress ad reduce the pathogen while yeast act as to promote fermentation for plant growth, produce bioactive substances and as substrate for other Effective Microorganism (EM). Photosynthetic bacteria function to produce of amino acid and amino nuclei, helps to bind nitrogen from air and help to convert toxic gases. Besides that, actinomycetes helps to produce and antibacterial matter and fermenting fungi helps to decompose organic matter, synthesize amino acids and glucose from carbohydrate and help control odours from the composting process (Aminah et al., (2016; Lokman et.al, 2013; (Sabas, Amos, & Wostry, 2010).

Each of microorganisms had their own function. For example the function of lactic acid is to holds down and stops the harmful microorganisms and increase the rapid decomposition such as the process of breakdown the organic matters, while the function of filamentous fungi is to fastening the decomposing process to produce alcohol, esters and antimicrobial substances which is to prevent the production of unpleasant odour and to prevent distinguishing of harmful insects and maggots. Next, yeast and Streptomyces acts as antimicrobial from amino acids and the photosynthesis bacteria will acts to synthesis the amino acids, nuclei acids, bioactive substances and sugar (Lokare,et.al, 2007).

Effective Microorganism (EM) is a mixture of groups of organisms that has reviving action on human, animals and natural environment founded by Professor Higa in 1995 and also has been described as an multi-culture of coexisting anaerobic and aerobic beneficial microorganism (Sekeran, Balaji, & Pushpa, 2005). Effective Microorganism (EM) contain lactic acid bacteria, photosynthetic bacteria, yeast, fermenting fungi and Streptomycetes (Sivasubramanian & S Namasivayam, 2013).

The different species and type of Effective Microorganism (EM) have the specific functions. According to report prepared by Sabas, Amos, & Wostry, (2010), there are several types of Effective Microorganism (EM) which is EM-A or Activated EM, EM-Bokashi, EM-1, EM-5 and EM-FPE or Fermented Plant Extract in market.

EM Activated Solution (EMAS) EM1 is the common type of EM that widely used in Malaysian rivers that used for yards, indoor plants, laundry fish pond and many more. EM1 is the original solution that need in the production of EM Activated Solution (EMAS) , EM 1 is a fermented EM which is consists of live microorganism but in dormant conditions, the concentration solutions was needed to activate EM1 (EM Malaysia Groups Sdn Bhd, 2017).

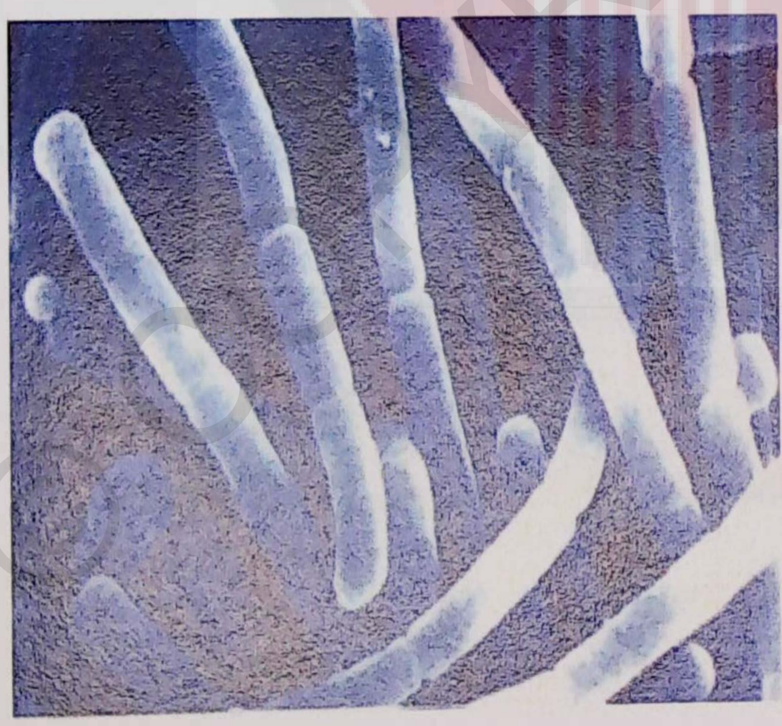


Figure 2. 7: Lactic acid bacteria

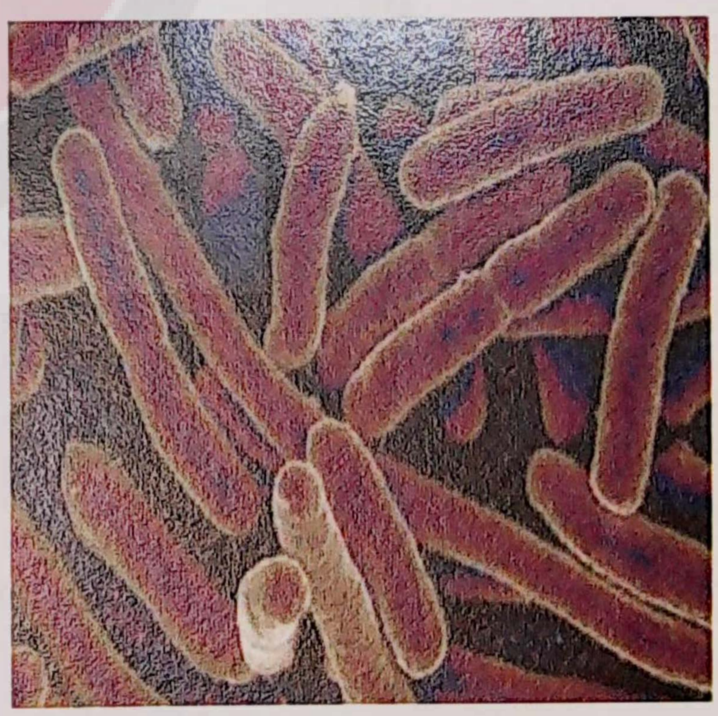


Figure 2. 6: Fermenting fungi

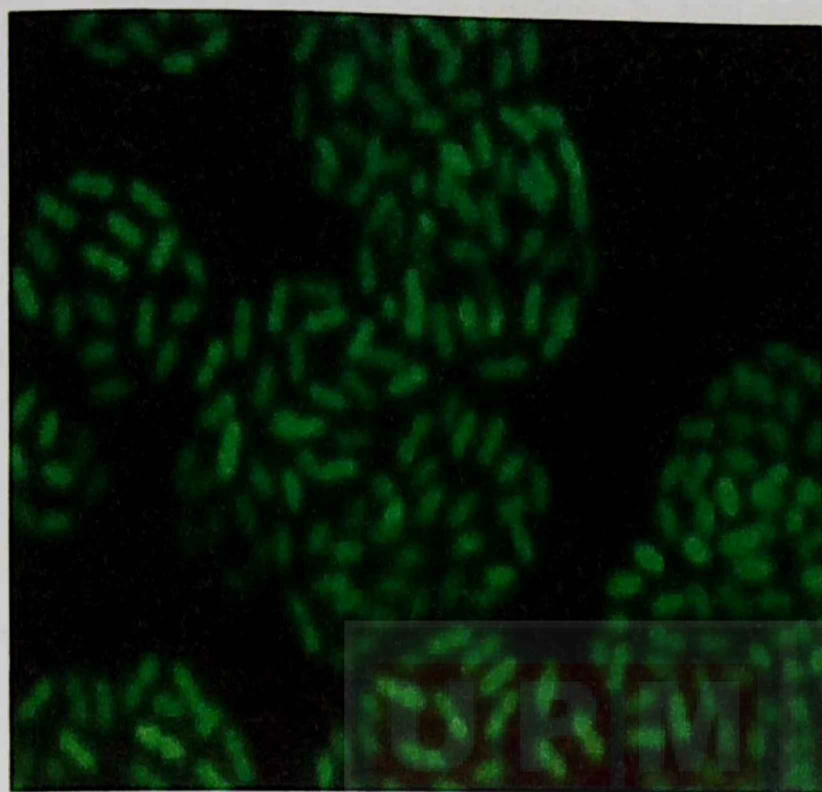


Figure 2. 9: Photosynthetic bacteria

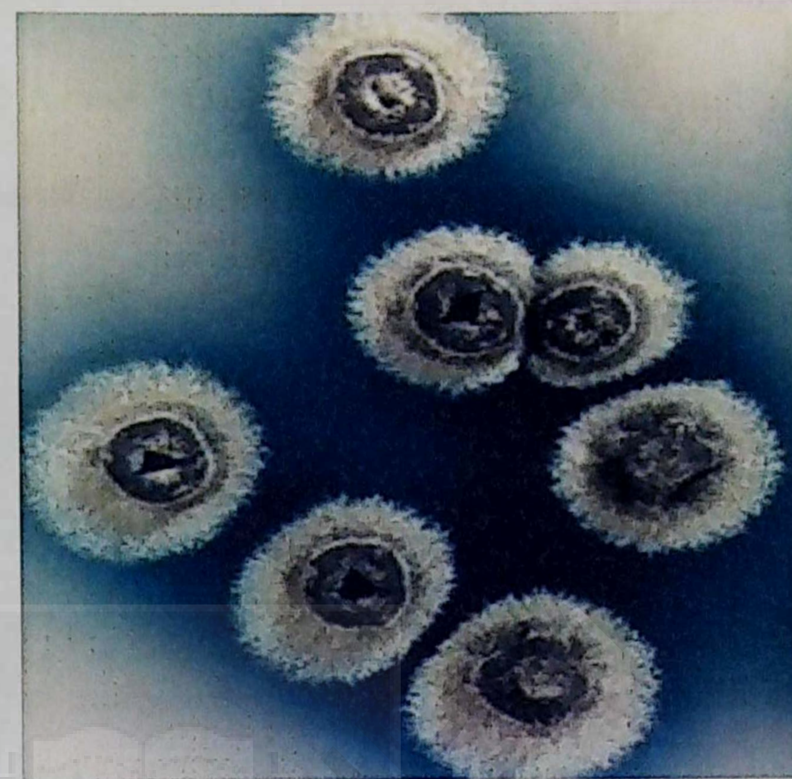


Figure 2. 8: Streptomycetes

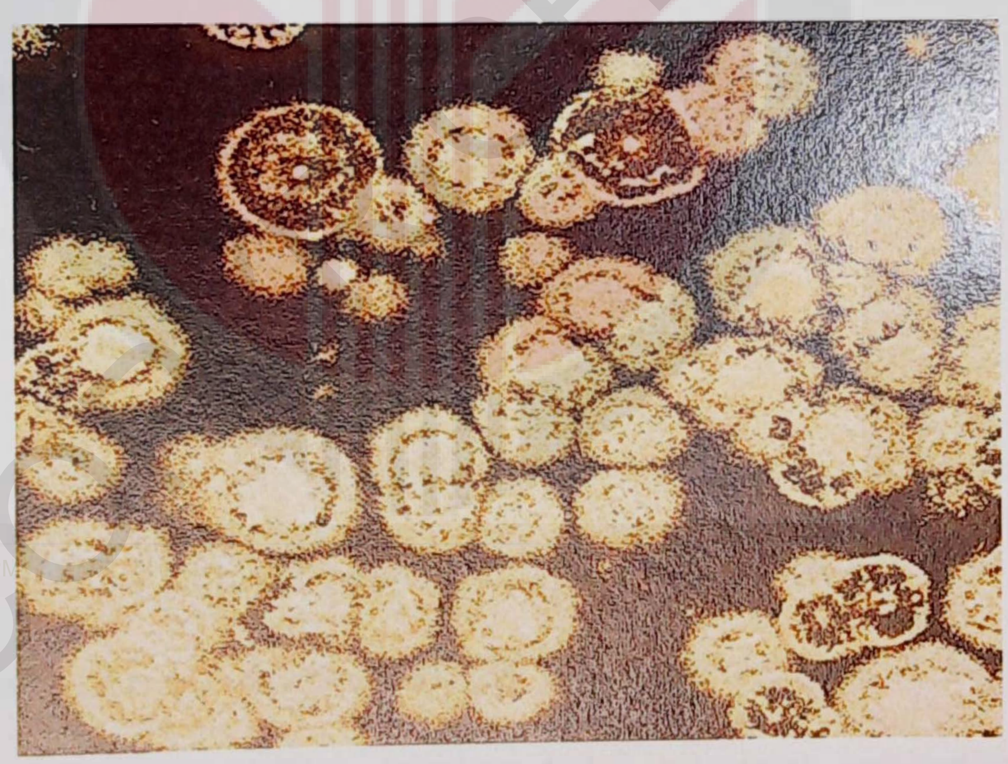


Figure 2. 10: Yeast

Lactic acid bacteria in EM solution will helps to accelerate the decomposition and fermentation process, supress and reduce the pathogen. While photosynthetic bacteria will function as the production of amino acids and amino nuclei, helps to bind nitrogen from the air and helps to convert gasses. Yeast in EM acts as to promote fermentation and for plant growth, produce bioactive substances and substrates for other EM. Fermenting fungi helps to decompose organic matter, synthesize amino acids and glucose from carbohydrates besides to control the odours and Streptomycetes helps in production of antibacterial matter (Aminah et al., 2016).

The application of Effective Microorganism (EM) not only can be used in agriculture but it also been used in industrial as an odour control, waste management and recycling, environmental remediation and eco-friendly cleaning (Zakaria et al., 2010).

In study by Sangakkara, (2001), Effective Microorganism (EM) usually used in agriculture and environmental management. In Agriculture, Effective Microorganism (EM) used as to enhance the productivity of organic farming. A lots of studies done on the use of Effective Microorganism (EM) on crops production, which is the successful of Effective Microorganism (EM) cause by few factors such as release of nutrient, enhanced photosynthesis and protein activity. In environmental management, the initial concept of Effective Microorganism (EM) used in process of composting of crop residue and animal waste to produce organic fertilizer. Besides that, Effective Microorganism (EM) also effectively use in purifying water for reuse in treating water so that can be recycled for garden and toilets.

EM is broadly used in agriculture sectors, to accelerate the microbial diversity of soil and minimize the use of chemical fertilizer. EM also used in aquaculture, which helps in keeping aquariums and fish ponds healthy and clean from fish dropping and residual foods. It also being used in waste water treatment, solid waste management, cleaning, composting and disaster treatment (EM Malaysia Groups, 2017).

2.6.3 Benefit of Composting

There are lots of benefits of composting such as reducing the volume of food waste that being disposed in landfills. This process helps to reduce the number of landfills build, reduce the groundwater contamination from leachate that produce at landfills, reduce air pollution and minimize of greenhouse gasses (GHG) emissions (Kadir et.al, 2016). Besides that, the product of the compost will produce new organic fertilizers for plants which are helps to improve the soil structure and fertility. The most important things is composting do not take a lots of space to be done and this process helps to turn unsafe organic materials to safety compost's products (The US Composting Council, 2001).

2.6.4 Food Waste Composting Challenges

However, composting process also has a few challenges. Fan et al., (2017) elaborates in their study that, composting process need to take a long time to produce matured compost, so that the product can be straight used as an organic fertilizer or soil amendment. Besides that, the process of composting also produce unpleasant odour because of the content of organic compounds (Aminah et al., 2016).

Other than that, the food waste composting need to be separate from the others waste before it start the process and this situation need a commitment from people to make sure all the food waste already separated (Siti Ghafar, 2017). According to this situation, Ministry or Urban Wellbeing, Housing and Local Government (2015), the government has made the Separation at Source as a mandatory for consumer to separate solid waste at source start from 1 September 2015 under the regulation Solid Waste and Public Cleansing Management Act 2007 (Act 672) (Solid Waste And Public Cleansing Management Act, 2017).

According to Fan et al., (2017), the compost quality will be different due to the different composting system, process of parameters, input materials and its formulation; and the environmental conditions. There are two method of composting which is traditional composting method (anaerobic decomposition, aerobic decomposition and large scale) and rapid composting method (bin composting, rotating drums, vermicomposting, shredding and frequent turnings, use of Cellulolytic Cultures, aerated static pile composting, rectangular agitated beds, silos, use of mineral nitrogen activator and use of effective microorganism (EM)), (Food and Agriculture Organization of United Nations, 2003).

There are indirectly effects of food waste towards human health. The waste degradation process in the landfill produces waste water or leachate in the landfills. Leachate contains toxic elements such as aromatic compounds, halogenated compounds, phenols, pesticides, heavy metals and ammonium (Aminah et,al , 2016) . The toxic compound leaves negative impacts to the environment as it can contaminate the surface water, pollute the soil and contaminate the groundwater beneath the soil layer. The toxic element such as heavy metals can accumulate from the water and soil to the aquatic life and other organism and contaminate the food chains which lead to human health concern. Several historical case studies such as the methyl mercury poisoning in Minamata disease and mass cadmium (Cd) pollution in Itai-Itai disaster have described the mechanism of heavy metals accumulation in the food chain that significantly contribute to human health (Hogarh et al, 2008).

CHAPTER 3

METHODOLOGY

3.1 Study Design

This is an experimental study to determine the effectiveness of Effective Microorganism (EM) on food waste composting and its risk on human health. The parameter that was determined involved the determination of pH, temperature, moisture content, odour, colour and nutrient content between the compost. Experimental study is relatively used to determine the effectiveness of an intervention.

3.2 Sampling Location

Food waste was collected from cafeteria of Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. The types of food waste collected such as rice, vegetables, fish, chicken, meat, and fruits. The dried leaves that used in this research were collected around the 17th College of Universiti Putra Malaysia.

3.3 Preparation of Homemade Effective Microorganism (EM)

The homemade Effective Microorganism solution was prepared by the mixture of fruits waste such as banana and apples, brown sugar, water and rice. This fermentation process use ratio 7:3:1 for water, brown sugar and fruits waste. The total amount of homemade EM solution was produces are approximately 9 litters. All the materials were put in plastic container and put in dark places. The fermentation processes of the mixture are left for about 3 weeks. Make sure for the first week of fermentation process, the mixture was stir for every day and the second and last week's only stir once a week. After the fermentation process complete, filter the mixture and take the solution as a homemade EM solution. The homemade EM solutions were kept in plastic bottle and avoid it from direct sunlight (modified from Ismail et.al, 2017).

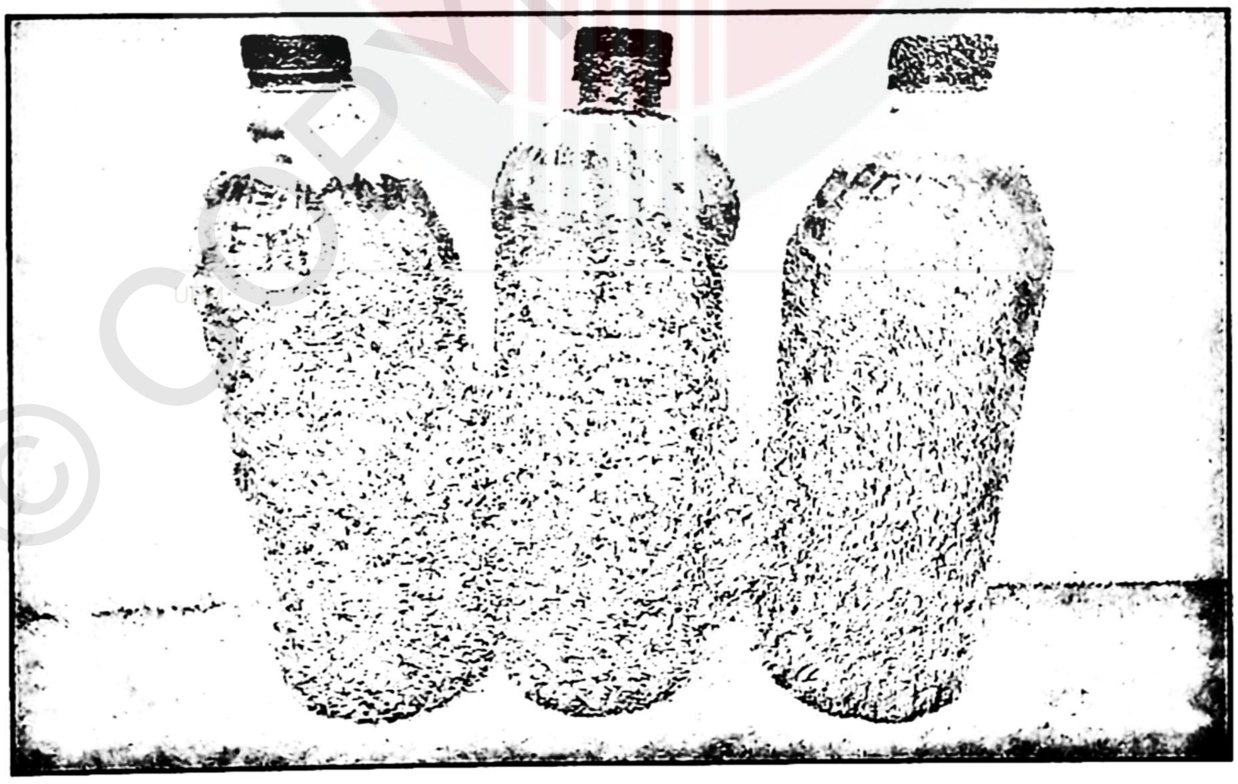


Figure 3. 1: Homemade Effective Microorganism (EM)

3.4 Activation of Commercial Effective Microorganism (EM) (EM Phototropic Bacteria)

Phototropic Bacteria is beneficial microbe living in nature, especially in water and soil. It not only produces beneficial substances from organic matters, but converts even harmful material into beneficial substances through its metabolic system. 1 litter of EM PB was diluted with 100 litre water. Keep the moisture between 45-55% and the temperature less than 55ºC in the compost during fermentation.

Figure 3. 2: Commercial Effective Microorganism (EM)

3.5 Preparation of Composting

The composting process was carried out in dark and covered plastic bins to maintain the heat from the composting process. 0.6 cm diameter holes were drilled above the plastic bins to supply the natural aeration to the composting process. Besides that, the holes are used to drainage the leachate that produced throughout the composting process (Cruz-Rodrigues et al., 2014). The experiment was conducted in three plastic bins as follows; Homemade Effective Microorganism (EM) Compost, Control Compost and Commercial Effective Microorganism (EM) Compost, which is control compost acts as control for this experiment.

Figure 3. 3: Set up composting process

3.6 Composting Materials

Dried leaves and paper was added at the bottom of the plastic bins as bulking agents to accelerate aeration. Each plastic bins were contained with 4kg of food waste: 50% of food waste (1.2 kg of rice, 250 g of meat, chicken and fish, 450 g of vegetables and fruits, 70 ml of oil, 15 ml of salt, 15 ml of sauces and 40 ml of distilled water) was collected from the cafeteria, 25% of dried leaves and 25% of paper. All the food waste was tearing to small pieces for faster decomposition and also well mixed autoclaves at 121^{0}C for 15 minutes. The plastic bin (with commercial EM and homemade EM) was added with 1.2 L EM. The initial moisture content must between 40-60 % (Fan et al., 2017). The turning frequency had be done for once a week (Cruz-Rodrigues et al., 2014).

3.7 Measurement

3.7.1 Temperature

The temperature of the compost was monitored along the plastic bins using the long thermometer. The thermometer was labelled for 0cm, 10 cm and 20 cm. The temperature was measured at three different depths and 5 different locations because the composts mays have different temperature at different depths and locations due to the moisture content and chemical composition of the ingredients (Cornell Waste Management Institute, 1996). The temperature was measured daily at the second first week until the temperature become stable for 8 weeks (Kutsanedzie et.al, 2012).

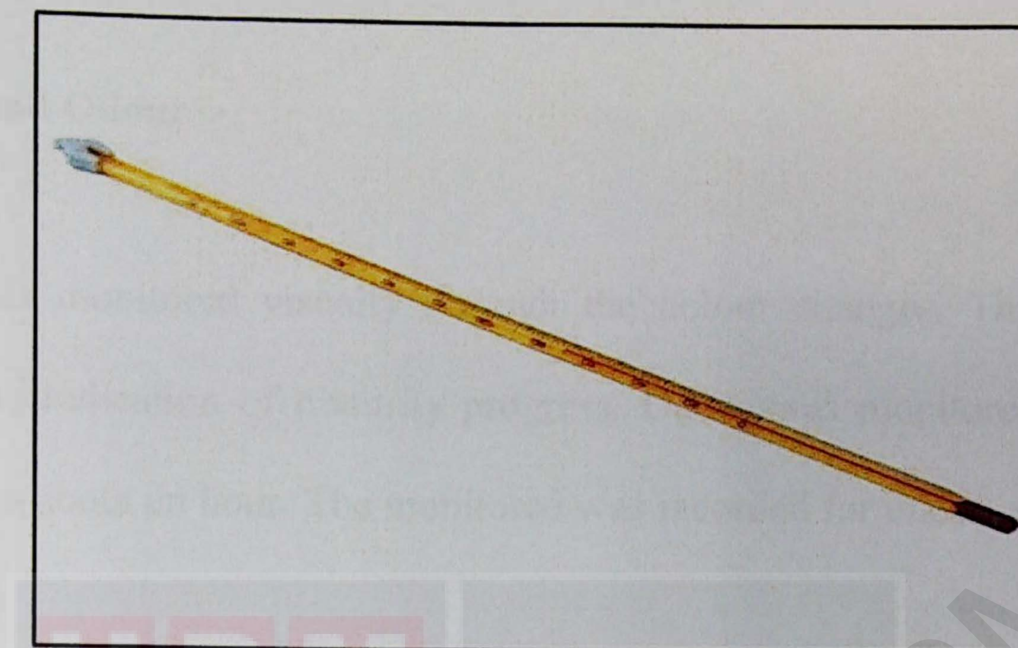


Figure 3. 4: Thermometer

3.7.2 pH

10 g of food waste compost from five different point and three different depths (0cm, 10cm, 20cm) after turning using hand auger. The food waste compost was weighted using analytical balance and put in beaker. Then, 25ml of distilled water was added and stirred it for 10 minutes. After 3 minutes, sample was tested by pH meter (Eutech pH 450) . The sample was measure once a week (Kadir et.al, 2016 and Kutsanedzie et al., 2012)

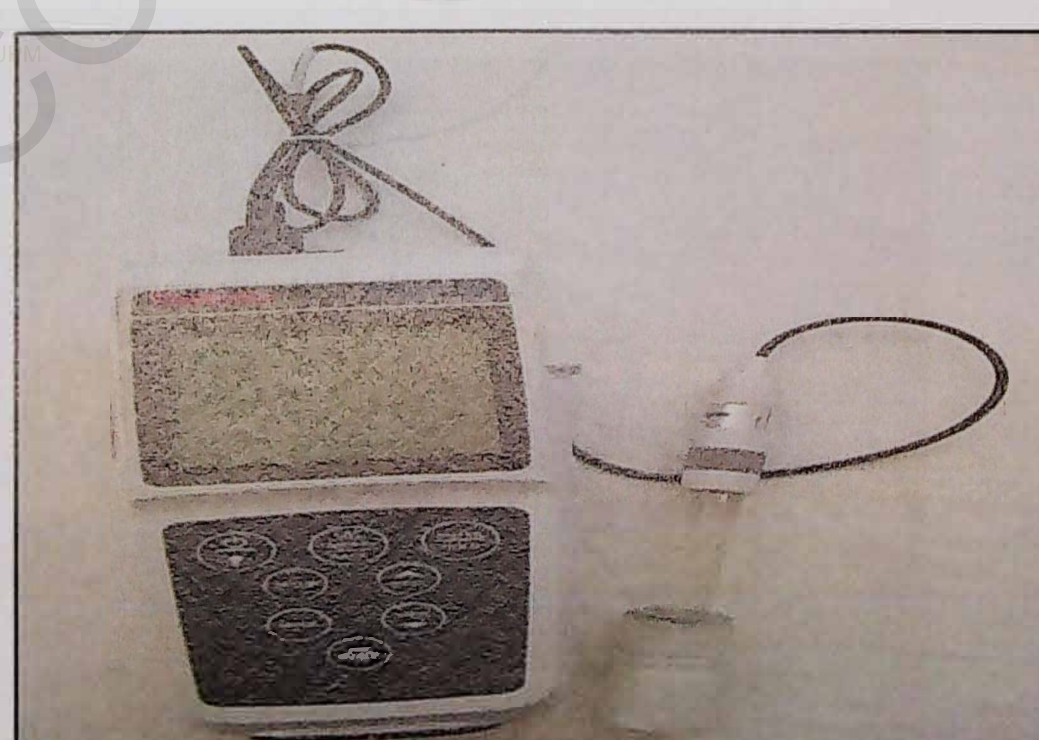


Figure 3. 5: pH meter

3.7.3 Colour and Odour

The compost was monitored visually through the colour changes. The darkening of the compost gives an indication of maturity progress. Odour was monitored by smelling after turning but within about an hour. The monitored was recorded for once a week along 8 weeks (Fan et al., 2017).

3.7.4 Moisture Content

10 g of food waste compost was collected and from five different point and three different depths (0cm, 10cm, 20cm) after turning using hand auger. The food waste compost was weighted using analytical balance. The sample was drying in oven at 105°C for 24 hours. After that, the sample was weighted using gravimetric analysis method (by deduction of water loss). The changes in weight of samples were averaged. The sample was measure for once a week (Tweib, Rahman, & Kalil, 2011 and Kutsanedzie et al., 2012).

Figure 3. 6: Analytical balance

The moisture content was calculated using the followed formula:

Moisture Content (%)

= (Wet weight (W) – Dry Weight (D)) / Wet weight (W) x 100%

3.7.5 Nutrient Content (Nitrogen, Phosphorus and Potassium)

After drying using oven, 1g of food waste compost was weighted using analytical balance. The sample was transferred into crucible and was put in furnace for 8 hours. After 8 hours, some distilled water was put into the sample. 2 ml of Hydrochloric Acids (HCL) was poured into it. The sample was put on the hot plate until the sample become dry. After dry, 17ml of 20% of Nitric acid was poured into the sample. Then, samples was removed into the water bath for 1 hour and cool the sample.

The solution was transferred into 50 ml of volumetric flask and the solution was added up with distilled water become to 50 ml. The solution was filtered using filtered through Whatsman filter paper No.44. Concentration of Potassium was analyse using Atomic Absorption Spectrophotometer and Phosphorus was determined using an and Auto Analyser, while the concentration of Nitrogen was measured using CNS analyser.

3.8 Quality Control and Quality Assurance

1. Measurement were taken in triplicate for each parameter such as pH level, temperature and moisture content to get the average value (Kadir et.al, 2016).

2. The two types of compost were placed at in the laboratory and avoid it from direct sunlight.

3. To maintain the quality of compost, the cover of plastic bins always being closing to keep the heat produced from composting process.

4. The pH meter was calibrated before analysing the sampling.

3.9 Data and Statistical Analysis

Results of pH, moisture content, temperature and nutrient content (Nitrogen, Phosphorus and Potassium) between homemade EM compost and commercial compost was analyse using Independent t-test. While for colour and smell, the descriptive analysis was used. The difference in nutrient content between homemade EM compost and commercial compost and standard was analysing using descriptive analysis. The Pearson correlation test was used to analyse the correlation between the variables.

CHAPTER 4

RESULTS

4.1 Comparison of pH, temperature, moisture content, odour and colour between homemade EM compost and commercial EM compost by weeks (8 weeks).

Table 4.1 highlights the comparison of pH level between homemade EM compost and commercial EM compost. After eight weeks of composting process, the pH level for homemade EM compost was ranged from 5.26 ± 0.64 to 8.32 ± 0.04, while pH level for commercial EM compost was ranged between 6.16 ± 0.12 to 7.70 ± 0.04. The level of acidity shows a decreasing trend from week 1 to week 8. The pH value in both methods was acidic in the first three weeks. It starts from acidic which is 5.26 in homemade EM compost and 6.16 in commercial EM compost.

Then it turns to neutral for homemade EM at week 5 which is at 7.83 ± 0.09, while for commercial EM compost it turns to neutral at week 3 which is at 7.07 ± 0.08. However, during week 4 and week 5, commercial EM compost turns to acidic which is at 6.69 ± 0.28 and 6.78 ± 0.61 and turns back to slightly alkaline at week 6 to week 8 , and ranged between 7.45 ± 0.02 to 7.70 ± 0.04. Homemade EM compost become slightly alkaline at week 6 to week 8 ranged from 8.10 ± 0.02 to 8.32 ± 0.04.

There is no significant difference of pH level for both homemade and commercial EM compost from week 1 to week 4 but significant difference in week 5 to week 8.

Table 4. 1: Statistical summary of pH level between homemade EM compost and commercial EM compost

pH Level	Mean (SD)		T-statistics (df)	p-value*
	Homemade EM Compost	Commercial EM Compost		
Week 1	5.26 (0.64)	6.16 (0.12)	-2.397(2.137)	0.131
Week 2	6.31 (0.37)	5.80 (0.24)	2.023(4)	0.113
Week 3	6.95 (0.11)	7.07 (0.08)	-1.460(4)	0.218
Week 4	6.26 (0.61)	6.69 (0.28)	-1.103(4)	0.332
Week 5	7.83 (0.09)	6.78 (0.61)	11.977(4)	< 0.001**
Week 6	8.10 (0.02)	7.45 (0.02)	43.603(4)	< 0.001**
Week 7	8.25 (0.03)	7.55 (0.07)	16.527(4)	< 0.001**
Week 8	8.32 (0.04)	7.70 (0.04)	18.984(4)	< 0.001**

Independent t-test

***p-value significant at 0.05 level**

Table 4.2 highlights the results of moisture content between homemade EM compost and commercial EM compost. After 8 weeks of experiment, the moisture content of homemade EM compost was ranged from 66.46% to 72.71%, while the moisture content for commercial EM compost was range from 66.63% to 72.65%. The trend of percentage of moisture content by week for both type of compost is fluctuating.

Both compost has quite similar range of moisture content in the initial stage of the experiment between 66.46% (homemade EM) and 66.63% (commercial EM). At week 2, the moisture content has decreased to 61.06% for homemade EM compost and 64.87 for commercial EM compost. However, the moisture content in both compost increased in week 3 and reduced afterwards until the final week of experiment. The moisture content was not significantly difference between homemade EM compost and commercial EM compost in all weeks except in week 6.

Table 4. 2: Statistical summary of moisture content (%) between homemade EM compost and commercial EM compost

Moisture Content	Mean (SD)		T-statistics (df)	p-value*
	Homemade EM Compost	Commercial EM Compost		
Week 1	66.46 (0.55)	66.63 (1.47)	-0.184(4)	0.863
Week 2	61.06 (3.12)	64.87 (1.28)	-1.959(4)	0.122
Week 3	65.78 (3.22)	70.94 (2.23)	-2.280(4)	0.085
Week 4	69.56 (2.76)	67.38 (2.82)	1.002(4)	0.373
Week 5	68.12 (8.19)	69.10 (3.70)	-0.186(4)	0.861
Week 6	69.77 (1.76)	73.78 (1.20)	-3.263(4)	0.031*
Week 7	67.74 (7.83)	70.32 (2.02)	-0.523(4)	0.629
Week 8	72.71 (0.41)	72.65 (3.38)	0.029(2.060)	0.980

Independent t-test

***p-value significant at 0.05 level**

Table 4.3 shows about the temperature of homemade EM compost and commercial EM compost. Along the eight week of experiment, the pattern of temperature fluctuated. Homemade EM compost starts with high temperature (28.90 ± 2.68) compared to commercial EM compost (27.71 ± 1.63).

After that, homemade EM compost's temperature decrease at week 2 (28.07 ± 1.90) until week 3 (26.69 ± 1.74) and commercial EM compost's temperature also decrease from week 2 (25.79 ± 2.23) until week 4 (25.00 ±4.57). Then, the temperature of homemade EM compost keep increasing at week 4 (27.57 ± 3.77) and at week 5 (27.67 ± 0.92). For commercial EM compost, temperature increase back at week 5 (26.13 ±0.55) but slightly decrease at week 6 (26.13 ±0.55) and slightly increase back at week 7 (25.27 ± 4.37). At week 6, homemade EM compost decreases at (25.05 ± 0.78) and slightly increase at week 7 (26.60 ±4.53). At the end of week 8, the temperature of homemade EM compost and commercial EM compost maintained at average temperature which is 20.78 ±0.83 and 20.64 ± 0.10.

There is also no significant difference of mean for temperature between homemade EM compost and commercial EM compost.

Table 4. 3: Statistical summary of temperature (°C) between homemade EM compost and commercial EM compost

Temperature	Mean (SD)		T-statistics (df)	p-value*
	Homemade EM Compost	Commercial EM Compost		
Week 1	28.90 (2.68)	27.71 (1.63)	1.558(12)	0.145
Week 2	28.07 (1.90)	25.79 (2.23)	1.909(10)	0.085
Week 3	26.69 (1.74)	25.19 (1,67)	1.079(4)	0.341
Week 4	27.57 (3.77)	25.00 (4.57)	0.752(4)	0.494
Week 5	27.67 (0.92)	26.13 (0.55)	2.473(4)	0.069
Week 6	25.05 (0:78)	23.87 (0.52)	2.182(4)	0.095
Week 7	26.60 (4.53)	25.27 (4.37)	0.367(4)	0.732
Week 8	20.78 (0.83)	20.64 (0.10)	0.277(2.062)	0.807

***Independent t-test**

p-value significant at 0.05

Table 4.4 present the results of colour between these two types of compost. Both of compost starts with brown colour. The changes of colour of homemade EM compost start from week 4, which is the colour of compost start, become dark brown until the end of experiment, week8. For commercial EM compost, the changes of colour start from 3, where the colour of compost becomes dark brown until the end of week 8. At the end of week 8, both of compost become dark brown which is indicates the maturity of compost.

Table 4. 4: The comparison of colour between homemade EM compost and commercial EM compost

Week	Homemade EM Compost	Commercial EM Compost
1	Brown	Brown
2	Brown	Brown
3	Brown	Dark Brown
4	Dark Brown	Dark Brown
5	Dark Brown	Dark Brown
6	Dark Brown	Dark Brown
7	Dark Brown	Dark Brown
8	Dark Brown	Dark Brown

Figure 4. 2: Brown colour of compost

Figure 4. 1: Dark brown colour of compost

Table 4.5 shows the results of smell within 8 week between homemade EM compost and commercial EM compost. At the first and second week, commercial EM compost already produces unpleasant smell compared to homemade EM compost. Homemade EM compost starts produces unpleasant smell at week 2 until week 5. Commercial EM compost loses the smell at week 3 and week 4, and produces back unpleasant smell at week 5. The result shows that these two types of compost start lose their smell and produce earthy smell from week 6 until week 8.

For the result of fungi, only the homemade EM compost has the result the present of fungi start from week 2 until week 8. Commercial EM compost does not have the present of fungi during the experiment.

For the result the present of maggot, during week 1 and week 2, commercial EM compost already had the present of maggot compared to homemade EM. At week 5, maggot also present in homemade EM compost, while at week 6, maggot present back in commercial EM compost. This present of compost is because of the occurring of process of breakdown of food waste.

Table 4. 5: The comparison of smell, present of maggot and present of fungi between homemade EM compost and commercial EM compost for 8 week

Week	Homemade EM Compost	Commercial EM Compost
1	No smell	Yes (Smelly)
	No fungi	No fungi
	No maggot	Present of maggot
2	Yes (Sour Smell)	Yes (Smelly)
	Present of fungi	No fungi
	No maggot	Present of maggot
3	Yes (Sour Smell)	No smell
	Present of fungi	No fungi
	No maggot	No maggot
4	Yes (Sour Smell)	No smell
	Present of fungi	No fungi
	No maggot	No maggot
5	Yes (Sour Smell)	Yes (Sour Smell)
	Present of fungi	No fungi
	Present of maggot	No maggot
6	No (Earthy Smell)	No (Sour Smell)
	Present of fungi	No fungi
	No maggot	Present of maggot
7	No (Earthy Smell)	No (Earthy Smell)
	Present of fungi	No fungi
	No maggot	No maggot

8	No (Earthy Smell)	No (Earthy Smell)
	Present of fungi	No fungi
	No maggot	No maggot

Figure 4. 4: Present of maggot

Figure 4. 3: Present of fungi

4.2 Comparison of nutrient content (Nitrogen, Phosphorus and Potassium)

Table 4.6 presents the results obtained from the analysis of nutrient content (Nitrogen, Phosphorus and Potassium) after the compost process complete within 8 weeks between homemade EM compost and commercial EM compost.

The mean of Nitrogen for homemade EM compost was 3.12 ± 0.25 % while the mean of Nitrogen for commercial EM compost is 2.26 ± 0.055 %. The mean of Phosphorus for homemade EM compost was 0.0019 ± 0.0003 %, while the mean for commercial EM compost was 0.0008 ± 0.0001%. The mean of Potassium for homemade EM compost was 0.0038 ± 0.0001% and for commercial EM compost was 0.0036 ± 0.0001% .

Only mean of Nitrogen for homemade EM compost was found in the typical range of fertilizer that being used for agricultural as mentioned in study of Fan et.al (2017). The mean of Nitrogen for commercial EM compost are below the typical range which is less that 3-4%. The value of Phosphorus and Potassium for both type of compost are not in adequate nutrient that not fall in the typical range.

Table 4. 6: NPK content (%) in Homemade EM Compost

Variable	Mean (SD)		Typical Range (Fan et al., 2017)
	Homemade EM compost	Commercial EM compost	
Nitrogen (N)	3.12 (0.25)	2.26 (0.055)	3-4%
Phosphorus (P)	0.0019 (0.0003)	0.0008 (0.0001)	0.2-2.0%
Potassium (K)	0.0038 (0.0001)	0.0036 (0.0001)	1% and above

4.3 The relationship between pH, moisture content and temperature of compost.

Table 4.7 shows the relationship between pH, moisture content and temperature of compost. Findings shows that pH has a moderate positive correlation with moisture content (r = 0.586) and temperature (r=-0.513). There is a no significant correlation between moisture content and temperature.

Table 4. 7: The correlation coefficient (r value) between *pH, moisture content* and temperature *of compost.*

Parameter	Moisture Content	Temperature
pH	0.586*	-0.513*
Moisture Content	-	-0.469

[a] Pearson Correlation test
**Correlation is significant at the 0.05 level (2-tailed)

4.4 Relationship between pH, moisture content and temperature with NPK concentration of compost.

Pearson correlation was used to determine the relationship between pH, moisture content and temperature with NPK concentration of compost. There is no significant relationship between NPK concentrations with pH, moisture content and temperature.

Table 4. 8: The relationship (r value) *between pH, moisture content* and temperature *with NPK concentration of the compost.*

Variables	Nutrient Content		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Temperature (°C)	0.464	-0.108	0.477
pH	-0.194	0.048	-0.090
Moisture Content (%)	-0.285	-0.583	-0.054

[a] Pearson Correlation test

CHAPTER 5

DISCUSSION

5.1 Comparison of pH, temperature, moisture content, odour and colour between homemade EM compost and commercial EM compost by weeks (8 weeks).

The level of acidity shows an increasing trend from week 1 to week 8. The pH value in both compost methods turned from acidic to neutral and lastly to alkaline. This show the stability of organic matter in the compost (Fan et al., 2017). According to Agriculture, (2000), the acidic stages are occurs caused by the formation of organic acids in anaerobic condition or the accumulation of organic acid that produce by the abundance of carbonaceous substrates. This condition usually will affect the aerobic microorganism such as slowing down the composting process.

After week 3, the pH level increased and turned to neutral. This is because of the process of ammonia gasses release from the compost and the changes of organic acid into Carbon dioxide due to microbial activity Fan et al., (2017). Besides that, the increasing of pH level is because of breakdown of protein from food waste (Mat Saad et.al, 2013)

The homemade EM compost changes from acidic to alkaline faster than commercial EM compost where it start to alkaline in week 5, while commercial EM start at week 6. This probably because high production of ammonia during ammonification and mineralization of organic nitrogen as a results of microbial activities (Huang, Wong, Wu, & Nagar, 2004). The another reason why homemade EM compost changes from acidic to alkaline more faster is because of the depletion of organic acids and the process of denitrification occurs leads to alkaline conditions ((Adhikari, Barrington, Martinez, & King, 2009)

The pH level of both compost methods were not difference from week 1 to week 4. However, the statistical analysis shows significant difference of pH value from week 5 onwards where composting with homemade EM have higher pH value (alkaline) compared to the commercial EM. This is probably because the changes of pH during maturation are consequently coincided with nitrate formation and probably caused by the H^+ release during nitrification

According to (Mat Saad et al., 2013), optimum pH level for degradation of organic waste such as food waste are between 6 to 9, and the pH level for matured compost, approximately between 7-8. The experiment in this study shows that the compost by homemade EM matured slightly earlier than the commercial EM at week 5.

For moisture content, both of compost starts approximately between 60%-70% of moisture content. In this study, the moisture content was high because the compost contain of organic material such as food waste. The moisture content need to be maintained between 40%-70% (Mat Saad et al., 2013). The moisture content need to be maintained at this ranged to promote competitive microorganism and to avoid regrowth of Salmonella. Too high of moisture content will make the compost become anaerobic conditions, and too low of moisture content will make the compost become dehydrated and the microorganism will die (Agriculture, 2000). Moisture content was the important factors in composting because the decomposition of organic matter depends on the presence of water to support microbial activity (Zavala et.al, 2005).

In this study, there is no significant difference for moisture content between homemade EM compost and commercial EM compost except moisture content at week 6. This is due to aeration during the process is crucial for removal moisture because the thermophlic stage are not reach during the composting process (Barrena et.al, 2014)

Temperature indicates the metabolism of microorganism in composting process which is will affects the activity of microorganism and the process of composting (Zhu, 2006). The trend of temperature for both compost methods do not show the dramatically increase week by week. According to Abdullah et.al, (2013), this conditions occurs because of the excessive loss of compost volume.

The heat that produced during the process was produced by respiration of the microorganisms. Besides that, the heat also produced when the process of decomposition of food waste occurs along the 8 week of experiment (Fan et al., 2017). As noted by Mote & Griffis,(1982), the process of microbial respiration that occurs during composting produces heat which normally results the increasing of temperature. The heat is produce spontaneously when the organic substances are assembled provided that moisture content, oxygen supply and nutrition are adequate.

Homemade EM compost shows a better ability to breakdown the organic substances because had a high temperature compared to commercial EM compost at initial stages. The previous study conducted by Zhu, (2006) states that the optimum temperature for the development of mesophilic ohase is 30-40°C and thermophilic phase at 45-60°C. Unfortunately, the temperature in this experiment only maintained at mesophilic phase from week 1 to week 8 for both type of compost.

In previous study by Lokman et.al, (2013), usually the mesophilic phase only maintains a few days, which is this phase will have the growth of bacteria and fungi, and rapidly occurs the breakdown of soluble sugar and starches from the sources of food waste. A possible explanation for this might be that the activity of microorganism was reduced because of the food waste has been fully decomposed at this stage. Statistically difference was found in both condition of compost.

Commercial EM compost start change from brown colour to dark brown colour of compost on week 3, while homemade EM compost change to dark brown of compost on week 4. At the end of the experiment, both of compost changes to dark brown colour. This is consistent with a study by Emeterio & Victor, (1988), the final product of compost after maturation, is as dark brown or almost black colour.

According to (Jilkova & Banout, 2012), the changes of colour in compost during the process can be used as to determine the maturity of the compost. The colour indicates the degree of stabilisation of the compost. Usually, the matured compost will produced dark brown or black colour.

Smell that produced from the composting process has a relationship with the pH level. According to (Fan et al., 2017), high pH level indicate the loss of Nitrogen through ammonia volatilisation which has produced the unpleasant smell. Similar to study by Pan & Sen, (2013), the smell is produced because of insufficient of oxygen supply to the composting process and it will cause the less effective activity of bacteria.

United States Department of Agriculture, (2000) states that the fungi will be present in composting stages because of the nature of the material they decompose such as woody substances and other decay-resistant material. In this study, only homemade EM compost had a present of fungi starts from week 2 until week 8. The present of fungi in homemade EM compost are because of the nature of the material they decompose such as woody substances and other decay-resistant material

The present of maggot in composting process is because of the process of breakdown of food waste. At week 1 and week 2, commercial EM compost already had the present of maggot compared homemade EM compost that only had the present of maggot at week 5. Process of decomposition of food waste in this experiment cause the present of maggot at this both type of compost. The present of maggot is the reaction from process of breakdown of food waste.

5.2 Comparison of the nutrient content (Nitrogen, Phosphorus and Potassium) after the compost process complete (8 weeks) with the typical ranged of fertilizer for agricultural.

As the result, the concentrations of NPK are not in the typical range as previous study. Only concentrations of Nitrogen of homemade EM compost are between the typical ranges which are 3.12%. The homemade EM compost showed higher N content (3.12%) than the commercial EM compost (2.26%). Previous study by Fan et.al, (2017), the compost that produced by food waste has a total N ranged between 3 and 4%. N immobilization might occurs when the N content is less than 1% and would be suitable to be used as mulch.

Phosphorus in compost is acts as carrier of important nutrient for root growth and important for plant metabolism. The amount of phosphorus in compost should be ranged between 0.2 and 2.0% which is expressed as P2O5. Both of P that found in this study is not in the ranged as in the previous study. No significant difference in the Phosphorus content was found in this study.

Potassium forms in compost are expressed as K_2O. Potassium was responsible as a regulator of water content within plant cell. Besides that, Potassium is essential for the formation of carbohydrates and proteins. Similar results were obtained in Phosphorus analyses, the amount of Potassium in both types of compost are below the typical range.

According to Lokman et.al (2013), the application of EM was able to increase the NPK content in the compost. However, only the Nitrogen content was significantly higher in this study. The sum of NPK content in the homemade EM compost (3.13%) was higher than the commercial EM compost (2.27%). These results recommend the positive effect of EM to enhance the NPK of compost (>3%) for supply nutrient to the soil.

5.3 The relationship between pH, moisture content and temperature of compost.

From the result, there is no relationship between pH, moisture content and temperature of compost. Contrary to expectation, this study did not find a significant different between temperature with moisture.

This finding is contrary to previous studies which have suggested that the temperatures will affected by moisture content (Bera et.al, 2014).

5.4 The relationship between pH, moisture content and temperature with NPK concentration of compost.

The results of this study did not show any significant relationship between NPK with pH, temperature and moisture content compost. It can therefore be assumed that these physical parameters will not affect the NPK concentration in compost. The possible factors that can affect the concentration of NPK are the composition and the type of waste used in composting process (Barrena et. al, 2014).

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The homemade EM has accelerated the process of food waste composting. The pH changed showed the compost with homemade EM reached stability at a faster rate which is at week 5 compared to the commercial EM at week 6. The moisture content of both type of compost maintained at suggested value which is 40-70% and produce earthy smell at week 6 and changes to dark brown starts from week 3. The concentration NPK for both type of compost was below than the typical range of fertilizer to be used in agriculture. However, the sum of NPK content in the compost with homemade EM (3.13%) was higher than the commercial EM (2.27%) that suggest the homemade EM has the positive effect to enhance the NPK of compost (>3%) and suitable to be used as organic fertilizer.

6.2 Limitation

There are some limitations found during conducting of this study. Firstly, the period time to conduct this study is too short due to the time constraints. Although the result of this study was positive, this study should be conducted in a long period of time to get better results. Besides that, this study only conducted in a small size of composting and it could affect the result of this study.

6.3 Recommendation

Based on the findings from this study, there is several recommendations for the future research. Firstly, the study should be including more physiochemical parameter such as carbon: nitrogen, electric conductivity and stability of the compost. Besides that, the content of heavy metal in compost also can be measure to make sure whether is it has the source of heavy metal from the components of food waste compost.

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8.0 APPENDICES

1) HOMEMADE EM SOLUTIONS

Figure 8. 2: Plastic Box

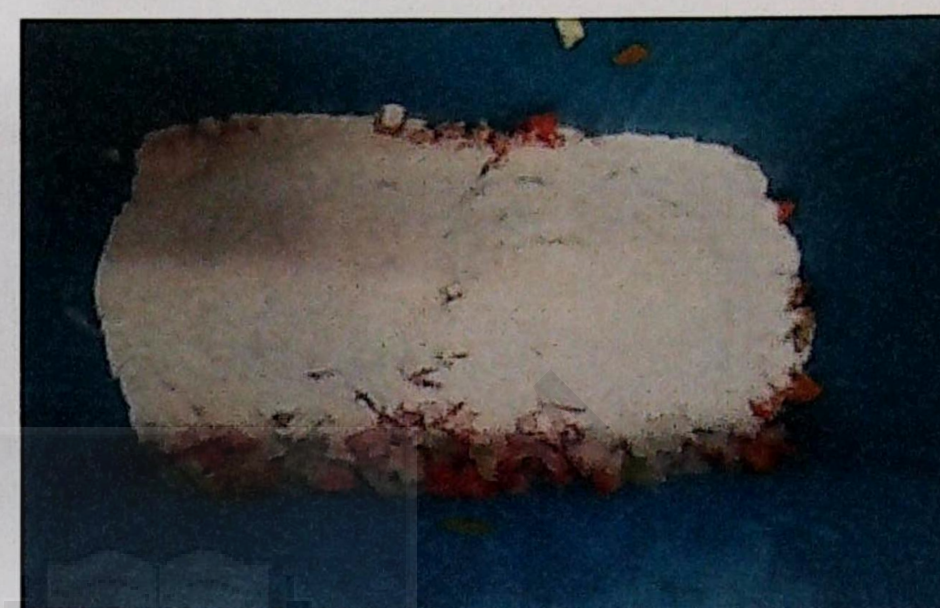

Figure 8. 1: Fruits Waste and rice powder

Figure 8. 4: Brown Sugar

Figure 8. 3: Mixture of fruits waste, rice powder, brown sugar and water

Figure 8. 6: Filter the mixture after 3 weeks

Figure 8. 5: Homemade EM Solution