Nutritious Fertilizer From UTP-Generated Organics Via Vermicomposting

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Dissertation submitted in partial fulfilment of the requirements for the
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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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APPROVED BY,

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JAN 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MUHAMMAD AZAM HAIKAL BIN RAMLI

ABSTRACT

The organic wastes around UTP were converted into fertilizer through vermicomposting. 2.3 kg organic wastes has been put into four different tray. Tray A and C consist 2kg grinded kitchen wastes, 200g dry leaves, 100 grass clippings while Tray B and D comprise of 2kg raw kitchen wastes, 200g dry leaves, 100g grass clippings. Temperature for all tray increase slightly and stabilized around temperature 32C ± 1 C. pH value of tray A, B, C and D increased from 6 to 8.0-9.0. Kitchen wastes in tray A and C decomposed completely after 10 days and kitchen wastes in tray B and D decomposed completely after 15 days. Hence, the size of particles can affect the vermicompost rate and quality. The smaller the particles size, the better. Further analysis on total nitrogen content and organic content need to be done to compare the quality of compost with readily fertilizer.

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CHAPTER 1. INTRODUCTION

The growing population and rapidly increasing urbanization have resulted in increased waste generation in the world, hence make the disposal of organic wastes is unavoidable (Külcü & Yaldiz, 2014). Malaysian thrown wastes 0.44kg more wastes than the average worldwide city, where they produced about 1.2kg wastes daily (Idrus, 2013). Idrus (2013) also stated that, if the rate of the wastes produced constants at this level, it would yield a drastic 65% increases of waste production from 10,000 tonnes per day in 2010 to 17,000 tonnes per day by 2020, which will filling up the capacity of two out of three landfills at Jeram in Kuala Selangor and Tanjung Dua Belas in Kuala Langat by 2035. Because of that, is important for us to start processing or recycling those wastes into something useful for mankind. Huge amount of organic wastes produced also possesses a problem for safe disposal as the wastes either burned or thrown away into landfill (Nagavallemma et al., 2004). One of the way to control and reduce the disposal of organic wastes is through composting. Composting is a controlled microbial aerobic decomposition which formed stabilized organic substances that can be used as organic fertilizer or soil conditioner (Külcü & Yaldiz, 2014). Composting can be defined as natural way of recycling where it is a process of breaking organic wastes biologically into a useful humus-like substance by various microoganisms. One of the composting method is vermicomposting, a composting process using worms as the agent.

Vermicomposting is a method of transforming organic wastes into more valuable product. In general, vermicomposting can be defined as a simple biotechnological process using certain species of earthworms to promote the conversion of waste and produced invaluable new products (Nagavallemma et al., 2004). Vermicompost using earthworms yield organic fertilizer rich in nutrition and much powerful ‘growth promoter’ compared to conventional compost and has been proven as protective towards farms as it increases the soil biological properties physically and chemically, and improving and restoring the soil fertility (R.K. Sinha, Herat, Chauhan, & Valani, 2009).

Chemical fertilizers used in agricultural sector have brought some environmental problems such as contamination of water resources and generation of carbon dioxide (CO_2). Chemical fertilizers resulted in loss of soil fertility due to the imbalanced use of fertilizers which has adverse effect on the agricultural productivity and hence degrade the soil quality(Nagavallemma et al., 2004). Heavy use of agrochemicals since 1960s has helped to increase the food productivity, but at the expense of the environment and society as it killed the organisms live in the soil. Furthermore, it destroyed the natural fertility of soil and decrease the resistance of the crops thus making them more susceptible to pests and diseases(Rajiv K Sinha, Agarwal, Chauhan, & Valani, 2010). The drawbacks of chemical fertilizers started to appear after many years of applications especially their counter-role as “slow-release poison” towards the soil (R.K. Sinha et al., 2009). By using the organic fertilizer, environmental issues can be tackled as it is more environmentally friendly. One of the way of producing organic fertilizers is via vermicomposting.

1.1 Problem Statement

Universiti Teknologi PETRONAS (UTP) generated organic wastes every day. Organic wastes such as kitchen wastes, fall leaves, mown grass, and used papers are type of wastes produced in UTP. In UTP, these organics wastes are contributed by the Cafés and fall leaves and grass around UTP. Therefore, it is preferable to process this wastes into more valuable products to limit the disposal of wastes to the landfill. By doing this, UTP can save the cost for garbage disposal and generate its very own compost for internal use. Besides, increasing worries on the usage of chemical fertilizers in industry towards environment means that the industry need to turn the focus to organic fertilizer. As vermicomposting can turn the kitchen wastes as well as other organic wastes into valuable organic fertilizer, hence it also provide alternative to the chemical fertilizer.

1.2 Objectives

The objectives of this study are:

- To transform commonly found organic wastes around Universiti Teknologi PETRONAS (UTP) into highly nutritious compost through vermicomposting method.

- Besides, this study also conducted to identify potential waste around UTP such as food scraps, leaves and grass that can be decomposed by the worms.
- This study also aim to monitor and assess parameters such as temperature and pH profile and their relation to rate of vermicomposting.

1.3 Scope of Study

Vermicomposting requires conducive environment for the worms to degrade the organics. In order to provide such conditions, key parameters for their survival will be monitored such temperature and pH. Finally, mass balance calculation will be performed to determine the yield of compost that can potentially be produced from UTP-generated organic wastes. The timeline for this project is 8 months which required the author to cover on the background study on producing highly nutritious organic fertilizer from organic wastes in UTP via vermicomposting, reviewed the recentness and relevancy of the literature review, the experimental part, final report as well as the presentation.

CHAPTER 2. LITERATURE REVIEW

2.1 Organic Fertilizer Vs Chemical Fertilizer

The use of chemical fertilizer in agricultural industry undoubtedly has increased the crop yield. However, the application of chemical fertilizers have raised many environmental concerns such as groundwater contamination, eutrophication and greenhouse gas release from the production of phosphate. Phosphorus release in the water reinforced the eutrophication(Correll, 1998). Eutrophication can be defined as an increase in the rate of supply of organic matter in an ecosystem(Nixon, 1995). Phosphorus, an organic matter, discharged to the river or lake and thus promote the growth of algae which will use the oxygen supply in the river or lake hence result in the death of other aquatic lives. Because of this issues and concerns, the world started to turn the attention towards organic farming. From the table below, it shows that the organic farming by the used of compost yield better properties of soil than chemical farming using the chemical fertilizer.

Table 2-1 Farm soil properties under organic and chemical farming

Chemical and Biological Properties of Soil	Organic Farming (use of compost)	Chemical Farming (use of chemical fertilizer)
Availability of nitrogen(kg/ha)	256.0	185.0
Availability of phosphorus(kg/ha)	50.5	28.5
Availability of potash(kg/ha)	489.5	426.5
Azatobacter(1000/gram of soil)	11.7	0.8
Phospho bacteria(100,000/kg of soil)	8.8	3.2
Carbonic Biomass(mg/kg of soil)	273.0	217.0

Source: (Suhane, 2007)

Since all compost are produced from waste materials, the organic compost is a renewable sources and can be easily obtained while the chemical fertilizer is made up from non-renewable sources, which is petroleum where will be depleted in the future(R.K. Sinha et al., 2009).Via sheep-manure vermicompost as the soil supplements, it increased tomato yields and soluble, insoluble solids and carbohydrate concentrations(Gutiérrez-Miceli et al., 2007).

Although earthworm casting produce slight alkaline soil with pH more than 7.0 and plant generally favor the pH 6 condition, but the peat can be added into the alkaline soil to lower down the pH (Edwards & Neuhauser, 1988).

2.2 Vermicomposting

Vermicomposting is a simple biological process that uses certain species of earthworms to enhance the conversion organic waste into valuable compost as the product(Nagavallemma et al., 2004). In short, worms act as an agent to convert the organic waste to a useful product such as fertilizer and soil conditioners. Vermicompost using earthworms yield organic fertilizer rich in nutrition and much powerful 'growth promoter' compared to conventional compost and has been proven protective towards farms as it increases the soil biological properties physically and chemically, plus improving and restoring the soil fertility (R.K. Sinha et al., 2009). Vermicompost produces a fertilizer that is high Nitrogen-Potassium-Phosphorus(NKP) value (nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25%), micronutrients, and useful soil microbes and also contains growth hormones and enzymes for plant (R.K. Sinha et al., 2009).

According to Kale and Bano (Kale & Bano, 1986), abundant content of nitrogen (N) and phosphorus found in worm's vermicast, which is 7.37 % of nitrogen and 19.58% phosphorus. In addition, vermicompost yield high porosity, aeration, drainage and water holding capacity soil, also have a vast surface area, providing strong absorbability and retention of nutrients(Panday, 2012).

2.3 Earthworms

Suitable environmental condition is vital for the earthworms to process the wastes. Parameters such as temperature, pH, moisture content and ventilation need to be taken into account. In composting process, microorganisms release heat and energy by decomposing organic material. The heat generated during the process increases the temperature of the compost pile, which ensures the inactivation of pathogenic microorganisms (Külcü & Yaldiz, 2014). According to (Nagavallemma et al., 2004), earthworms can tolerate the temperature ranging from 0-40°C and regenerate at temperature 25-35°C and 40-45 % moisture level of the bin. Too much water content will reduce the oxygen in the soil and 'drowned' the worms. Earthworms eat rapidly and probably work best at the temperature range between 15-25°C (Appelhof & Fenton, 1997). Because of that, it is very important to measure the temperature as well as the moisture level of the bin in composting process to ensure the process working very well. *Eisana festida*, a species of earthworms, can process organic material at least half of its body weight per day (VermiCo, 2013). Generally, an earthworm weighs between 0.5-0.6g, consume waste equivalent to its body weight and produces cast about 50% of the waste consumed earlier (Nagavallemma et al., 2004). On the other hand, according to United States Environmental Protection Agency, one pound of earthworms (approximately 800-100 worms) can consume about up to half of pound of organic wastes per day. Red wiggler worms can tolerate fairly wide range of pH(pH 5-9), with slightly acidic soil condition is the optimum condition and are found died in soil from pH 4 and below (Appelhof & Fenton, 1997). Air circulation in the vermicompost container is important for the ventilation as worms use oxygen in their bodily processes (Appelhof & Fenton, 1997).

2.4 Carbon To Nitrogen (C/N) Ratio

In vermicomposting, proper ratio of carbon to nitrogen need to be taken into consideration before start. Sufficient supply of carbon and nitrogen for earthworms during vermicomposting must be provided at correct ratio(Ndegwa & Thompson, 2000). This is because microorganisms consumed carbon as source of energy and nitrogen in building tissue structure during decomposition(Composting, 2014). According to Ndegwa & Thompson (2000), 25 is a suitable C/N ratio for vermicomposting, produce the best fertilizer, and produce less pollution towards environment.

CHAPTER 3. METHODOLOGY

3.1 Research Methodology

Collection of samples:

Food wastes are obtained from Kafe Sajian Ria in UTP, consists of kitchen wastes such as green vegetables and fruits. Meat wastes is not taken because it can attract the presence of rodent. Dry leaves around UTP areas are collected and stored in a plastic bag. Collection of mown grass from football field and rugby field is stored in a plastic bag.

Experimental set-up of composting activities:

All the wastes including food scraps, leaves, and grass are mixed together. After that, the mixed wastes are divided into 4 trays, A, B, C and D respectively, where each tray consist 2.3 kg of mixed organics wastes.

Table 3-1 Mass of organic wastes and worms in each tray A,B,C and D

Tray A	**Tray B**	**Tray C**	**Tray D**
Mass of kitchen waste(grind) = 2.0kg Mass of dried grass = 0.1 kg Mass of dried leaves = 0.2 kg 3kg of worms 200 g of compost	Mass of kitchen waste (raw) = 2.0kg Mass of dried grass = 0.1 kg Mass of dried leaves = 0.2 kg 3kg of worms 200 g of compost	Mass of kitchen waste (grind) = 2.0kg Mass of dried grass = 0.1 kg Mass of dried leaves = 0.2 kg 1.5kg of worms 200 g of compost	Mass of organic waste(raw) = 2.3kg Mass of dried grass = 0.1 kg Mass of dried leaves = 0.2 kg 1.5kg of worms 200 g of compost

Figure 3-1 Set up apparatus for Tray A, B, C and D.

C/N ratio:

From on farm composting handbook by Cornell composting, the typical value for carbon percentage, nitrogen percentage and moisture content for each type of waste are as in Table 3-2.

Table 3-2 (%) of Carbon, Nitrogen, Moisture Content and Weight of Wastes

Type of Wastes	% Carbon	% Nitrogen	Moisture content (%)	Weight (g)
Kitchen waste	52	4	87	2000
Dry leaves	104	1	0	200
Grass clipping (dry)	150	5	0	100

C/N ratio is calculated using formula:

$$\frac{C}{N} ratio = \frac{Q_1[C_1 \times (100 - M_1)] + Q_2[C_2 \times (100 - M_2)] + Q_3[C_3 \times (100 - M_3)]}{Q_1[N_1 \times (100 - M_1)] + Q_2[N_2 \times (100 - M_2)] + Q_3[N_3 \times (100 - M_3)]} \quad \text{(equation 3.1)}$$

Source: (Richard & Trautmann, 1996)

Where Qn = mass of materials, g

Cn = % carbon

Nn = % nitrogen

Mn = moisture content of materials

C/N ratio = 25.2

Watering frequency:

Every 3 days or depend on the moisture of the soil. The moisture level must be 50% (1.15kg) of the total initial mass of organic wastes added into the tray.

Measurement of weight:

Initial weight of each tray are taken at the start of the experiment using 50kg household balance. After one week the tray is weighed again to find the mass of wastes after partial degradation by the worms.

Measurement of temperature and pH:

Temperature and pH readings are at least every 3 days. Soil thermometer is used to measure temperature and pH meter.

Mass balance:

Mass balance will be performed at the end of this experiment, after 35 days and the yield of the compost will be calculated by using formula:

Yield (%) = (mass of organic / initial mass) x 100% (equation 3.2)

CHAPTER 4. RESULT AND DISCUSSIONS

4.1 RESULT

4.1.1 Temperature and pH

The experiment has been conducted for 35 days. Temperature and pH readings has been recorded every day and the result is in Figure 4-1 and Figure 4-2.

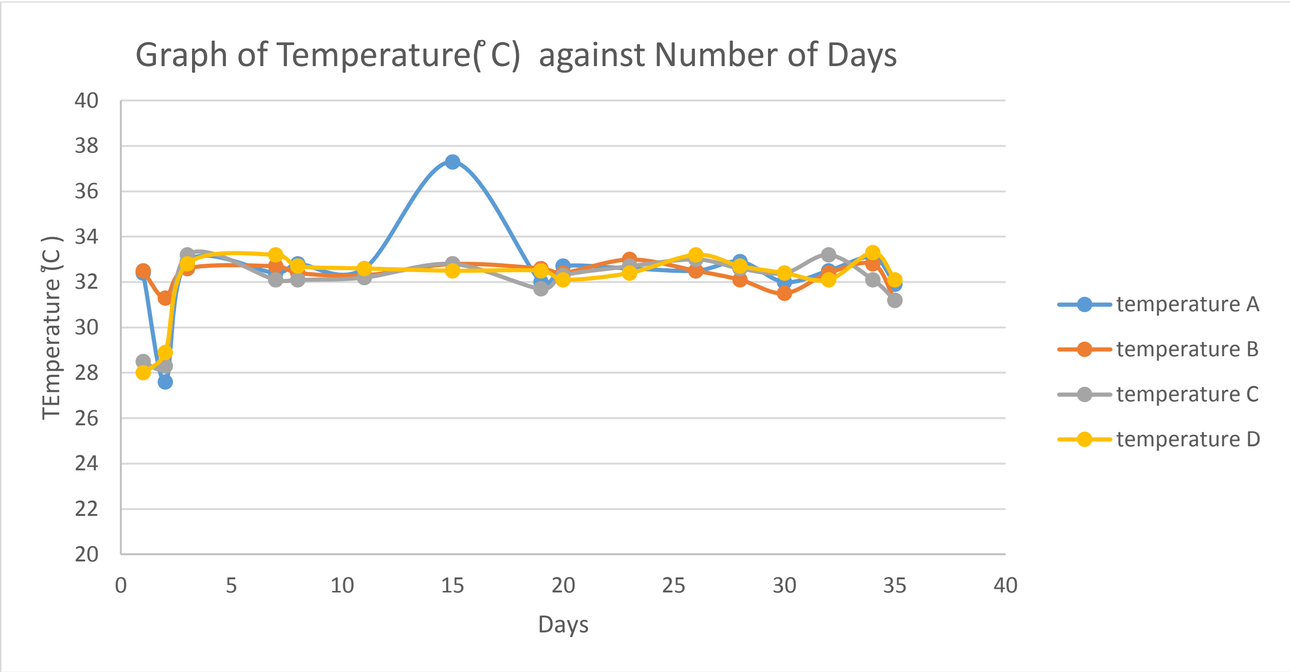

Figure 4-1 Graph of Temperature against Number of Days for Tray A,B, C and D

The temperature for all 4 trays shown an early increase in trend from 28℃ to around 32℃ from day 1 to day 7. After that, temperature for all tray seems to maintain at temperature ranging from 31℃ to 33℃.

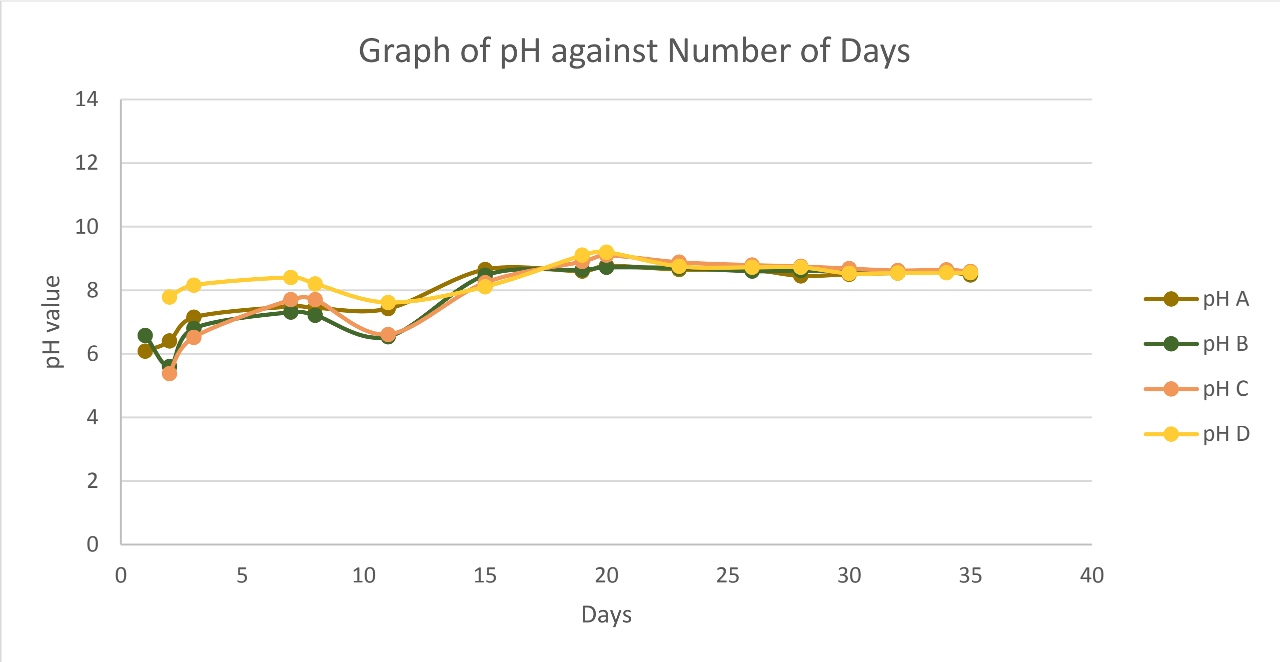

Figure 4-2 Graph of pH against Number of Days

The pH profile in Figure 4-2 show that the pH for tray A in day 1 is 6.08 and increase steadily until reaching pH value of 8.65 after 15 days. From day 15 onwards, the pH of tray A maintain within the range of 8.0 to 9.Tray B and C also follow almost the same pattern as both recorded initial pH of 6.58 and 5.38 and after that increases to pH 8.47 and 8.24 in day 15, and maintain from day 15 onwards within the range pH of 8 to 9. Tray D recorded initial pH value of 7.78 and stabilize during range of pH 7 to 9 throughout the study.

4.1.2 Physical Observation

<u>Initial (Day 1)</u>

Tray C (Tray A initial observation same as Tray C)

Figure 4-3 Tray C at the start of experiment

The mixture of the grinded kitchen wastes, grass and dry leaves can be clearly seen during the starting date. After 10 days, no green-coloured particles were seen in the tray, indicating the complete composting of kitchen wastes.

Tray D (Tray B initial observation same as Tray D)

Figure 4-4 Tray D at the start of experiment.

Raw kitchen wastes, leaves and grass can be clearly seen at the starting date. After 15 days, all kitchen wastes were considered completely composted because no green particles can be seen any more in the tray.

Day 35

Figure 4-5 Tray A after 35 days

Figure 4-6 Tray B After 35 Days

Abundance amount of grass and leaves still can be seen in both tray A and B after 35 days.

Tray C and D

Figure 4-7 Tray C after 35days

Figure 4-8 Tray D after 35 days

Abundance amount of grass and leaves still can be seen in both tray C and D after 35 days.

4.1.3 Mass Balance

Table 4-1 Initial Mass and Final Mass of each tray

Tray	Initial Mass (kg)	Mass after 35 days (kg)	Difference (kg)
A	6.05	3.75	2.30
B	6.05	4.15	1.90
C	4.85	2.60	2.25
D	4.85	2.85	2.00

4.2 DISCUSSION

4.2.1 Temperature and pH profile

From the temperature profile in figure 4-1, it can be seen that there are increases in temperature for all tray A, B, C and D during first 3 days. This suggest there were decomposition of wastes by worms and also microorganisms happened in all tray. However, the temperature profile started to stabilize within temperature 32 ±1C. This result completely different from the finding by (Rupani, Ibrahim, & Ismail, 2013) as the temperature profile should increase up to temperature 50 C before decrease back to temperature around 30 C. This is most likely cause by the slow decomposition of wastes by worms because of the large particles size of dry leaves and grass, thus made it harder for worms to further continue the decomposition process.

The pH profile in figure 4-2 generally shown slight increment in pH reading in all tray A, B, C and D. This could indicate the release of ammonia which resulted from degradation activities of worms and microorganisms and also mineralization of organic compound. According to (Ansari & Rajpersaud, 2012), large amount of ammonia excreted by earthworms which leads to temporary rises in pH reading. This reaction also called the alkalination of food. This study in line with finding of (Majlessi, Eslami, Saleh, Mirshafieean, & Babaii, 2012) as their study also yield almost the same pH profile.

4.2.2 Physical Observation

From the physical observation, it can be seen that grinded kitchen wastes in Tray A and C decomposed faster than Tray B and D. Due to small surface area of grinded particles, therefore it is easier for the worms and microorganisms to consume and further degrade the wastes. According to Urban Composting (2014), the temperature of the sample increase faster when the particles size is smaller.

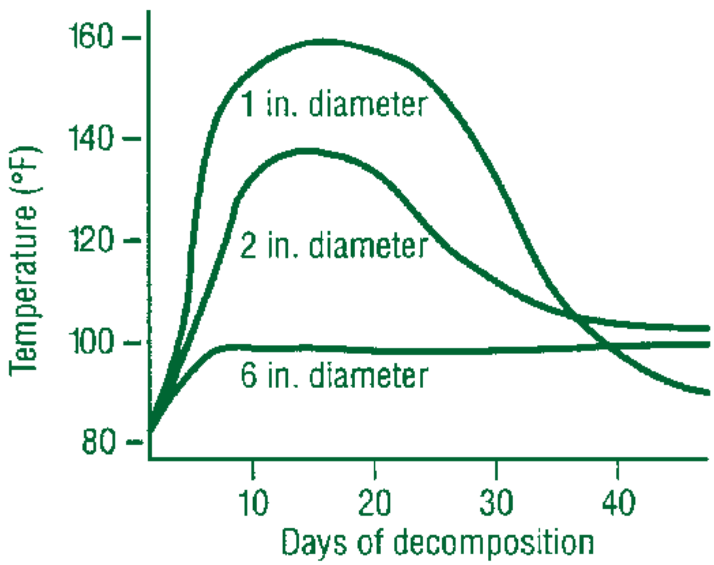

Figure 4-9 The effect of particles size on temperature and day of decomposition

Source: Urban Composting (2014)

However, in all tray, large amount of dry leaves and glass still not being processed by the earthworms. This is due to the large particles size of both of them which reduces the effectiveness degradation activities of earthworms as well as microorganisms.

4.2.3 Mass Balance

The remaining mass of the tray cannot be used to calculate the yield of each tray as the composting process are still unfinished. However, from the table 4-1, it shows that the final mass decreases about 2kg in every tray. Most likely, the kitchen wastes has been completely consumed by the earthworms as correspond to the physical observation in each tray after 35 days, no more green particles can be traced.

CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

As a conclusion, increases in temperature indicate that there are composting activities occurred in the trays. The pH value of the compost tends to increases from 6 to a pH range 8 to 9 and stabilized after reaching that range of pH. Vermicomposting is affected by the particle size. The smaller the particle size, the faster the rate of composting. As in this study, the grinded kitchen wastes composted completely after 10 days and raw kitchen wastes composted completely after 15 days. However, for dried leaves and grass clippings, there are still abundance of leaves and grass that still not composted yet. This is most likely cause by the large particles sizes since both of them are not grinded and thus have high particles size and therefore take longer time to decompost. In this study also, it has been found that, the mass of the samples at the end of experiment decreased more than 50% from the initial mass for all trays. Thus, it can be concluded that vermicomposting can be an option to reduce the amount of wastes from filling up the big space in landfill.

As for recommendation for further study on vermicomposting, it is suggested to grind or cut the leaves and grass into smaller sizes to increases the rate of composting. Other than that, it is recommended to extend the duration of the experiment to increase the possibility of completion of vermicomposting process. In addition, it is recommended to assess the organic content and nitrogen content of the compost so that comparison with readily fertilizer in current market can be done.

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