Process Improvement of Bioconversion of UTP Leaves Waste into Compost using Pilot Composters

by

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Dissertation report submitted in partial fulfillment of

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CERTIFICATE OF APPROVAL

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Approved by,

____

(Dr M Rashid Shamsuddin)

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SERI ISKANDAR, PERAK

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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 the acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

CHERYL KOK HUI YING

ABSTRACT

Universiti Teknologi PETRONAS (UTP) is a private university of 400 hectares and mostly covered with greens. Every day, UTP produce huge amount of green wastes such as fallen leaves, branches and vegetable scraps. Other than collecting them and disposing them or burning them, composting can be an alternative in reducing green wastes in UTP. This goal of this paper is aimed to study the effect of composting key parameters on the quality and maturity of piles of compost. Parameters like initial C:N ratio particle size, moisture content, porosity, aeration rate, amount of worm inside the pilot composters, and turning frequency is fixed. From this paper, it is a goal to determine ideal C:N ratio to compost green waste which is leaves, branches and vegetable scraps in Malaysia. Research papers suggested that C:N ratio is highly significant in determining a mature and quality compost. The carbon content is related to nitrogen content because carbon contributed to the organic amount in the compost whereas nitrogen contributed for the nutrient content in compost, thus, an ideal C:N ratio is suggested to range between 25 and 30 for fast and effective composting. Since vegetable scraps are rich in nitrogen and dried leaves contain higher carbon content, by performing four composting experiments in four identical pilot composters, varying the mixture ratio of dried leaves and vegetable scraps to C:N ratio of 20, 25, 30, 35, parameters such as temperature profile, pH profile, moisture content, Total Nitrate Content (TKN), Total Organic Carbon Content (TOC), and $C:N_{aqueous}$ are determined. Throughout the experiments, manual turning at a frequency of one turn per three days for every composter is done. Composting temperature and pH are monitored and recorded once per 3 days to plot the temperature profile and pH profile, in order to determine the compost maturity. Concentration of carbon and nitrogen are measured at the end of the experiment to determine the quality of compost. $C:N_{aqueous}$ are measured based on the result of TOC and TKN. According to research, it was suggested composts which have matured has a $C:N_{aqueous}$ of 5–6.

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Yours Sincerely,

Cheryl Kok Hui Ying

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Crop residue or leftover, green vegetables, vegetables scraps or vegetable leftover, dried leaves, branches or twigs are all consider as green waste. These green wastes can be reduced by landfilling, or rather, composting. According to Haug[1], organic wastes are used and converted into value-added products by composting activity. Some of the value added products are commonly referred as fertilizer and soil additives. The basic of composting is actually to leave a pile of organic waste decomposed under natural elements.

Various studies had been conducted to determine the methods and ways which can improve and enhance the quality of compost. In fact, the recent studies and researchers have identified the use of additives because additives can shorten the time for decomposition period of organic wastes and thus, enhancing the quality of the compost product[2]. Giving an example, researchers conclude that several specific biodegradable plastic can improve compost quality[3]. Another way is co-composting. Co-composting using different type of organic wastes at the same time also can increase the quality of compost, and it is proven in research which compost leaf waste and chestnut burr together with solid poultry manure [4]. Additives are further identified and ventured to improve the quality and maturity of the compost during composting. Some of the proven additives are brown sugar and calcium superphosphate. They produced a mature and of course high quality of compost faster than the conventional and traditional way of composting [5]. Researchers have previously explored more additives which are carbohydrate (sugar), bentonite, urea, crushed straw, furfural residue, calcium superphosphate and few others more [6, 7].

Of all this, many research studies had stated and demonstrated the importance of earthworm in the ecological system because they can digest and consume wastes such as animal manure, sewage sludge, green wastes, food waste, crop residues, and industrial effluent [8-11]. In fact, earthworms feed on most of the waste. When earthworms are at work, they will chew and digest the waste into fragments thus increase the decomposition rate of the organic waste. This definitely improves the chemical properties so as the physical properties of the initial organic waste. By oxidizing the unstable organic matter into value-added product, or in this case vermicompost, earthworm contributes to effective composting.

Application of vermicompost is as wide as to enhance growth and increase yield in agriculture and also in environment which is to reduce waste in landfill and reduce the use of chemical fertilizer. Hong Kong Environmental Department [12] recommends that vermicomposting provides a better alternative method in dealing with disposal of solid waste management, since it transformed the organic waste to material that can be utilized and also environmental friendly.

1.2 Problem Statement

Universiti Teknologi PETRONAS (UTP) is a private university where it has a compound area of 400 hectares and mostly covered with greens. Given such environment, UTP is bound to produce huge amount of green wastes such as fallen leaves, branches and vegetable scraps. Outside contractors like Livline are hired and assigned to dispose green wastes from UTP to allocated disposal area outside from UTP every day.

To not utilizing the massive amount of green waste and convert them into value-added products like soil additives and fertilizer, this further increase the amount of solid waste and landfill. In fact, vegetable scraps consisting of high nutrient contents (especially in nitrogen) and dried leaves consisting of high level of organic content (carbon content). Therefore, they can be converted into value-added product if they are co-compost together in a right and optimum C:N initial ratio.

The compost which is mixed with the worm excretions together with waste, and in this case, green waste, is called vermicompost. Leaves contain high amount of cellulose and lignin[13], which is hard to decompose. Thus they exhibit a relatively slow decomposition rate, therefore, vegetable scraps with high nitrogen content would compensate the high carbon content of leaves with for composting.

With the aid of worms in order to fragment the waste and produce worm castings, vermicompost has concentrated nutrient and nitrogen content compared with the regular compost. Furthermore, not only as soil additives, this value-added vermicompost can be utilized as a power source to run a chem-e-car in which the model car is powered up by chemical reaction. Vermicompost contains humic acid and with several additives, it can be generated as power source which its electrical conductivity is high enough to run a car.

1.3 Objectives and Scopes of Study

The aims of this research are:

- To determine the suitable C:N ratio generated from mixture of green wastes on the maturity and quality of compost under same parameters for each set. The parameters are the amount of worms (kg) in each composter, moisture content, type of organic wastes, turning frequency, particle size and porosity.
- To establish the composting time via pH and temperature profile
- To access the compost quality via MC, TOC, and TKN
- To study the feasibility of composting activity of leaves waste in UTP as an alternative way to existing disposal system via mass balance, timing, cost and man power analysis.

Once the compost is ready, it can potentially collaborate with UTP Chem-E-Car team which currently uses humic acid from vermicompost as car fuel. The team is highly appraised locally and internationally on its green power source. Therefore, composting UTP leave waste is a win-win situation- eco-friendly way of dealing with UTP leaves waste, generating nutritious fertilizer for campus use and potential collaboration with our very own winning Chem-E-Car team

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Vermicompost

This study portrays the technique for determining the ideal C:N ratio for composting pile in setting up pile and fertilizing the waste which comprises of fallen leaves, vegetable scraps and little broken bits of twigs. This method of composting is enhanced by inserting earthworms in each composting pile to create a high supplement estimation of vermicompost toward the end of the time of fertilizing the soil. This improvised enhancement in inserting earthworms into the composting pile result in the shorten period of composting time is reduced substantially. Due to the increment of activity of the microorganisms, the maturation time for compost has shortened.

2.2 Control Parameters of Composting

Several factors are crucial in efficient composting. The parameters in controlling composting activity such as particle size, porosity, C:N ratio, nutrient content, moisture content, temperature, and pH have shown to be the key for composting the waste for optimization since these factors decide the ideal conditions for microbial advancement during composting period[14-18] [1]

The present research also has accentuated on the significance of the initial C:N ratio in setting up the compost pile to generate a quality and mature compost [19-26]. The range of suggested initial composting C:N ratio for process is approximately from 25 to 35 [27-31], due to the reason that it is suggested that the useful microorganisms to compost the pile need 30 units of carbon for one unit of nitrogen[32]. Permitting big initial C:N ratio lengthen the composting activities and processes since there is an abundance of degradable substrate for the microorganisms. [33] However, with a small initial C:N ratio, there is excess of unused nitrogen per unit of degradable carbon, in which either carbon content is too little or nitrogen content is too high. Inorganic nitrogen is generated in excess and can be lost either by leaching (leachate) from the composting waste or ammonia volatilization. To correct this situation, by adding a bulking agent such as sawdust and shredded paper which consist of high organic-Carbon content, it can provide sufficient degradable organic-Carbon

Other than C:N ratio, pH also plays an important role in optimizing composting. pH of 6.7–9.0 which is slight alkaline provides medium for good microbial activity during composting activity. Ideal range of pH values are between 5.5 and 8.0 [15, 18]. Since most composting matters are inside of this pH range, pH commonly is not a key component for composting, but rather, this variable is extremely important for controlling and maintaining the loss of nitrogen by volatilisation of ammonia, which can be especially high at pH more than 7.5. To improve and upgrade and enhance composting activity, elemental sulphur (S) has been used to avoid high pH values when composting activity is conducted[34].

Furthermore, distribution of particles and particle size are basic for adjusting the surface interaction area for development and growth of useful microorganisms, as well as the upkeep of suitable air porosity. The bigger particle the size, surfaces range to mass ratio gets lower. Therefore compost with low surface area indicating large particles size does not break down ideally in light of the fact that the inside of the particles has difficulty in accessing the useful microorganisms. It is because during decomposition period, particles might attached to the surface, with an impervious humidified layer[35]. In any case, tiny particles can conserve the pile of composting mass, decreasing the porosity. However, such components are particular in terms of the physical of the material such as distribution and particle size, packing, moisture content, and shape in maintaining and controlling the porosity of the mass for composting.

Material (pile) porosity applies an incredible impact on the performance of composting since proper and adequate physical environment's conditions for air flows distribution ought to be kept up throughout the period. Porosity more than fifty percent makes the composting waste pile to stay at a low temperature for the reason that energy lost is faster than the heat which has been produced, thus lost more heat than producing it. Too compacted pile also represents low porosity pile, prompts anaerobic conditions and bad/smelly odour is generated. The percentage of pore space which is filled by air alone (porous) of composting piles should be within range of 35% to 50% for optimum composting activity.

Aeration is a key element for treating the soil. Appropriate aeration controls and maintain the temperature of composting piles, remove excess dampness and moist and CO2. Aeration also provides O2 for the microbial activity. The ideal O2 concentration is somewhere around 15% to 20%[18]. Controlled aeration ought to keep up temperatures below 60–65oC, which guarantees enough O2 is supplied.[36].

For moisture content, the ideal water amount for composting changes/differs with the organic waste which is to be composted; however the mixture ought to be at 50 percent to 60 percent of moist. [37]. At the point when the moisture content of the substance surpasses 60% O2 development is hindered and the procedure has a tendency to become anaerobic [38]. Amid composting a vast amount of water can evaporate, which is the way to control and maintain desired temperature, and as water substance reduces, the decomposition rate declines, then rewetting ought to be required, keep in mind that the end goal is to control and maintain the ideal water moisture content for the movement of activity of microorganisms.

Experiments have been conducted and done by altering the frequency of rotation of each pilot composter at different time intervals, after that they are all compared with each other on the frequency of turning of turning once every day, one time for each 3 days and once every week towards the effect of composting activity. [13] However, daily turning brought about a retard in rising the temperature because of fast heat loss. Low turning frequency such that weekly turning has brought about a slow decomposition action and moderate stabilization of compost as demonstrated by the lower soluble organic carbon content, smaller weight reduction, and decreased in germination index(GI). Turning period of three days had the most astounding level of rate of decomposition as demonstrated by the increased carbon and nitrogen mineralization.

The pattern of temperature demonstrates the happening of composting activity and the microbial activity. The ideal range of temperature for treating the soil is 40oC to 65oC[39], temperatures above 55oC are required to kill microorganism thus not allowing them to survive under this circumstances. However, if the composts' temperature obtained has exceeded the allowable range during thermophilic decomposition, it is not good for composting. The temperature scope of 52oC to 60oC is most ideal for improving decomposition rate [18]. It is required to regulate the temperature for any controlled composting activity. Extra heat produced can be removed and accomplished through a few methods[18]: control the shape and size of the composting waste mass; enhance cooling and favorable temperature redistribution through suitable amount of turning operations, with this heat is removed through vanishing cooling, thus able to accomplish adequate temperature control.

CHAPTER 3

METHODOLOGY

3.1 Pilot Composters

In order to study the compost dynamics, four identical pilot composters with each capacity of 250L are used. The composter is made up of a 5mm thick recycled plastic sheet having outer diameter and length of 0.6m and 0.9m, respectively. The interior of the composters is marked with paint labeling the percentage of the capacity in the composter. It is placed on a four legged metal stand and can be manually rotated by rolling the composter by the metal handle since it has shaft at the center of the composter. In order to provide better mixing environments, 28 aeration holes at the wall of pilot composters were made to drain out excess leachate and water. Cover is attached on top of the pilot composter and side cover too is prepared as backup. The shredded mixed green waste is loaded into the pilot composters and filled up to 50% of the total capacity.


Figure 3.1 Pilot Composter


Figure 3.2 Side view of Pilot Composter


Figure 3.3 Front View of Pilot Composter


Figure 3.4 Standing mount

3.2 Feedstock Materials and Setup

Leaves and vegetable scraps are collected from all around the compound of Universiti Teknologi PETRONAS (UTP). Green waste collected like leaves and vegetable scraps are finely ground and tested for Total Organic Carbon and Total Kjedahl Nitrate test to determine the actual C content and N content of the substances. Knowing the C and N content of leaves and vegetable scraps, calculation can be done to prepare the composting ratio. Four composting waste piles were prepared consisted of leaves and vegetable scraps in a ratio of 0:10 (weight/weight, fresh weight), 2:8 (weight/weight, fresh weight), 4:6 (weight/weight, fresh weight) and 6:4 (weight/weight, fresh weight) for Pile A, B, C and D respectively, in order to achieve C:N of 25, 30, 35 and 40 for Pile A, B, C and D, respectively. The aim of using vegetable scraps is to adjust and set C:N because it has high nitrogen content.

The typical range of the ratio in waste according to On-Farm Composting Handbook, Cornell Composting is as shown in below table.

Table 3.1 Cornell Composting Handbook Extraction

Material	C:N Ratio
Leaves	50
Vegetable Scarps	25

As for the summary of the composition of the four piles:

Table 3.2 Summary of composition of the four piles

Material	Amount of dried leaves (kg)	Amount of vegetable scraps (kg)	Initial C:N ratio
Pile A	0	10	25
Pile B	2	8	30
Pile C	4	6	35
Pile D	6	4	40

The following recipe listed in Table below has been formulated according to the carbon to nitrogen ratio value obtained through literature.

Table 3.3 Calculation for Pile 3

Material	C:N Ratio	Mass (kg)
Leaves	50	4
Vegetable Scarps	25	6

Validity of this recipe can be proven through the following calculation:

$$\frac{Sum\ of\ [Material\ Mass]\ x\ [C{:}N\ Ratio\ of\ Material]}{Total\ Mass} = C{:}N\ Ratio \quad (1)$$

$$\frac{(4x\ 50)+(6x\ 25)}{10} = 35\ (Pile\ 3) \quad (2)$$

Experiments and lab testing were done by setting the frequency of rotation of every pilot composter at every 3 days' time [13]. Composting period is determined based on temperature profile and pH profile, which take approximately 3 months. In fact, anticlockwise turning was carried out by manually rotating the composters with the handle. Thus, aerobic condition is maintained by closing the top cover partially and air is able to aerate the pile. The cover does not seal onto the pilot composters (not vacuum). To ensure that the material which are on the top portion in the pilot composters are moved to the central portion, three rotations at a time were made, where it is exposed to higher temperature[40]. Five packs of earthworm which is approximately 100 earthworms are put in each composter filled with mixture of grinded leaves and vegetable scraps. Leaves and vegetable scraps are grinded into fine size with Analytical Mill Grinding Machine which grinds dried leaves until 6mm size. Equal amount of twig in terms of weight (5% of the total volume of the compost pile) is broken down into small sizes and added into the pile of green compost to increase porosity.

3.3 Experimental

To analyze the parameters which need to be determined, six compost samplings are extracted from different location of the compost in the pilot composters. About 30 g of each samples of A, B, C, and D were collected, mostly at the two ends of the composter and mid span without disturbing the nearby materials. All the six samples are mixed gently for equal distribution of temperature and pH. [41]

3.3.1 Temperature and pH Profile

Temperature and pH are monitored periodically using a combination of digital thermometer and pH meter, the WalkLab Microcomputer pH Meter TI9000 from Trans Instruments throughout the period, once per week.

3.3.2 Moisture Content

Each sample was diagnose for the moisture content, water moisture content is measured by drying at 105oC for 24 h [42] using Contherm® Designer Series Oven. The MC is calculated by:

$$\frac{Mass\ sample - \ Mass\ dried}{Mass\ sample}\ x\ 100\% = Moisture\ Content \qquad (3)$$

3.3.3 TOC and TKN

For total nitrogen (Total Kjedahl Nitrogen) and TOC -total organic carbon content, at the end of the study, both TKN and TOC are obtained to define the maturity of the compost.

Total organic carbon content (TOC) and Total Carbon (TC) was analysed by TOC-L SHIMADZU® Total Organic Carbon Analyzer.

Total nitrogen was determined by using the established Kjeldahl method [43]. The standard Kjedahl Nitrogen determination method is to prepare 1000mg weight of sample, adding 10 selenium tablets as catalyst and pouring 20ml of concentrated sulphuric acid (98%) and be digested by the TKN equipment in a fume cupboard for an hour. After that sample is cooled for half an hour and analysed by TKN analyser. Chemical decomposition of the sample is complete when the initially very dark-coloured medium has turned out to be clear and colourless. Small amount of sodium hydroxide of concentration 30% is top up to the previous Kjedahl solution to 140ml, which converts the ammonium salt to ammonia. Steam is then channelled and be run for 3 minutes while the other end of the condenser of the TKN analyser is dipped into a 60ml of boric acid solution. TKN is determined by the amount of sulphuric acid needed to titrate the solution. Total Kjedahl Nitrogen (TKN) content if calculated manually (given cases that automatic TKN machine is not available), the formula to calculate the percentage of N content is as shown as below:

$$N\% = \frac{\text{v1−v2(ml)}}{\text{1g}}\ x\ C\frac{mole}{litre}\ x\ \frac{1\ litre}{1000\ ml}\ x\ 14.04\frac{g}{mole}\ \text{x100\%} \quad (4)$$

Where,

V1= volume of acid (H2SO4) used to titrate the solution to pH 4.65

V1= volume of acid(H2SO4) used to titrate the blank solution to pH 4.65=0.013ml

C= molarity of acid (H2SO4) used to titrate the solution to pH 4.65=0.25M

3.3.4 Final C:N Ratio

It is suggested compost with C:Naqueous of five (5) to six (6) have matured [44]. To determine the final C:N ratio, Total Carbon (TC) in percentage value is determined by TOC analyzer is divided by TKN percentage value.

3.3.5 TOM

Total Organic Matter (TOM) is calculated as the difference between ash and dry weight on ignition at 550oC for 4 h using Protherm® Furnace. Before that, the samples are heated to 105oC for 4 hours to remove the water content. The decrease of organic matter in terms of percentage can be calculated from the initial (M1) and the final (M2) ash content in fractions based on below equation:

$$\Delta OM\% = \frac{M1-M2}{1-M1}\ x\ M2\ x\ 100\% \qquad (5)$$

Where,

M1= mass of sample after heated at 105oC for 4 hours in heater

M2= mass of sample after heated at 550oC for 4 hours in furnace

For Pile D:

$$\Delta OM\% = \frac{0.0314-0.019444}{1-0.0314}\ x\ 0.019444\ x\ 100\% = 0.024\% \quad (6)$$

3.3.6 Mass Yield

To calculate mass yield percentage is to determine the effectiveness and feasibility of the composting activity of green waste alone which is the co-composting of vegetable waste and dried leaves. The lower the mass yield, it means more waste is able to turn into value-added product, in this case, vermicompost. Mass yield percentage can be calculated by equation 7. Since vegetable scraps are easier and takes shorter time to decompose during a period of time, thus the mass yield of A is smallest, followed by B,C and D.

Mass Yield (%)= (Mass final)/(Mass Initial) x 100% (7)

Where,

Mass final = final mass of compost

Mass initial = initial mass of compost = 10kg

The experimental analysis can be shown in the flow chart below:

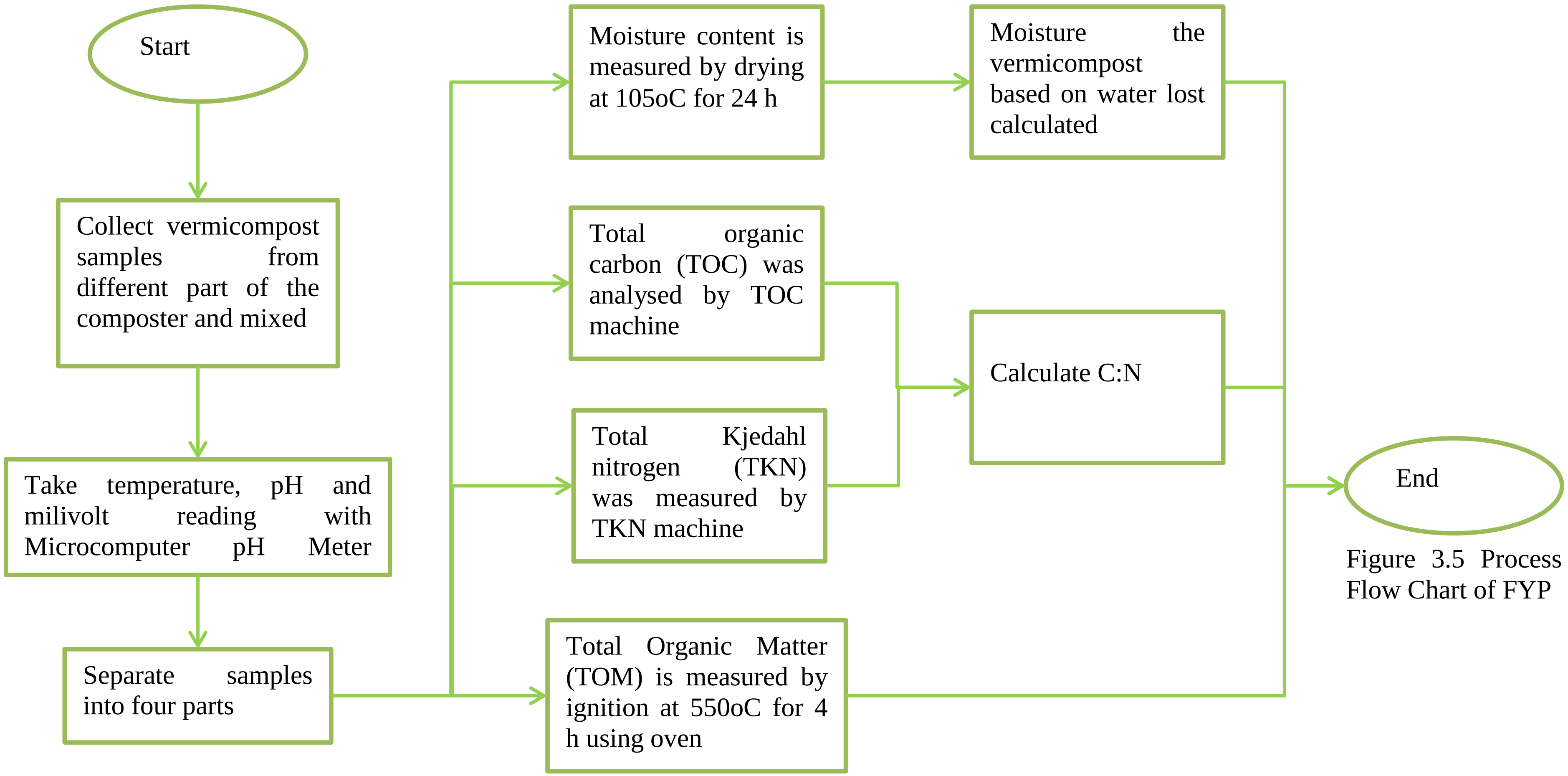


Figure 3.5 Process Flow Chart of FYP

3.4 Feasibility/Relevancy of Project

To ensure that there's sufficient amount of time allocated for the completion of this project, Table below summarize the key milestones and gantt chart for this project.

Table 3.4 Milestone for FYP 1 and 2

Step	Period	Key Milestone
1	FYP 1	Submission of Extended Proposal
2		Proposal Defense
3		Arrival of equipment
4		Green waste collection
5		Composting Activity
6		Collection of Data (pH, temperature, moisture content, nitrogen content and organic content)
7		Submission of Interim Report
8	FYP 2	Calculation and Analysis of Data (TOC,TKN,TOM)
9		Submission of Progress Report
10		Submission of Dissertation (soft bound)
11		Submission of Technical paper
12		Viva
13		Submission of Dissertation (hard bound)

Table 3.5 Gantt Chart for FYP 1

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Study Week	Final Exam
Selection of Topics																
Preliminary Research Work																
Submission of Extended Proposal																
Proposal Defense																
Arrival of leaf shredder and composting bins																
Waste collection																
Composting Activity																
Collection of Data (pH, temperature, milivolt, nitrogen content and organic content)																
Submission of Draft Interim Report																
Submission of Interim Report																

Table 3.6 Gantt Chart for FYP2

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Study Week	Final Exam
Collection of Data (pH, temperature, milivolt, nitrogen content and organic content)																
Calculation and Analysis of Data																
Submission of Progress Report																
Preparation for Dissertation and Final Report																
Submission of Draft Final Report																
Submission of Dissertation (soft bound)																
Submission of Technical Paper																
Viva																
Submission of Dissertation (hard bound)																

CHAPTER 4

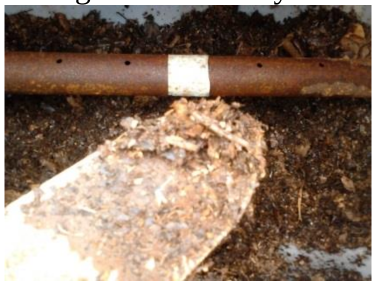
RESULTS AND DISCUSSION

Any natural material is suitable for treating the soil process. The materials require an appropriate proportion of high-C materials and high-N materials. Among the high-C materials utilized are dried leaves; high-N materials are fresh or green, for example, grass cutting. The carbon gives organic or energy to the organisms and the nitrogen gives proteins. Mixing certain sorts of materials or changing the ratios can improve the effect of decomposition rate. Accomplishing the best mix is good to comprehend the decomposition rate and in the end, the best mix for tropical climate in Malaysia. In this manner, in the current research, vegetable waste and dried leaves were utilized for composting activity. Initial C:N proportion of green waste was kept by only using dried leaves and vegetable scraps and grass cuttings as well. The pilot composters' composted material was tested for few properties, for example, physical and chemical properties. It was identified that waste required further development to be completely matured for every one of the compost

4.1 Physical Properties

As expected, all piles in pilot composters have observed a distinct volume decrease as time stretched. It is due to the fast decomposition of vegetable scraps in each pilot composter. Pile A with the initial C:N ratio = 25 which contains only vegetable scraps decomposed fastest as compared to Pile B, C and D. It is very much obvious as of Day 1 and 3 weeks after (day 22): All the green vegetable scraps are gone, left with the dried leaves and soil. Earthworms which are initially put into Pilot Composter A had all died after 3 weeks. This is due to the lack of food (vegetable scraps) for the earthworms after all the green wastes had been eaten up. Surprisingly there is no appearance of maggot inside pilot composter A. In fact every pilot composter do not contain maggots and flies. This might due to the extra covering (black plastic sheet) on top of each pilot composter to prevent unnecessary contaminant to affect the results and the composting activity. As for Pile B, C and D, the volume decreases as time goes by, and earthworms are visible still until now. This could be boldly assumed that they are relying on the shredded leaves which are slow to decompose.

Date	Compost A	Compost B	Compost C	Compost D
3/9/15	 Figure 4.1 A-Day 1	 Figure 4.2 B-Day 1	 Figure 4.3 C-Day 1	 Figure 4.4 D-Day 1
10/9/15	 Figure 4.5 A-Day 8	 Figure 4.6 B-Day 8	 Figure 4.7 C-Day 8	 Figure 4.8 D-Day 8
24/9/15	 Figure 4.9 A-Day 22	 Figure 4.10 B-Day 22	 Figure 4.11 C-Day 22	 Figure 4.12 D-Day 22
5/10/15	 Figure 4.13 A-Day 33	 Figure 4.14 B-Day 33	 Figure 4.15 C-Day 33	 Figure 4.16 D-Day 33

13/10/15	 Figure 4.17 A-Day 41	 Figure 4.18 B-Day 41	 Figure 4.19 C-Day 41	 Figure 4.20 D-Day 41
23/10/15	 Figure 4.21 A-Day 51	 Figure 4.22 B-Day 51  Figure 4.23 Worms visible in B Day 51	 Figure 4.24 C-Day 51  Figure 4.25 Worms visible in C Day 51	 Figure 4.26 D-Day 51  Figure 4.27 Worms visible in D Day 51

28/10/15	 Figure 4.28 A-Day 56	 Figure 4.29 B-Day 56	 Figure 4.30 C-Day 56	 Figure 4.31 D- Day 56
5/11/15	 Figure 4.32 A- Day 64	 Figure 4.33 B-Day 64	 Figure 4.34 C-Day 64	 Figure 4.35 D-Day 64
12/11/15	 Figure 4.36 A-Day 71	 Figure 4.37 B-Day 71	 Figure 4.38 C-Day 71	 Figure 4.39 D-Day 71

19/11/15	 Figure 4.40 A-Day 78	 Figure 4.41 B-Day 78	 Figure 4.42 C-Day 78	 Figure 4.43 D-Day 78
25/11/15	 Figure 4.44 A-Day 84	 Figure 4.45 B-Day 84  Figure 4.46 Worms visible in B Day 84	 Figure 4.47 C-Day 84  Figure 4.48 Worms visible in C Day 84	 Figure 4.49 D-Day 84  Figure 4.50 Worms visible in D Day 84

4.2 Moisture Content

Since decomposition results in heat generation, it speeds up the vaporization. Moisture loss during high rate of composting can be seen as index of decomposition. However, the composting waste pile should have certain water moisture content in for the organism to live. To enable optimum decomposition rate for the composts, approximately 50-60% of the moisture content of each pilot composter is maintained. It is essential to make sure there is enough moisture for the earthworms inside as well. Since UTP, Perak in Malaysia only undergoes sunny day or rainy day only without seasonal weather conditions like spring, summer, autumn and winter, which temperature changes drastically, the temperature inside the pilot composters are as outdoor temperature, which is around 27 degree celcius to 32 degree celcius. Since temperature greatly influence the evaporating rate, when is sunny day, water has to be added more frequent than it is in rainy day to maintain an ideal moisture content of 50-60% in each composter.

$$\text{For Pile A} = \frac{2.971g - 1.515g}{2.971g}\ x\ 100\% = 49\% \quad (8)$$

$$\text{For Pile B} = \frac{2.925g - 16255g}{2.925g}\ x\ 100\% = 45.6\% (9)$$

$$\text{For Pile C} = \frac{3.123g - 1.913g}{3.123g}\ x\ 100\% = 61.58\% (10)$$

$$\text{For Pile D} = \frac{7.29g - 4.64g}{7.29g}\ x\ 100\% = 63.6\% (11)$$

Table 4.1 Summary Table of Quality of Compost

	Pile A	Pile B	Pile C	Pile D	Commercial Compost
Moisture Content	49.01%	45.6%	61.58%	63.6%	-
Initial C:N Ratio	25	30	35	40	-
TOM (%)	0.014	0.017	0.021	0.024	0.035
TC (%)	0.9168	6.22	6.713	7.211	17.65
TOC (%)	0.9168	6.216	6.548	7.175	17.39
TKN (%)	0.45	1.00	1.38	1.81	9.63
Final C:N ratio(TC/TKN)	2	6.22	4.86	3.98	1.83
Difference of final and initial C:N ratio	23	23.78	30.14	36.02	-
Mass Yield (%)	1%	41.5%	48%	89%	-

4.3 Temperature Profile

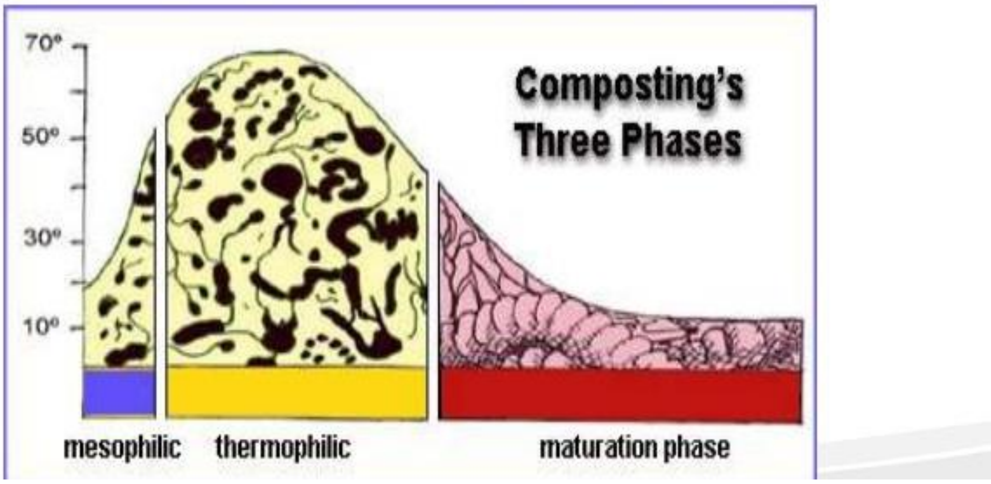


Figure 4.51 Composting Temperature Profile (source from: organicsoiltechnology.com)

As shown in Figure above, to determine the maturity of compost, temperature profile can be plotted. Composting period undergoes three phases, mesophilic, thermopholic and, maturation phase.

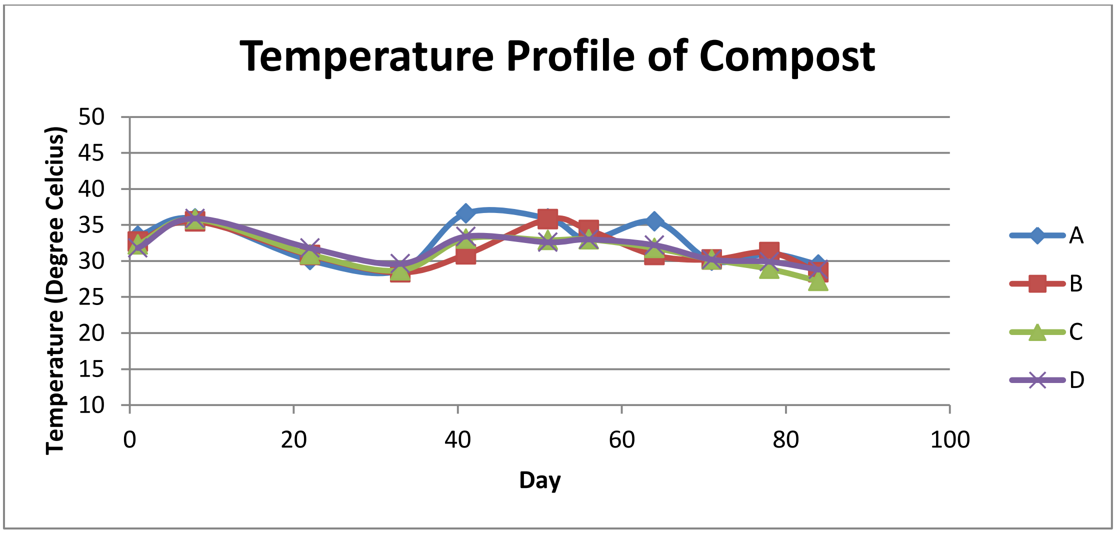


Figure 4.52 Temperature Profile of Compost

As shown in Figure 42, all the piles in the pilot composters had seen a rise in temperature due to the decomposition of the composts. Since the pilot composters are placed outdoor and outdoor temperature and weather are the main factors, the most reasonable factor of the drastic drop of 6 degree Celsius and 8 degree Celsius at Day 8 to Day 22 and Day 8 to Day 33 respectively. This could be the rainy day and the cool weather affected the temperature taken from the compost itself.

Pile A reached thermophilic phase first at 38 degree Celsius, indicating the quick and active microbial activity in the green waste pile up at Day 42 approximately. It is then followed by Pile B, which enter thermophilic phase at Day 51 at 36 degree celcius. As compared to Pile A, it takes longer time to reach thermophilic phase, due to the presence of carbon material in Pile B, which slows down the decomposition rate since it is much related with the initial C:N ratio of the compost.

Pile C and Pile D are further monitored until it reaches thermophilic phase. Pile C is expected to reach the thermophilic phase first before Pile D. Periodical short-term temperature drop can be observed for all the piles, high probably is caused by effect of cooling by rotating and flipping of the piles.

It is expected that after the thermophilic phase, the temperature of the piles decrease sharply and enter the cooling state. The phenomenon is observed for Pile A first, followed by Pile B, C and lastly D.

4.4 pH Profile

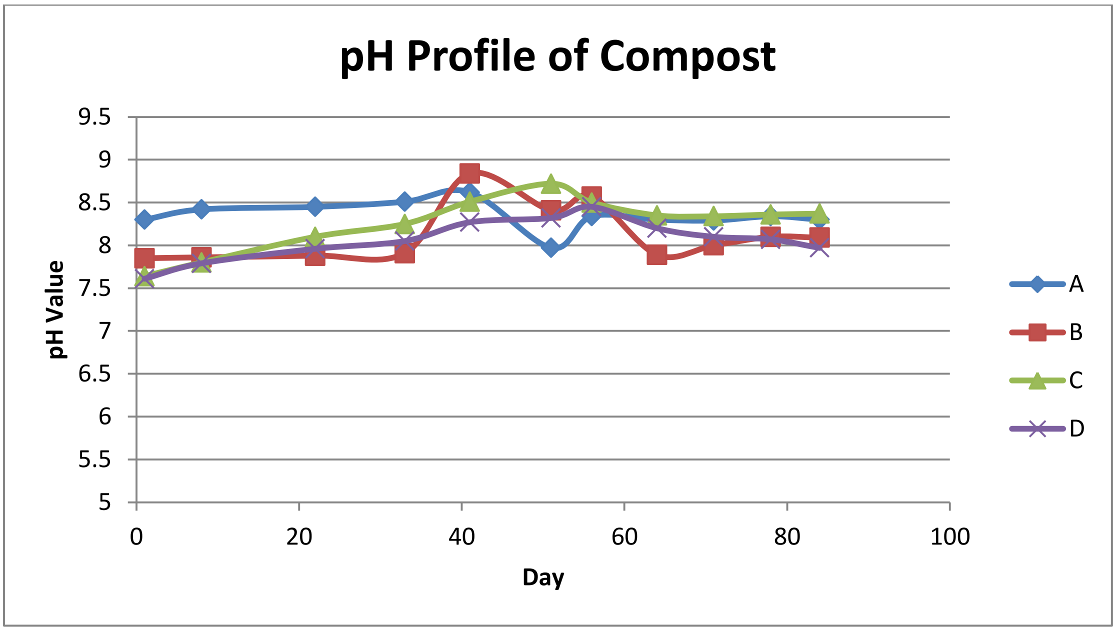


Figure 4.53 pH profile of compost

All composts have a pH value ranged from pH 7 to 9. Figure 43 shows the results of pH of the composting activity in all pilot composters. The difference in pH for all piles had the same trend with slow rise to 8.63, 8.84, 8.72, 8.45 of pH maximum for Pile A, B, C and D respectively on day 40, 41, 51 and 56. Composting continues most proficiently at the thermophilic phase when the pH is around 8[45]. The pH rise was because of the production of NH3 (ammonia) during mineralization and ammonification of organic nitrogen amid the composting microbial period [46] Ammonium production was low after the compost has stabilized and become steady due to slow organic waste degradation. Amid the nitrification handle, the nitrifying microorganisms lessened the pH of the medium[47]. The decomposition of organic waste and formation of acids from the activities of microorganisms in waste would likewise be responsible of the lessening[48]. It is additionally caused by the increase amounts of carbon dioxide which have been given off during the composting amid the composting activity may likewise be responsible of the lessening in pH.

4.5 TOC,TKN and TOM

Organic content and nitrogen content is analyzed for each pile of the composts. Commercial compost from the market is taken as sample to be compared to the result of the compost in Pile A, B, C and D. It is to evaluate and determine the quality of the compost of experiment against the commercial product.

The total organic matter (TOM) is the amount of organic matter found in composts following a standard procedure.. Commercial compost from the market is taken as sample to be compared to the result of the compost in Pile A, B, C and D. It is to evaluate and determine the quality of the compost of experiment against the commercial product.

As for organic carbon content, it is shown to be declined significantly as the initial C:N ratio gets higher. The content of organic carbon in Pile D is highest as shown in Table 4.1, followed by Pile C, Pile B and last but not least Pile A since Pile D contains the most amount of dried leaves which contributed to the organic carbon.

Total nitrogen content is evaluated using Total Kjedahl Nitrogen method. Total nitrogen content is evaluated using Total Kjedahl Nitrogen method. The weight percentage falls in the range of expected result where anything in the range of 0.5% to 2.75% weight percent of nitrogen in compost would represent a good quality compost. The nitrogen content of the piles is increased after composting due to the emission of ammonia during decomposition. Pile D has the highest TKN percentage since the composting activity is still active thus releasing more NH3.

$$Pile\ A\ N\% = \frac{13-0.013(\text{ml})}{1\text{g}}\ x\ 0.25\frac{mole}{litre}\ x\ \frac{1\ litre}{1000\ ml} x\ 14.04\frac{g}{mole}\ \text{x}100\% = 4.55\%$$

(12)

4.6 Final C:N Ratio

It is shown that after a period of time, there is a decrement of value in C:N ratio of final for all of the composting piles. With the higher initial C:N ratio of the pile, the difference of C:N ratio between the initial and final is definitely bigger. It is shown that Pile D which has highest initial C:N ratio decrease most to a final C:N than pile C and the rest. The smaller decrease for pile A is due to the poorer decomposition of carbon content when the initial C:N is lower. Because the composting reaction is a biochemical decomposition of organic waste which happened mainly in the aqueous phase, C:N aqueous is used instead of C:N solid. It is suggested compost with C:Naqueous of five (5) to six (6) have matured [44].

4.7 Mass Yield

To calculate mass yield percentage is to determine the effectiveness and feasibility of the composting activity of green waste alone which is the co-composting of vegetable waste and dried leaves. The lower the mass yield, it means more waste is able to turn into value-added product, in this case, vermicompost. Mass yield percentage can be calculated by equation 7. Since vegetable scraps are easier and takes shorter time to decompose during a period of time, thus the mass yield of A is smallest, followed by B, C and D.

For Pile A = Mass Yield (%)= 0.1kg/10kg x 100% = 1%(13)

For Pile B = Mass Yield (%)= 4.15kg/10kg x 100% = 41.5%(14)

For Pile C = Mass Yield (%)= 4.8kg/10kg x 100% = 48%(15)

For Pile D = Mass Yield (%)= 8.9kg/10kg x 100% = 89%(16)

4.8 Feasibility Study

To determine whether the project is relevant/ feasible to be conducted, estimation and assumption have been done to do prediction and the calculations are as such:

Assume

Total wastes in UTP=200kg/day

Green waste =50% of total wastes = 100kg/day

UTP is capable to generate the following green wastes per month:

$$Green\ wastes\ \frac{kg}{month} = Total\ wastes\ \frac{kg}{day}\ x\ 0.5\ x\ 30\ days$$

$$= 1{,}500\,\frac{kg}{month}\ (17)$$

Out of the 1,500kg of green wastes generated per month 60% will be successfully be converted to compost.

$Composts\ \frac{kg}{month} = Green\ wastes\ \frac{kg}{day}\ x\ mass\ yield\ percentage\ (0.6) =$ $900\,\frac{kg}{month}$ (18)

UTP will be capable of generating 900 kg of good quality compost per month. This amount is enough to replace the current usage of 200kg fertilizers per month. Excess of compost can also be considered for commercialization purposes. Not only that, decreasing the cost of the hired service either to dispose green waste or to buy fertilizer is not the ultimate, moreover, by using the excess of 700kg of green compost, landscape of UTP can be enhanced and be fertile, thus fully utilized the land and soil in UTP for future betterment.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Short term composting (84 days) suggested that green wastes, which are shredded leaves and vegetable scraps, were not successfully compost yet in the pilot composters. Co-composting of vegetable scraps and leaves with an initial C:N ratio of 25, 30, 35 and 40 have been done and resulted in all the compost reaching maturity after long days of composting. Lowest initial C:N ratio of Pile A of 25 reaches maturity the fastest as compared to Pile B, Pile C and Pile D. This is suggested that lower initial C:N ratio result in faster decomposition rate. The compost in Pile B matured after Pile A, however Pile C and Pile D have yet to fully matured due to the slow decomposition rate. Although the compost of Pile A reaches maturity the fastest, however, the earthworms inside Pilot Composter A has the lowest survive rate than in Pilot Composter B, C and D. It is probably because the earthworms have no more food to digest and decompose after all the vegetable scraps have turned into compost fully (reaches maturity). In a nutshell, the results of the experiments suggested that the composting time is dependent on the initial C:N ratio. Reasoned with the above justification, initial C:N ratio of 30 is suggested to be used for the composting activity in Malaysia due to the several justification:

1. Earthworms can survive even after 84 days, indicating suitable atmosphere and bedding for earthworms to live in.
2. Dried leaves of 20% can be reduced, thus not limiting the type of green wastes as compared to Pile A, which only utilized vegetable scraps.

3. It has relatively fast decomposition rate, which turns matured after 80 days as shown in the Temperature profile, in which temperature of Pile B has stabilized after 80 days.

5.2 Recommendations

Some of the recommendations for future studies and improvements:

1. Design method of C:N ratio that could allow recycled material with carbon or nitrogen content (shredded paper) instead of green waste alone.
2. Increase the amount of earthworms in each pilot composters for faster composting rate.
3. Reduce particle size of ingredient of compost for faster composting rate.
4. Use the same inner wall surface colour for all the pilot composters to eliminate the difference in temperature through inner wall surface colour.
5. Provide a shelter for all the pilot composters to avoid rain water flows into the pilot composter (over-moisturise the compost) and the heat of the sun to evaporate the water (over-dry the compost).
6. Take the readings for temperature and pH every time at the same period of the time to avoid over fluctuation of the temperature.
7. Include Germination Index as one of the requirements in determining the level of composting activity.

Some of the recommendations for implementing the composting project in UTP:

1. Provide a designated location to place the pilot composters with shelter.

2. Provide knowledgeable personnel (lab technicians) to monitor the composting activity.
3. Construct C:N ratio for compost according to the availability of organic wastes generated in UTP

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APPENDICES

Figure 5.1 Earthworms in package

Figure 5.2 Vegetable Scraps

Figure 5.1 Equipment to determine moisture content

Figure 5.2 dried leaves shreded into 6mm

Figure 5.1 Pilot composters with black sheet of plastic as covering

Table 5.1 pH Profile of Compost A

Day	Date	Ph Reading of A						Average
		1	2	3	4	5	6	
1	03-09-15							8.3
8	10-09-15	8.4	8.396	8.45	8.39	8.46	8.424	8.42
22	24-09-15	8.45	8.42	8.39	8.51	8.46	8.47	8.45
33	05-10-15	8.51	8.48	8.49	8.54	8.5	8.54	8.51
41	13-10-15	8.6	8.65	8.59	8.63	8.6	8.65	8.62
51	23-10-15	8.01	7.99	7.89	7.97	7.95	8.01	7.97
56	28-10-15	8.35	8.34	8.29	8.31	8.4	8.35	8.34
64	05-11-15	8.27	8.31	8.29	8.34	8.25	8.34	8.3
71	12/11/2015	8.27	8.3	8.21	8.27	8.4	8.29	8.29
78	19/11/2015	8.31	8.43	8.34	8.23	8.35	8.38	8.34
84	25/11/2015	8.29	8.21	8.35	8.37	8.29	8.29	8.3

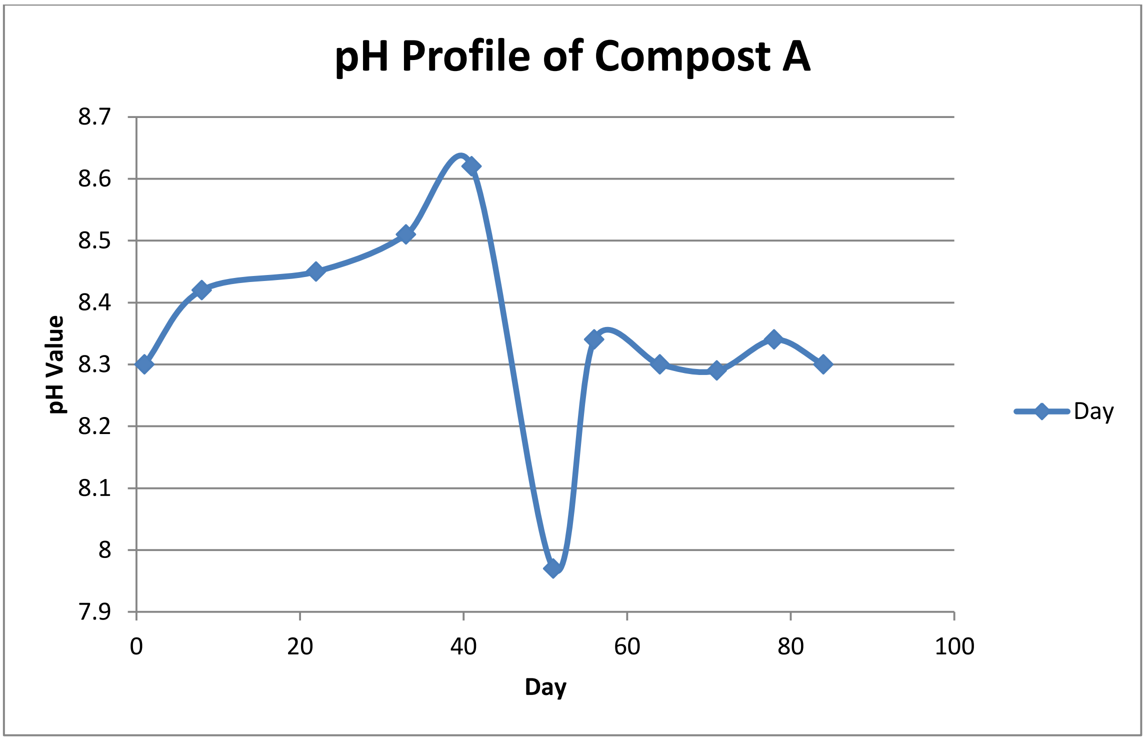

Figure 5.1 pH Profile of Compost A

Table 5.2 pH Profile of Compost B

Day	Date	PH Reading of B						Average
		1	2	3	4	5	6	
1	03-09-15							7.85
8	10-09-15	7.95	7.85	7.6	7.86	7.93	7.97	7.86
22	24-09-15	7.95	7.88	7.81	7.79	7.82	8.03	7.88
33	05-10-15	8.01	7.95	7.72	7.83	7.94	8.01	7.91
41	13-10-15	8.9	8.8	8.84	8.89	8.88	8.73	8.84
51	23-10-15	8.45	8.44	8.47	8.34	8.4	8.36	8.41
56	28-10-15	8.55	8.64	8.59	8.53	8.49	8.62	8.57
64	05-11-15	8.01	7.98	7.78	7.85	7.82	7.9	7.89
71	12/11/2015	8.21	8.2	7.91	7.29	8.21	8.18	8
78	19/11/2015	8.22	8.11	7.88	7.91	8.25	8.23	8.1
84	25/11/2015	8.1	8.12	8	7.99	8.15	8.18	8.09

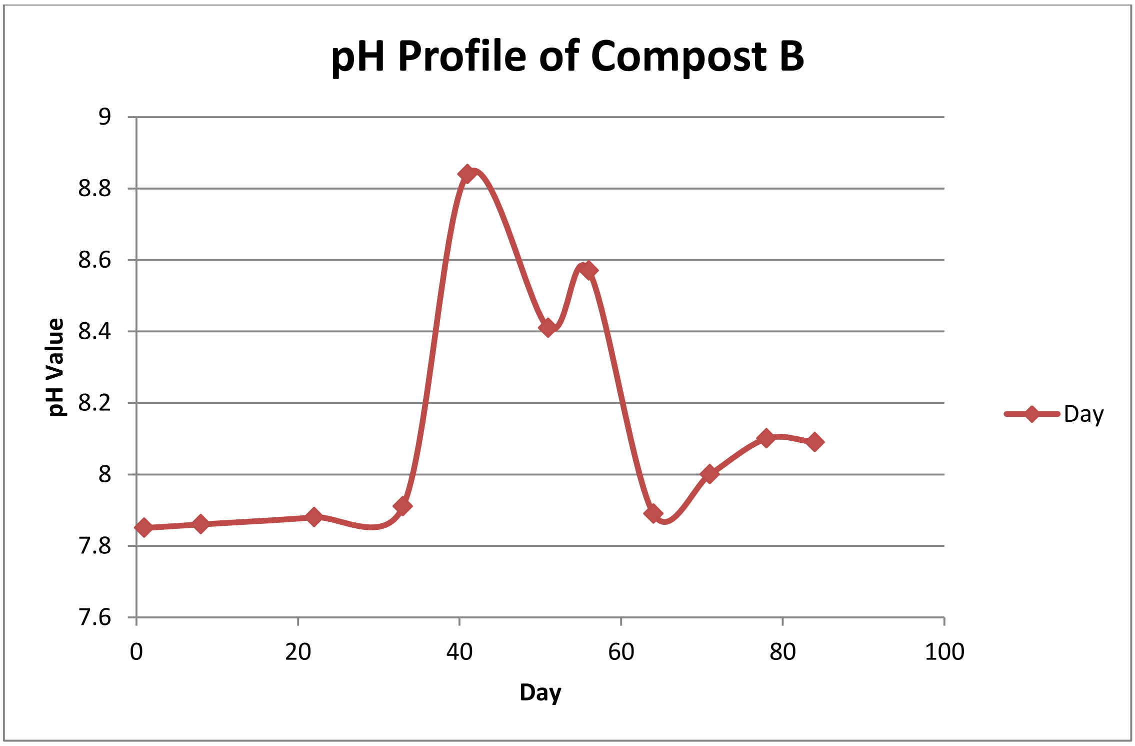

Figure 5.2 pH Profile of Compost B

Table 5.3 pH profile of Compost C

Day	Date	PH Reading of C						Average
		1	2	3	4	5	6	
1	03-09-15							7.64
8	10-09-15	7.78	7.85	7.79	7.82	7.81	7.75	7.8
22	24-09-15	8.01	7.98	7.89	8.3	8.1	8.32	8.1
33	05-10-15	8.21	8.26	8.19	8.21	8.3	8.33	8.25
41	13-10-15	8.56	8.49	8.51	8.5	8.55	8.45	8.51
51	23-10-15	8.72	8.79	8.69	8.75	8.64	8.73	8.72
56	28-10-15	8.45	8.65	8.6	8.45	8.41	8.44	8.5
64	05-11-15	8.34	8.45	8.4	8.31	8.35	8.25	8.35
71	12/11/2015	8.29	8.21	8.32	8.2	8.46	8.56	8.34
78	19/11/2015	8.29	8.35	8.42	8.35	8.37	8.38	8.36
84	25/11/2015	8.37	8.45	8.13	8.38	8.42	8.47	8.37

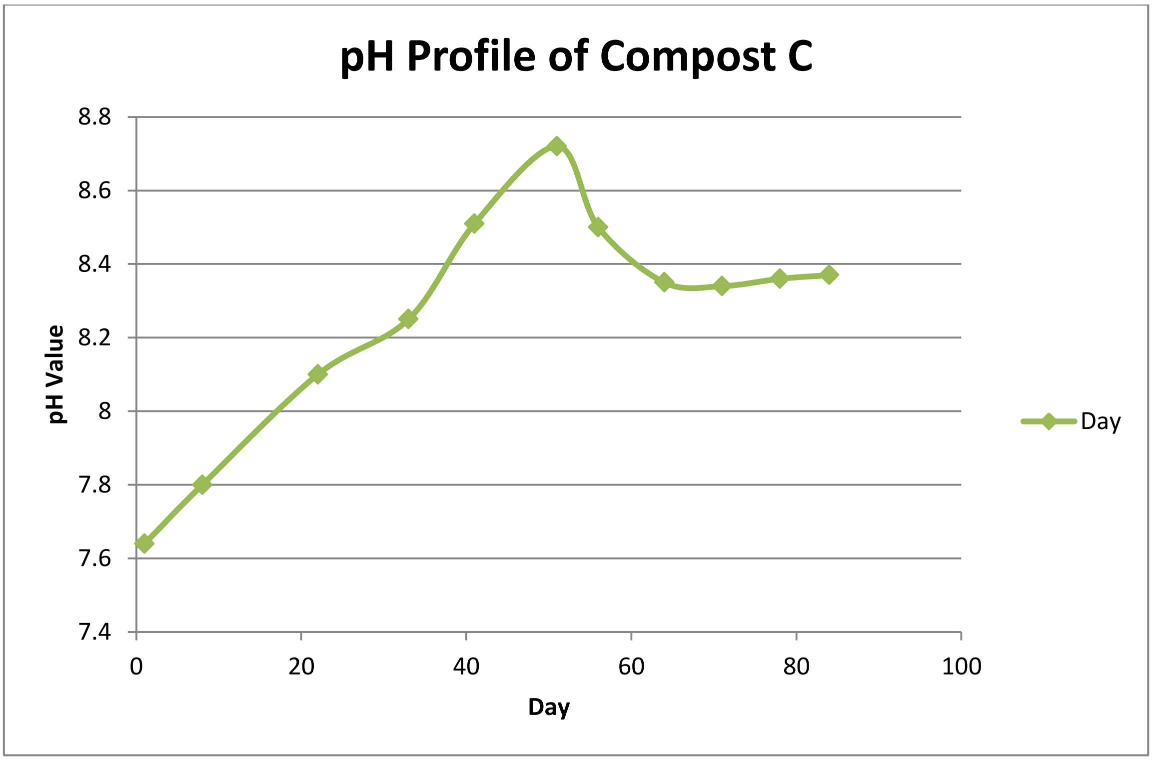

Figure 5.3 pH Profile of Compost C

Table 5.4 pH Profile of Compost D

Day	Date	pH Reading of D						Average
		1	2	3	4	5	6	
1	03-09-15							7.61
8	10-09-15	7.81	7.69	7.78	7.8	7.83	7.83	7.79
22	24-09-15	8.01	8	7.93	7.91	7.95	7.96	7.96
33	05-10-15	8.03	8.1	7.99	8.01	8.06	8.11	8.05
41	13-10-15	8.31	8.26	8.25	8.34	8.25	8.21	8.27
51	23-10-15	8.33	8.35	8.29	8.27	8.34	8.34	8.32
56	28-10-15	8.46	8.49	8.35	8.37	8.5	8.53	8.45
64	05-11-15	8.19	8.15	8.24	8.23	8.3	8.09	8.2
71	12/11/2015	7.89	7.99	8.15	8.16	8.21	8.2	8.1
78	19/11/2015	8.01	8.16	7.98	7.79	8.21	8.27	8.07
84	25/11/2015	8.12	8.18	7.86	7.87	8.01	7.78	7.97

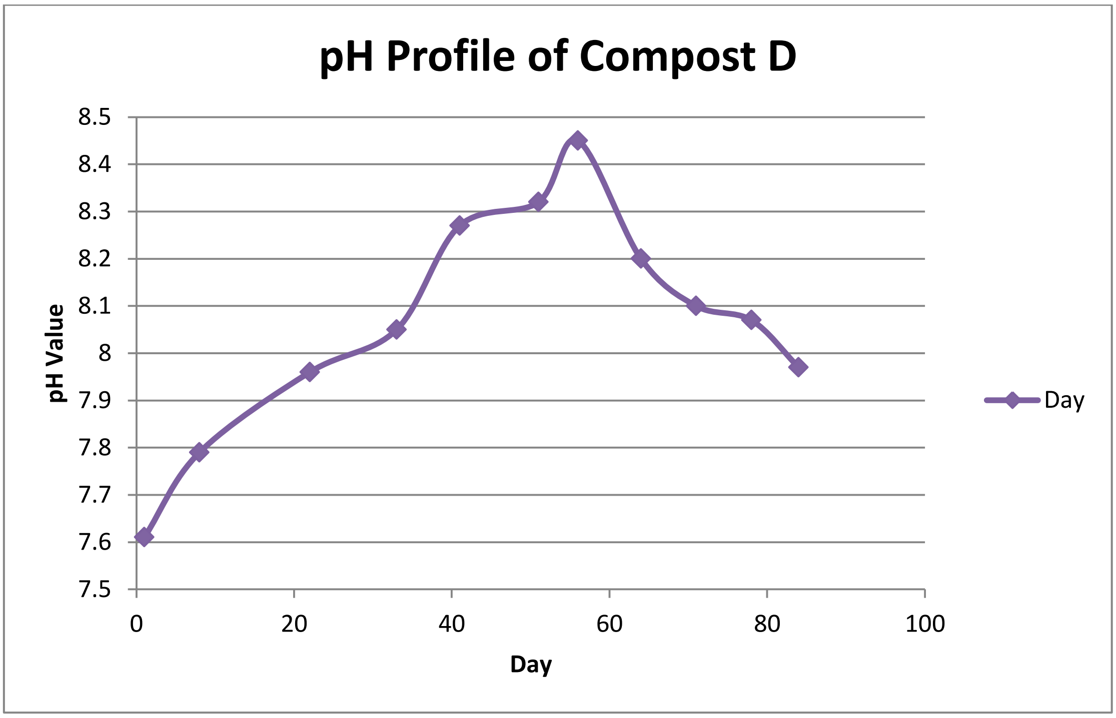

Figure 5.4 pH profile of Compost D

Table 5.5 Temperature Profile of A

Day	Date	Temperature Reading of A						Average
		1	2	3	4	5	6	
1	03-09-15							33.5
8	10-09-15	36.2	35.8	34.9	36.3	36.1	36.1	35.9
22	24-09-15	29.9	28.9	30.5	31	29.8	30.5	30.1
33	05-10-15	28.5	27.9	29.9	28.9	29	28	28.7
41	13-10-15	36.8	35.9	37	36.9	35.4	37.6	36.6
51	23-10-15	36.1	35.8	36	35.9	37	34.6	35.9
56	28-10-15	32.5	33	31.9	31.2	35.4	34	33
64	05-11-15	35	36.1	34.9	37.5	34	35.5	35.5
71	12/11/2015	31.2	30.8	30.4	29.5	29	29.1	30
78	19/11/2015	30.8	30.9	31.2	31.3	32	29.8	31
84	25/11/2015	29.2	29.5	29.7	31	28.9	28.7	29.5

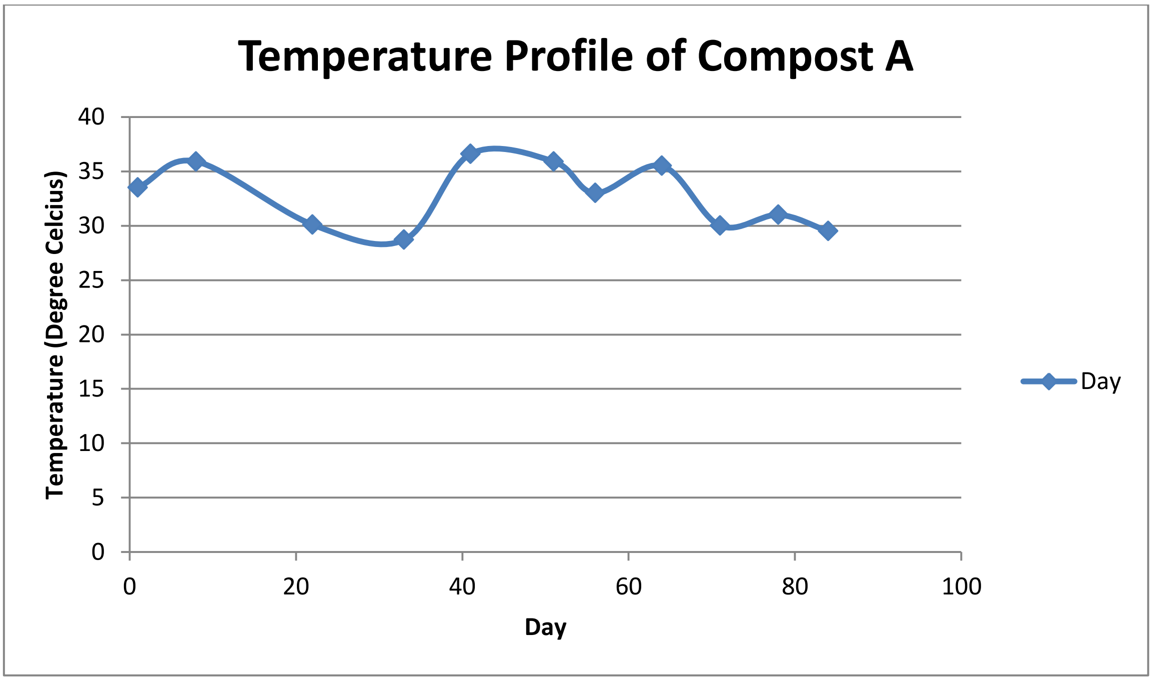

Figure 5.5 Temperature Profile of A

Table 5.6 Temperature Profile of B

Day	Date	Temperature Reading of B						Average
		1	2	3	4	5	6	
1	03-09-15							32.7
8	10-09-15	35.5	36.1	34.1	34.6	36.7	36	35.5
22	24-09-15	29.8	31.7	30.9	29.6	31	31.8	30.8
33	05-10-15	27.9	28.5	29.6	27.1	28.9	28.4	28.4
41	13-10-15	31.5	32.9	30.9	28.7	29.8	31.6	30.9
51	23-10-15	35.9	34.9	36.7	35.7	36	35.6	35.8
56	28-10-15	34.9	35.1	33.9	34.5	33.8	33.6	34.3
64	05-11-15	30.8	32.9	28.9	31.1	30.5	30.6	30.8
71	12/11/2015	29.9	30.1	28.9	31.2	31.4	29.7	30.2
78	19/11/2015	31.4	32.1	29.9	28.9	30.9	34	31.2
84	25/11/2015	27.9	28.7	28.6	27.8	30.1	27.3	28.4

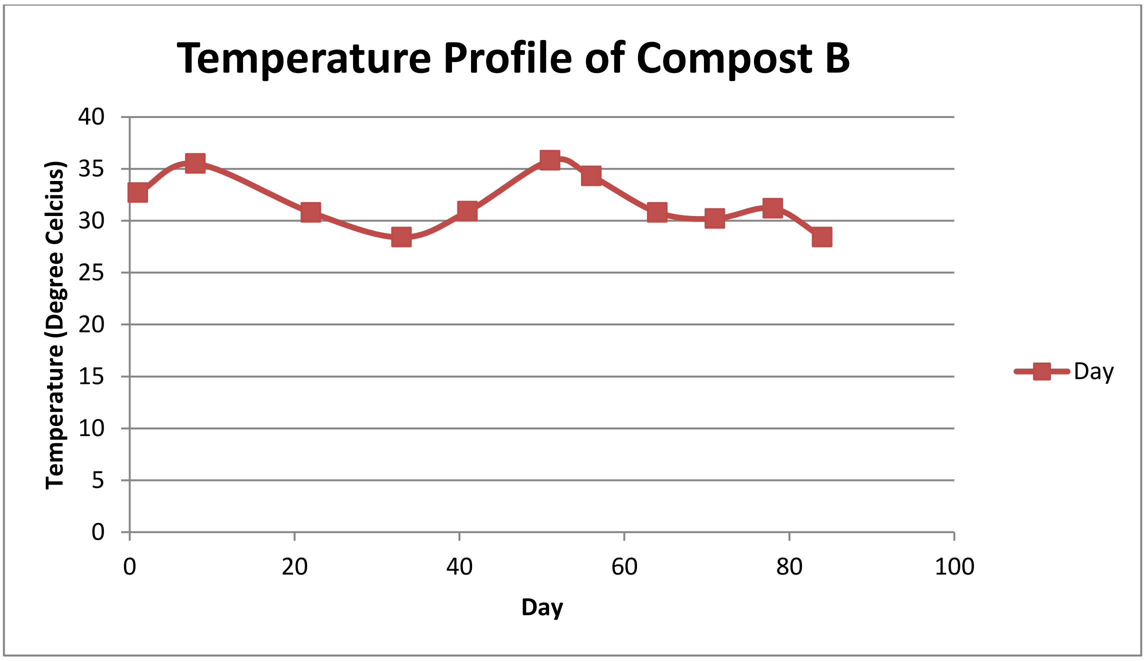

Figure 5.6 Temperature Profile of B

Table 5.7 Temperature Profile of C

Day	Date	Temperature Reading of C						Average
		1	2	3	4	5	6	
1	03-09-15							32.3
8	10-09-15	35.7	35.9	36	35.6	35.7	35.9	35.8
22	24-09-15	29.8	31	31.4	30.2	32	31	30.9
33	05-10-15	28.5	29.1	28.7	27.9	28.8	29.2	28.7
41	13-10-15	33.4	32.9	33.5	34.1	32.7	32	33.1
51	23-10-15	31.5	33.4	32.8	32.9	33	33.8	32.9
56	28-10-15	33.5	34.9	32	31.9	34	31.7	33
64	05-11-15	30.5	33.5	29.8	30.8	33	33.2	31.8
71	12/11/2015	30.2	32.5	29.7	29.4	31.5	27.9	30.2
78	19/11/2015	29.8	30.1	30.1	27.9	26.8	28.7	28.9
84	25/11/2015	26.8	26.4	28.1	28.7	27.6	25.6	27.2

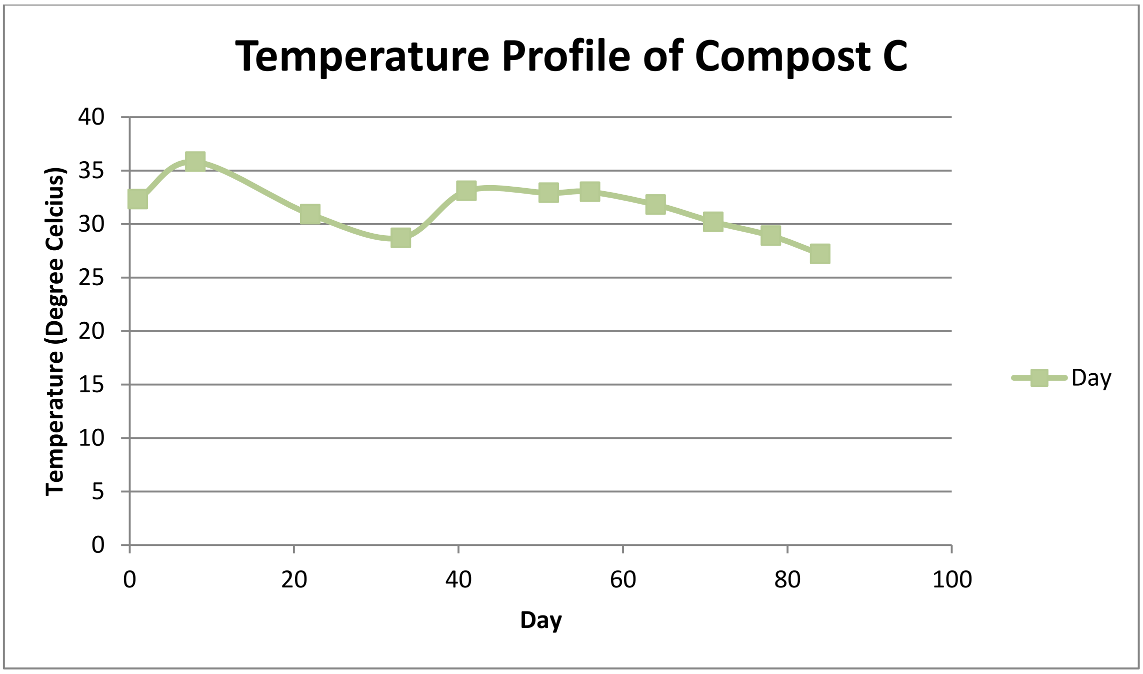

Figure 5.7 Temperature Profile of C

Table 5.8 Temperature Profile of D

Day	Date	Temperature Reading of D						Average
		1	2	3	4	5	6	
1	03-09-15							31.8
8	10-09-15	36.2	35.4	35.8	36.1	35.8	36.1	35.9
22	24-09-15	32	32.1	31.2	30.9	31.4	33.2	31.8
33	05-10-15	29.8	30	29.7	30.5	28.9	28.7	29.6
41	13-10-15	33.5	32.9	33.8	31.7	32.6	35.9	33.4
51	23-10-15	32.6	34.5	33.8	31.7	29.7	33.3	32.6
56	28-10-15	33.3	34.9	31.8	32.7	32.6	32.7	33
64	05-11-15	34.5	29.7	28.5	35	34.7	30.8	32.2
71	12/11/2015	31.4	30.9	32.1	29.9	28.9	28	30.2
78	19/11/2015	28.9	30.1	30	32.1	28	30.3	29.9
84	25/11/2015	28.9	30.2	30.1	28	26.8	28.8	28.8

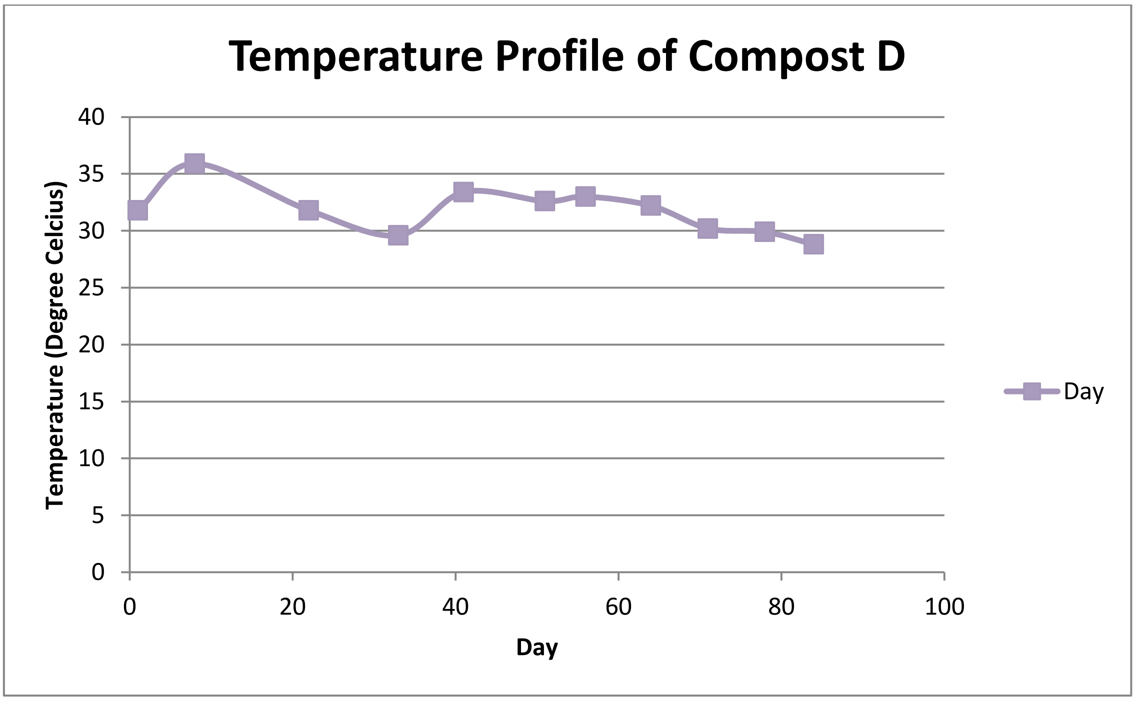

Figure 5.8 Temperature Profile of D

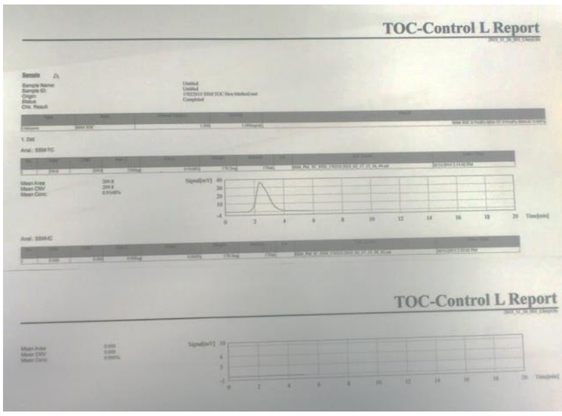

Figure 5.9 A-TOC Result

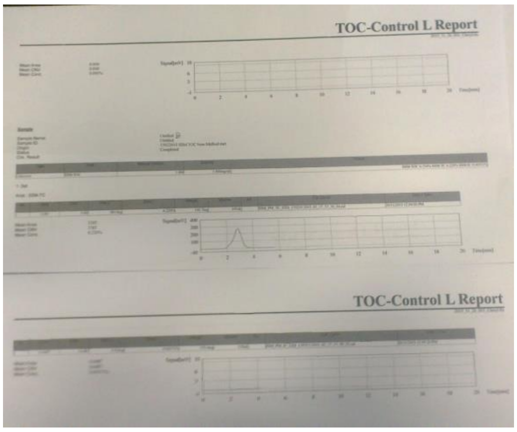

Figure 5.10 B-TOC Result

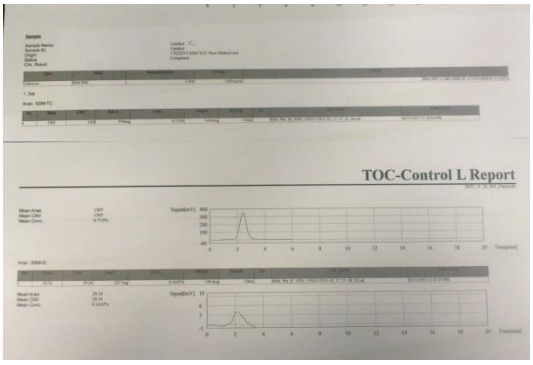

Figure 5.11 C-TOC Result

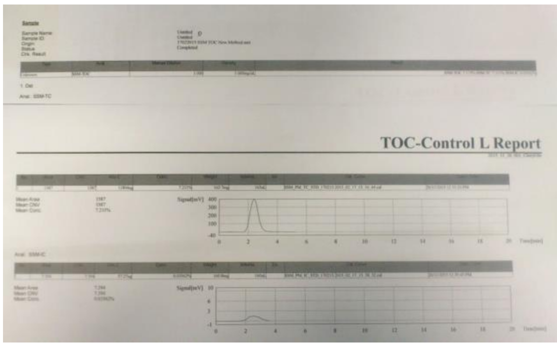

Figure 5.12 D-TOC Result

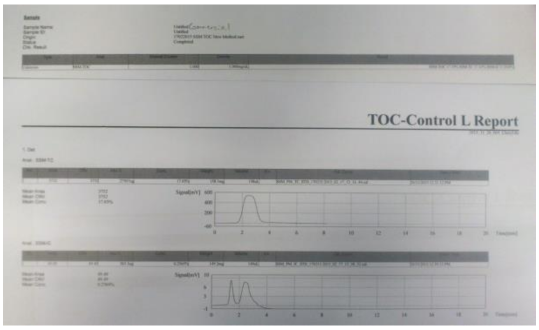

Figure 5.13 Commercial Compost-TOC Result