Rapid Conversion of Leaves Waste into Nutritional Vermi-Compost Using Hot Compost Method

by

Muhamad Mukhriz Bin Md Anuar

14821

Dissertation submitted in partial fulfilment of

the requirements of the

Bachelor of Engineering (Hons)

(Chemical)

JANUARY 2015

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Rapid Conversion of Leave Waste into Nutritional Vermi-Compost Using Hot Compost Method

by

Muhamad Mukhriz Bin Md Anuar

14821

A project dissertation submitted to the

Chemical Engineering Programme

Universiti Teknologi PETRONAS

In partial of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(CHEMICAL)

Approved by,

_____

(Dr. Muhamad Rashid)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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

MUHAMAD MUKHRIZ BIN MD ANUAR

ABSTRACT

Composting is a method that managed by human control which microorganism break down plant and animal materials into more valuable forms suitable for application to soil. Then evolution happen when research show how earthworm play important role in agriculture field which produce better compost called vermicompost. Vermicomposting is a process whereby earthworm is used to convert all type of biodegradable waste such as kitchen waste into nutrient rich organic fertilizer which contain in the excreta of the earthworm.

Universiti Teknologi PETRONAS (UTP) is generating leave wastes at a high volume daily. There is significant potential of carrying vermicomposting for UTP's leave waste to reduce operation cost in handling waste which UTP usually hired contractors to disposed the leaves. The study aims to identify rapid conversion of leaves waste into vermicompost using hot compost method. Literature review on vermicomposting serve as fundamental and guideline to this project. Discussion about vermicomposting and suggested methodology that have been done by researchers helping this project to run well. At the end of this project, expecting same nutritional vermicompost is produce compare to market vermicompost and to identify rapid conversion using hot compost method.

ACKNOWLEDGEMENT

With the name of Allah the Most Gracious and Most Merciful

First and foremost , I would like to express my utmost gratitude and thankfulness to Allah SWT Lord Almighty whom had made my final year to be very meaningful . The preparation of this final year project "Rapid Conversion of Leave Waste into Nutritional Vermicompost Using Hot Compost Method" would not be possible without the guidance of my supervisor, Dr. Muhamad Rashid Shamsuddin. He gave me continuous guidance throughout the period . Gave important advices and comment on the work especially in writing the report.

I owe my profound gratitude to Chemical Engineering Department of ies Universiti Teknologi PETRONAS (UTP), Labs and Facilities Technical Assistants, Postgraduates of Civil Wastewater Department and Chemical Engineering Final Year coursemates. Thank you to the coordinator, Dr Asna for her effort conducting few adjunt lectures to guide the student in completing the final year project.

At the end of the note, thank you everyone and may Allah swt bless us all.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 Background Study

Many people have a basic understanding on the composting process, few people understand its complexity. Yet the better people understand the composting process, the better the decision they can make for effective and efficient composting. Compost is a product derived from degradation process for breaking down plant and animal by microorganism into more friendly form suitable for soil benefits [1]. Typically composting reduces manure volume or a combination of plant and animal materials into a beneficial material under certain parameter such as aerated pile system, optimum temperature, amount of moisture and others. In a simple word, human control of the biological decomposition process what differentiates composting from natural decomposition of organic matters. In this proposal, author is interested in rapid conversion waste into nutritional vermicompost.

Vermicompost is the excreta of earthworm, which are capable of improving soil health and nutrient status. Worms are used act as biological agents to consume those wastes and to deposit excreta in the process called vermicomposting. As simple biotechnological process of composting, certain species of earthworms used to increase the performance of waste conversion and produce a better product which differs from composting [3]. Through a type of biological alchemy, earthworm are capable of transforming garbage into gold. The result of earthworm castings or worm manure which are rich in microbial activity and plant growth regulators make vermicomposting faster than composting [2,3]. What makes vermicompost nutritional to the plant roots

because the existence of enzymes like amylase, lipase,cellulose and chitinase which work to break down the organic matter in soil [4].

Bedding is required to provide a stable habitat for worm. They also requires conducive environment such as suitable moisture, aeration, temperature and pH. In hot compost method heat is very important aspect for fast composting as it reduces composting time and produce more yield. Therefore, the composting setup with the highest temperature generation within the system is highly desirable.

1.2 PROBLEM STATEMENT

Universiti Teknologi PETRONAS (UTP) campus which currently have 400 hectares of build area and there are many trees planted around the campus. Given such set up cause UTP naturally to generate large amount bags of leaves waste every day. Apparently, the method of handling this leaves is to dispose it off campus. The contractors will gathered the leaves daily before being picked up by another company of contractors to transport all the leaves to be disposed. This practice definitely cause a lot of cost and manpower. As an alternative by using the vermicomposting it will help to convert this leave waste into more beneficial nutrient fertilizer. Plus, from the study it shows that this method can make rapid conversion and helps

1.3 OBJECTIVES

The objectives for this project are as following ;

a) To study how much of leaves waste can convert into nutritional compost via vermicomposting.
b) To determine is hot composting method enhance the vermicomposting of leave waste.

c) To study the C/N ratio, temperature, pH value and moisture content and nitrogen content of the compost.

d) To determine the feasibility of introducing vermicomposting method for daily UTP's leave waste.

1.4 SCOPE OF STUDY

The scope of study of vermicomposting system are;

1. This project focused on conversion of leave wastes into nutritional compost.
2. The scope of this work are limited only by using leave waste as main waste to convert and only red worms type.
3. Study on important parameter that will be collect which are the pH value, temperature, moisture content, and nitrogen content.
4. This project to focused on small scale composting using aerated bin.

CHAPTER 2: LITERATURE REVIEW

2.1 OVERVIEW OF VERMICOPOSTING SYSTEM

In part of sustainable society, waste management is considered vital which by necessity diversion of biodegradable fractions of the societal waste from landfill into alternative management process. In recent decade, the role of earthworm has caught attention of researcher when a revolution is unfolding in vermiculture studies for vermicomposting of diverse organic wastes by waste eater earthworms into a nutritional organic fertilizer [7].

Vermiculture and vermicomposting is two different process. The one author interested is vermicomposting which define the process of using worm to convert organic material or waste into nutritional vermicompost [11]. When earthworm consume organic waste , it would produce cast equivalent to about 50% of waste consume.

There are three basic types of vermicomposting system of interest to farmers which are windrows, bed or bin, and flow-through reactor [11]. Mostly used static pile windrow where this piles are usually elongated but can also be in squares or rectangles. Plus this system need to be either watered or covered to maintain the moisture and avoid leaching of nutrients into the ground beneath.

Figure 1: Example of windrows

Figure 2 : Red worm used for vermicomposting process

Vermicompost is said as an excellent soil additive made up from worm casting which contain up to 5 times the plant available nutrients found in average soil mixes. Various studies had show that in vermicompost product it contain all nutrients where the example of rice (Oryza sativa) plant have highest intake of nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) when the fertilizer combined with vermicompost [12].

2.2 BASIC OF VERMICOMPOSTING

Carbon to nitrogen ratio or **C:N ratio** are the most important factor of composting for efficient working pile or bin.Carbon simply an energy source the brown materials such as paper,dead leaves or straw. While nitrogen is crucial component of proteins the green material such as . The ideal C/N ratio is 30:1 because if lower that 30:1 the compost will become excess nitrogen will be list as ammonia gas and cause undesirable odour. Meanwhile if the C/N ratio is higher then the compost will degrade slowly since the compost did not provide enough nitrogen for optimal growth [15]. However there are also study showed that the ideal C/N ratio is between 25/1 to 30/1 [1].

Worms. Most of the studies show that there are about 3000 species of earthworms are found worldwide. Since earthworm are well-known to inhibit in ecological niches, therefore the earthworm can be found in organic materials such as compost and manure litters. The one most type of worm used for vermicomposting is called Red Wiggler or Eisenia Fetida. This redworm can handle in 0 to 35 degree celcius besides it can take a lot of handling and rough treatment [11].

Bedding is any material that provide the worms with a relatively stable habitat. Since the worm breathe through it skins, the worms will die in the absent of moist environment . The present of the bedding are expected to absorb and retain water fairly well if the worms are to thrive. Besides, when high protein/nitrogen levels can result in rapid degradation and its creating inhospitable, associate heating condition. While heating is happening at food layer but not in the bedding. Bedding is said to have good bulking potential because of the high straw content to help the worm to received oxygen and also relatively good moisture retention. Besides horse manure as bedding material, the addition of high-absorbency such as peat moss and shredded paper or cardboard.

Moisture is one of the basic element in vermiculture to make sure the worms can be enormously productive and reproductive.That is why the bedding that have been choose need to be able hold enough moisture if the worm are to have a livable environment. The ideal moisture-content range for materials conventional composting systems is 40-60% while in vermicomposting is 70-90% [8]. Other

researchers gave different range of moisture mostly around 70% but commonly the worm weight increased with moisture content.

As oxygen breather, worm cannot survive in anaerobic condition or absence of oxygen. Anaerobic can happen when the feedstock contain high level of grease combined with poor **aeration** conspire to cut off oxygen supplies [7]. The fact that the worm help themselves by moving in the bed area for making own aeration.Thus worm work at best when ventilation is good and the material they are living in is relatively porous and well aerated.

Controlling **temperature** that suit to worm is important in vermicomposting process. Worms response to temperature differential [9]. The worms will move themselves within piles, beds or windrows according to temperature gradient.Other parameter is **pH value.** One of the research found that worm can survive in pH range 5.0-9.0 [10]. Most experts found that the optimum pH value is at 7.0-8.0 [9].

CHAPTER 3: METHODOLOGY

3.1 EXPERIMENTAL SET UP

3.1.1 Waste Collection

Refer to **Figure 8** in the Appendix, UTP leave wastes (green or dry leaves) can be collected around campus area early in the morning . The management is hiring LIVINE contractors to collect leaves and then it will be send for disposal usually around 10am. Before noon few bags of leaves can get from the contractors. This experiment will be conducted near the area of Wastewater Laboratory of Civil Department (**Figure 9**).

3.2.2 Bin Set Up

This experiment will have two set up with and without cover to make sure different temperature as heat is very importat to a fast composting [6]. Refer to **Figure 3** below both set up will have few holes for aeration and to collecting leachate.

Figure 3: Aerated Bin with holes

The setup of both bins will add starter of vermicompost from NMS Trading company to encourage the degradation. All the leaves only able o grind manually using bare hand. Setup will be conducted as **Table 1** below;

Table 1 : Raw material to setup compost bin

Set Up A (Cover)			Set Up B (w/o cover)		
No	Item	Quantity	No.	Item	Quantity
1	Leaves	2 kg	1	Leaves	2 kg
2	Grass clipping	0.55 kg	2	Grass clipping	0.55 kg
3	Wood chip	0.1 kg	3	Wood chip	0.1 kg
4	Shredded paper	0.1 kg	4	Shredded paper	0.1 kg
5	Vermicompost	0.5 kg	5	Vermicompost	0.5 kg
6	Red Worm + Soil	2.2 kg	6	Red Worm + Soil	2.2 kg
7	Soil	4.2 kg	7	Soil	4.2 kg
8	Bin	1 kg	8	Bin	1 kg
	TOTAL	**10.65 kg**		**TOTAL**	**10.65 kg**

Every four days the composting material in the bin will be mix evenly so that the worm can have time to work. Besides, continues add adequate of water to keep the moisture steady will also be doing every four days. Get water into the bins as turning or moving it. Observed and record the data to be analyse. The data will be collected is temperature of composting material and pH value. Then this data will be analyse as mentioned in next chapter. The observation of the bins is to see the progress of vermicomposting result if its turn exactly like vermicompost at the market.

Figure 4: Set Up of Compost Bin

3.2 DATA COLLECTION

3.2.1 Measurement of pH and temperature

1. The measurement of pH and temperature is taken every four days using the soil meter which can measure both parameter.

2. Each time , the author will take six reading and record it for analysis.

3.2.2 Measure moisture content

1. Sample will be collected from 6 different point in compost bin. Then it will mix before one smaller sample will be used for determination.
2. The apparatus that going to be used are drying oven, balance, gloves, and porcelain dish .
3. Place 100g compost from the bin on the dish
4. Oven will operate at 105°C for 3 hours
5. The data will be calculated to determine moisture content [16]
6. $$\textbf{Moisture content} = \frac{\textbf{Mass}_1 - \textbf{Mass}_2}{\textbf{Mass}_1} \textbf{ x } \textbf{100}\%$$

   $Mass_1$: Mass of procelain dish + moist sample

   $Mass_2$: Mass of procelain dish + dry sample at 105℃

3.2.3 Measure of organic content

1. Dried sample from moisture content analysis is heated up in frunace at 550°C.
2. After 6 hours, then remove the sample carefully and let it cool down to room temperature.
3. The calculation of data as below ;
4. $$\mathbf{M_{organic} = mass_2 - mass_3}$$

$M_{organic}$: Mass of organic matter

$Mass_2$: Mass of dried sample at 105℃

$Mass_3$: Mass of sample at 550℃

$$\textbf{Yield } (\%) = \frac{\textbf{Mass }_{\textbf{Organic}}}{\textbf{Mass }_{\textbf{1}}} \textbf{ x 100}\%$$

3.3 DATA ANALYSIS

3.3.1 Compost Analysis

As mention in the literature review, carbon o nitrogen ratio (C/N ratio) is he most important parameter for composting. The ideal C/N ratio is between 25/1 to 30/1 which show more carbon than nitrogen in the pile. If the C/N ratio is greater so much longer time is needed the pile to decompost as it did not provide sufficient nitrogen for optimal growth of microbial and tend to degrade slowly [15]. Therefore having the right ratio which is around 25:1 to 30:1 at the beginning of the experiment is important.

3.3.2 Temperature and pH Profiling

Temperature data will be collected every 4 days. This data will be plotted on the graph with temperature of compost versus time. From the graph expected result the graph will increase with time to get optimum composting parameter. It then will stabilized and will maintain as the rate of change in temperature showing the speed of decomposition of compost. Profiling of pH values against time to make sure red worm work at its optimum degradation activity. Same as temperature profile, the graph of pH value will also increase and maintain as expected.

3.3.3 Mass Balance

The mass taken earlier in the experiment will compared with final mass of the compost. This is to determine the overall yield of it. The yield in mass is important as an factor to evaluate mass of waste that been compost. Yield can be calculated as follows :

$$\textbf{Yield}\ (\%) = \frac{\textbf{Mass}_{\textbf{initial}} - \textbf{Mass}_{\textbf{final}}}{\textbf{Mass}_{\textbf{initial}}} \times \textbf{100}\%$$

3.3.4 TOC and TN

Total Nitrogen(TN) and Total Organic Content (TOC) analysis will be conduct in the lab using Kjeldahl method [17]. Firstly sample collected will be heated with sulfuric acid and will be undergone acid digestion at 420 ℃ before it will be determine the content using the apparatus **Figure 6** which can read both parameter ie TOC and TN. The result of nitrogen content will define the product is a nutritional vermicompost.

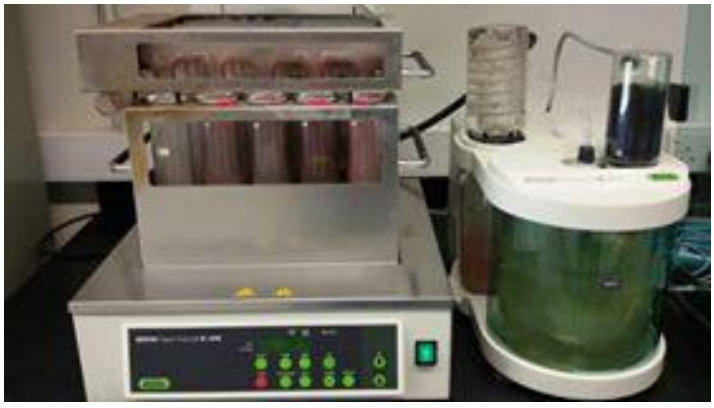

Figure 5: Acid digestion method for compost sample

Figure 6: Shimadzu Total Nitrogen Module

3.3.5 Physical Observation

Despite physical observation is not consider as an absolute measurement but it can be consider as qualitative method of assessment. As mentioned in the literature review, the product of vermicomposting will be in dark brown or black in colour . So picture will be taken from the first day and at the 60th day which are two month process.

3.4 KEY MILESTONE

Table 2 : Key Milestones

Step	Period	Key Milestones
1	**FYP 1**	Submission of Extended Proposal
2		Proposal Defence
3		Settle the forms required by lab and security
4		Search worm supplier and starter
5		Collect leaves
6		Set up compost pile
7		Submission of Interim Report
8	**FYP 2**	Data collection and analyse from composting process
9		Submission of Progress Report
10		Pre-SEDEX
11		Continue to compost
12		Record and analyse data
13		Submission of Dissertation (softbound) and Technical Paper
14		Viva
15		Submission of Dissertation (hardbound)

3.5 GANTT CHART

Please refer to **Table 6** at the **Appendices**

CHAPTER 4: RESULT AND DISCUSSION

4.1 OBSERVATION

Started up the compost bins on 5th February and took 8 reading within two month of composting process. **Figure X** and **Figure Y** are the latest picture taken.

Figure 7: Compost bin at the 1st day

Figure 8 : Compost bin set up A at 60th Day

Figure 9: Compost bin set up B at 60th Day

From the observation of this two set up, it shows that the waste leaves did not compost much within two month process. From the study, the decomposition of leaves is taking much longer time . Since the worms are still alive it show that vermicomposting is still working on.

4.2 DATA ANALYSIS

Data taken are the temperature and pH value for both set up using portable soil meter which can measure both parameter . In almost two months author able to took eight time reading and for each time, six reading are taken and took the average and plot the graph.

4.2.1 Temperature

Table 3: Result of temperature reading for both set up

Set Up\ Reading taken	1	2	3	4	5	6	7	8
A	30.35	33	33.17	32	35.1	35	37	37.4
B	32.4	33.8	33	32.3	34	35	37	37.4

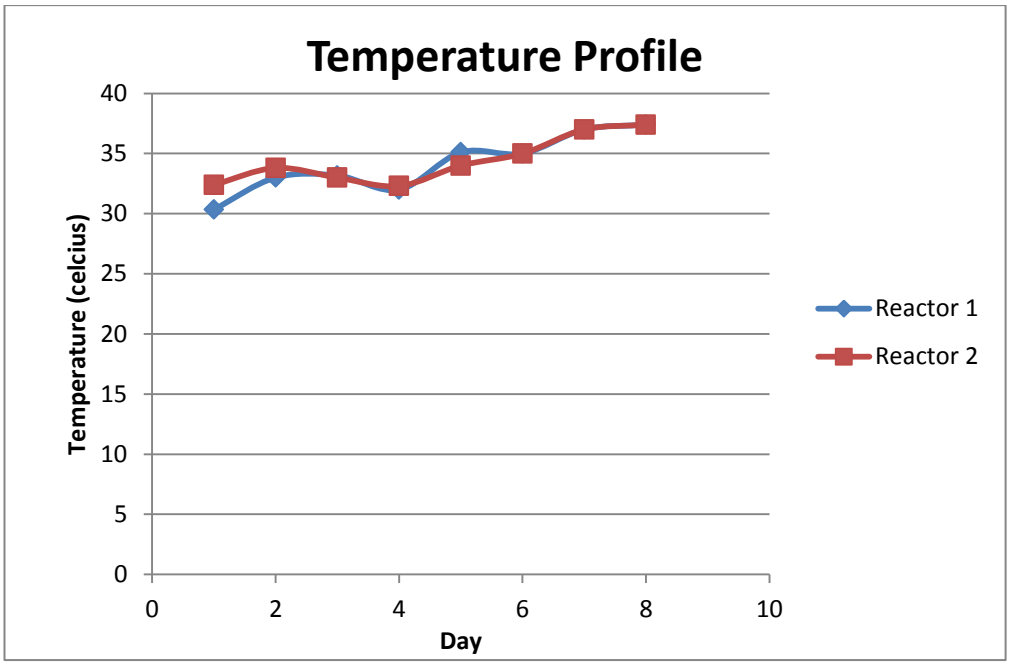

Figure 10: Graph of Temperature Profile

From the temperature reading of both set up is fluctuate. The range of the temperature are from 30℃ to 35℃. From the literature review the worm are active around 32℃ temperature within the pile. To make the composting process faster , the pile need to increase it's temperature so author has decided to put set up A with cover while set up B without cover under the sun. However, both set up reached almost the same temperature reading. From Organic Agriculture Centre of Canada, it said that worms response to temperature differential, it will redistribute themselves within the pile so most of the worm move in the middle of pile .

The temperature reading should be increase exponential and decrease before it will keep maintaining in low temperature which shows the vermicomposting process is done and produced products.

4.2.2 pH Value

Table 4: Result of pH reading for compost bin

Set Up \ Reading	1	2	3	4	5	6	7	8
A	7.03	8.68	5.7	7.2	6.62	6.3	5.5	5.4
B	6.7	6	4.7	6.7	6.7	6.6	6.5	6.5

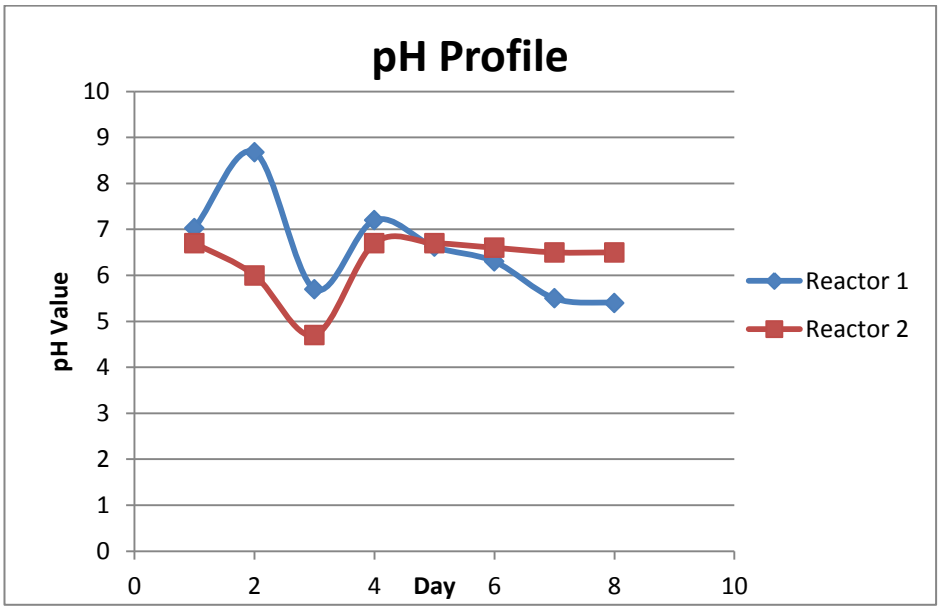

Figure 11 : Graph of pH profile of both set up

From the reading of both set up, the pH value generally varies between 4.7 and 8.7 and it is suitable for worms that can survive in range of 5 to 9 [11]. The initial pH depends on the composition of set up. It might be different because of slightly different in composition during early stage of the project. It happened that the bedding become acidic and cause the pH to drop until 4.7. The organic acid may accumulate as a byproduct of the digestion of organic matter by bacteria and cause fungi growth which active in the decomposition of cellulose and lignin. The pH rises again because during the composting process organic acid breakdown further. As expected result , generally the vermicompost product should be between 6 and 8 [15]

4.2.3 Mass Yield

To determine the yield in mass and calculate as below formula ;

$$\textbf{Yield}\ (\%) = \frac{\textbf{Mass}_{\textbf{initial}} - \textbf{Mass}_{\textbf{final}}}{\textbf{Mass}_{\textbf{initial}}} \times \textbf{100}\%$$

Table 5: Yield % of Composting

Set Up	Initial (kg)	Final (kg)	Yield (%)
A	16.0	14.30	10.6
B	16.0	14.60	8.75

From this result, it shows that for both compost bin only able to produce 10.6% and 8.75% of yield within two month period. This has a lot work need to be done to achieve much higher percent of product.

4.2.4 Organic Content

Firstly author able to setup both compost bin around 26 C/N Ratio which is suitbale for vermicomposting.

Ingredient	% H20	Weight	% Carbon	% Nitrogen	C/N Ratio
grass	50	550	15	2	
Leaves	50	2000	35	1	
wood chip	50	100	50	0.1	
				Result:	26.768488745980

Calculate Reset

Figure 12 : Calculated C/N Ratio for compost bin

4.2.5 Total Organic Content (TOC)

Table 6: Data Total Organic Content

Sample	Mass of compost (g)	Volume of solution (ml)	ppm	% C
A	3	100	278.7	0.93
B	3	100	206.3	0.69
Market	3	100	695.9	2.32

4.2.6 Total Nitrogen Content

Table 7: Data on Total Nitrogen

Sample	Mass of sample (g)	Volume of solution (ml)	ppm	% N
A	1	100	289	2.89
B	1	100	240	2.4
Market	1	100	463	4.63

Total Nitrogen (TN) is essential content to make sure the compost is nutritive enough to be the soil additives. Starting materials low in N may also be a contributing factor. Nitrogen contents above 2.5% are most often associated with high organic matter levels (>60%), and/or nitrogen-rich starting components. As for this project the compared to market the TN is almost the same which show it also a better product.

CHAPTER 5: CONCLUSION & RECOMMENDATION

Vermicomposting simply means making of compost by worms by utilizing worm's behaviour. The most effective uses of earthworms are organic waste management and supplement of readily available plant nutrients and vermicompost demand as it maintains and improves soil health. In many countries have studied and being implemented from home worm bins to large scale. People around the world have make vermicomposting as business while other have make further research about earthworm and vermicomposting [18].

Based on the problem statement , it provide opportunity to improvise the waste management in UTP especially leaves wastes. The methodology are set up based on research and clear overview and important parameters on vermicomposting process. The recommendation of this project is to have proper timeline and increase the speed of progress to avoid failure in producing quality vermicompost. Besides, if this project is success using the rapid conversion than it is recommended to implement in UTP as it gives benefits . The benefits are in term of cutting cost, proper waste management and using the vermicompost for futher research in chemical or civil department.

From the experiment it show that using hot composting method is not suitable for vermicomposting as worm can only work in below 40℃, otherwise worm will die because of high heat. This study strongly suggested that if suing hot composting method applicable to use conventional composting which have few types of composting method such as windrow or using heater in the bin. Then only rapid conversion will happen. However using vermicomposting is also can help rpid conversion if the waste are grind properly and moisture content can maintain 50% of the bedding. Having the right portion of food waste and bedding setup using C/N ratio calculation will help optimization of vermicomposting.

The Total Organic Content (TOC) and Total Nitrogen(TN) result is very important to determine the product is nutritive enough. Using the Kjeldahl method and Shimadzu Total Nitrogen Module to determine the TOC and TN data and compare with market vermicompost.

5.1 RECOMMENDATION

For future studies and research here are few recommendation and improvements;

1. Make sure all leaves must be totally grind and maintain the moisture content to 50% so that worm can easily compost the waste
2. Make sure C/N ratio at the ideal ratio to make shorter composting period.
3. If want to compost only leaves wastes then need to mix with food waste as well so that worm can have variety of foods to compost.
4. Study further on hot composting method using the right bin design to make sure rapid conversion on the waste.

CHAPTER 6: REFERRENCES

[1] L.Chen, M.,de Haro Marti, A.,Moore, C.Falen.2011.*The Composting Process*, University of Idaho Extension.

[2] A.Sujit.2012. "Vermicompost, the Story of Organic Gold : A Review'. Agriculture & Ecological Research Unit, Biological Sciences Division, Indian Statistical Institute, Kalkota, India , August 2012.

[3] Gandhi, M.,Sangwan, V.,Kapoor, K.K. and Dilbaghi, N.(1997). Composting of household wastes with and without earthworms. *Environment and Ecology*, 15, 432-434 .

[4] Chaoui, H.I., Zibilske, L.M. and Ohno, T. (2003) Effects of eartworms casts and compost on soil microbial activity and plant nutrient availability. *Soil Biological and Bio-Chemistry*, 35, 295-302.

[5] Vermi Co. (2001) Vermicomposting technology for waste management and agriculture L An executive summary. Vermi Co., Grants Pass. http://www.vermico.com/summary.htm

[6] K. Atchley . 2013. "Hot Composting with the Berkeley Method" . Kerr Center for Sustainable Agriculture. http://www.kerrcenter.com

[7] A.Sujit.2012. "Vermicompost, the Story of Organic Gold : A Review'. Agriculture & Ecological Research Unit, Biological Sciences Division, Indian Statistical Institute, Kalkota, India , August 2012.

[8] Rink, Robert (Editor), 1992. Authors: Maarten van de Kamp, George B. Wilson, Mark R. Singley, Tom L Richard, John J.Kolega, Francis R. Gouin, Lucien Laliberty, Jr., David Kay, D.W. Murphy, Harry A.J. Hoitink, W.F.

Brinton. On-Farm Composting Handbook. Natural Resource, Agriculture, ad Engineering Service (NRAES-54), Ithaca, NY.

[9] GEORG,2004. *Feasibility of Developing the Organic and Transitional Farm Market for Processing Municipal and Farm Organic Wastes Using Large Scale Vermicomposting.* Good Earth Organic Resources Group, Halifax, Nova Scotia.

[10] Edwards, C.A. 1998. "*The Use of Earthworms in the Breakdown and Management of Organic Wastes".* In: Edwards, C.A. (ed) Earthworm Ecology. St. Lucie Press, Boca Raton, pp. 327-354.

[11] Munroe *"Manual on Farm Vermicomposting and Vermiculture"*. Organic Agriculture Centre of Canada.

[12] Jadhav, A.D., Talashilkar, S.C. and Pawar, A.G. (1997) Influence of the conjunctive use of FYM, vermicompost and urea on growth and nutrient uptake in rice. *Journal of Maharashtra Agricultural Universities,*22, 249-250.

[13] M.Amirhossein, N.Syazana, E.Noor. (2013) Anaerobic Transformation of Biodegradable Waste;Simulatneous Production of Energy and Fertilizer

[14] (2014).*Composting TutorialI.* Retrieved from http://www.urban-composting.com/composting-tutorial.html#TOP

[15] Kayhanian, M. and G. Tchobanoglous. 1992. Computation of C/N ratio for various organic fractions. *BioCycle* 33(5): 58-60.

[16] L. Cooperband, "The Art and Science of Composting". March 29(2002)

[17] "*A Guide to Kjeldahl Nitrogen Determination Methods and Apparatus"*. Consultant and Labconco engineers. Industry Service Publication.

[18] Applehof, M., Webster, K. and Buckerfield, J. (1996) Vermicomposting in Australia and New Zealand. *BioCycle,* 37, 63-66.

CHAPTER 7: APPENDICES

7.1 Appendix 1

Figure 13: UTP leaves collecting area

7.2 Appendix 2

Table 8: FYP II Gantt Chart

No	Activties / Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**Progress Report**															
2	**Project Work Continue**															
	Setting Up Pile															
	Collection of Leaves															
	Start composting															
	Mix the mixture for for even vermicomposting															
	Sprinkle with water for moisture															
	Record pH and temperature value															
	Weighing the waste															
	Analyse the data															
3	**Pre Sedex**															
4	**Submission**															
	Softbound															
	Technical Paper															
5	**Oral Presentation**															
6	**Submission of Hardbound**															

7.3 Appendix 3

Figure 14: Civil Department Lab