KEMENTERIAN PENDIDIKAN TINGGI

JOJAPS

eISSN 2504-8457

POLITEKNIK MALAYSIA PORT DICKSON

Journal Online Jaringan Pengajian Seni Bina (JOJAPS)

A Research of Comparative Nutrient Value in Food Waste Composting (ECO-COMPOST)

Nora Binti Ismail [a*]
Siti Nur Yusra binti Yusof [a*]
POLYTECHNIC OF PORT DICKSON
(*nora@polipd.edu.my*)
(*nuryusra@polipd.edu.my*)

Abstract

Composting is a process where the organic materials are transformed into compost via a process of controlled biological decomposition by microorganisms under the presence of oxygen. The constantly increasing population of the world and the constant push for more profitability that has come from the industrialization of our food system has pushed farmers to produce more food per acre of available land and to increase productivity. The shift to mass-produced synthetic fertilizers came at a high environmental cost because the production of synthetic fertilizer uses non-renewable resources and causes air and water pollution. Study of the best combination of food waste composting (eco-compost 16) suitable for plant growth. Composting parameter involved are temperature, pH value, moisture content, ratio C/N. Nutrient Value investigated in this study is limited to carbon, nitrogen, phosphorus and potassium due to retrained of laboratory apparatus. Compilation of making compost, nutrient value and the growth parameter of plant is done simultaneously with searching for suitable title for the study. Discussion of the results obtained will focus on the key parameters that affect the composting process such as moisture content, pH, temperature, carbon content, nitrogen content, C: N, the nutrients such as nitrate (N03-), phosphate (P04 3-) and potassium (K +). Comparison of the results of composting the best among 6 samples studied can be determined through the plots. The researcher realized the importance and beneficial of compost in maintaining and sustainable of the environment for future generation.

Key-word: - compost, fertilizer, nutrient

1. Introduction

Municipal solid waste in Malaysia contains high amount of organic matters, particularly food waste. The National Strategic Plan (NSP) for Solid Waste Management estimates that about 45% of the municipal wastes are food waste, followed by other components such as papers, plastics, metals, etc. This figure has been reported to reach even higher levels at nearly 70% when the waste arrives at the disposal site due to the separation of other recyclables from the waste and the lack of food waste recovery in Malaysia. Most food waste is disposed of at the disposal. (Nazeri, 2005)

Food waste can be converted into useful materials such as soil conditioner or fertilizer if it is source-sorted and herby, avoiding contamination from other waste materials. However, except some food waste collected from eateries by farmers for animal feed, source separation of food waste for recycling is not commonly practiced in Malaysia due to various constraints.

These constraints include low awareness among the waste generators and low demand of the products produced from the food waste such as the composts. It is importance of promoting food waste recycling in order to increase the overall recycling rate, save resources and divert solid waste from entering the disposal sites where it constitutes a financial burden and gives rise to environmental impacts. Composting is one of the methods of recycling for the food waste. Composting is a process where the organic materials are transformed into compost via a process of controlled biological decomposition by microorganisms under the presence of oxygen. Alternatively, fermentation could have been selected. In such case, no oxygen is involved and biogas is produced in the addition to the compost.

Many composting techniques are available for converting the organic waste into compost. There are advanced in-vessel, high speed composting method, and using effective microorganism under controlled high temperature. Like any other recycling methods, composting of food wastes, garden wastes and other organic wastes can help to reduce the amount of solid wastes for disposal, thereby, reducing the disposal costs, prolonging the lifespan of the disposal sites and minimizing the environmental impacts. Food waste is the main contributor to greenhouse gas (methane) emission at landfills and is the main contributor to leachate formation due to the high humidity of the waste. It further contaminates other recyclables and complicates their separation from the waste stream. Compost is also a valuable product that can be used as fertilizer or soil conditioner in farming, gardening, parks and landscaping activities. management of waste and construction waste for this housing construction project is not taken seriously by all parties, then it is feared that it will create a culture and negative attitude towards some parties in managing waste and floods.

The constantly increasing population of the world and the constant push for more profitability that has come from the industrialization of our food system has pushed farmers to produce more food per acre of available land and to increase productivity. To be able to produce more food and therefore be more productive, farmers are every day more dependent on synthetic fertilizers. The shift to mass-produced synthetic fertilizers came at a high environmental cost because the production of synthetic fertilizer uses non-renewable resources and causes air and water pollution. Furthermore, in order to combine hydrogen and nitrogen gases to make fertilizer, chemists use a process that submits both elements under enormous pressure and heat in presence of a catalyst (Pollan, 2006).

In addition, excess fertilizer from agriculture lands and residential areas is a non-point pollution contaminants that can cause severe damage to ground waters, rivers, lakes and coastal zones (Environmental Protection Agency, 2008). Based only on the environmental footprint of synthetic fertilizer, compost represents a much more sustainable and viable soil amendment. The composting process does not burn fossil fuels and the use of compost as soil amendment does not pollute our waters. Food waste is an important component of all municipal waste generated and its disposal in landfills has critical environmental effects (EPA, 2009). Every day local and national governments are pushed more and more by their citizens to manage their waste handling needs, but increasingly more scrutiny has been put on the way the waste is handled with citizens now asking for this to be done in an environmentally sustainable way. Furthermore, a constantly increasing population makes the land available to use as landfills more difficult to find (especially in metropolitan areas) and local governments are faced with the need to extend the life of their landfills and avoid the cost of purchasing and building a new landfill.

Compost continues to attract more and more people not only due to being an environmentally sustainable product but also for its great qualities as soil amendment. Compost use not only helps to improve soil quality and reduces soil loss, but also increases soil water retention and reduces the need for extra inputs (United States Composting Council [USCC], 2008). In addition, composting food waste represents a sustainable alternative for businesses, public institutions and schools to save money on tipping fees and profit from the advertisement of green practices.

1.1 Objective of Study

This study was conducted to achieve these objectives:

a) To identify the factors affecting food waste composting process.
b) To study the best combination of food waste composting (eco-compost) suitable for plant growth.
c) To compare the quality in term of nutrient value of eco-compost 16 from the existing compost in the market.

1.2 Scope of Study

The project is focused on composting different types of food waste. The raw ingredient was taken from the Port Dickson Market and Port Dickson Cafe. There are 4 type of sample food waste consisting raw fish waste, raw vegetables waste, combination of raw fish waste + raw vegetables waste and cooked food waste. Another 2 types of sample were taken from the fertilizers in the market, involve as comparative sample (urea and organic fertilizers). Composting parameter involved are temperature, pH value, moisture content, ratio C/N. These parameter is control in order to achieve optimum composting. Effective

microorganism, fiber and soil were added to neutralize the compost. The duration of the composting process is 60 days. Nutrient Value investigated in these study is limited to carbon, nitrogen, phosphorus and potassium due to retrained of laboratory apparatus. The testing is done in Science Faculty, UKM, Bangi under supervision of Senior Laboratory Personal, En Azman.

2. Literature

Food waste is defined as abandoned food such as rice, meat, fish, noodles, bread, potatoes etc. (Derman & Bentham, 2006). In Malaysia, residential and food processing industries such as hotels, restaurants, food stores, meat processing plants, seafood processing factories and bread manufacturing plants generate a lot of waste every day. Moist food waste rich in organic matter (Tsai et al., 2007) and minerals are easily decomposed (Yang et al., 2006). If food waste is neglected and left untreated immediately, it is easily decomposed by microorganism pests from the environment (Tsai et al., 2007), promotes a stopover pest, disease and emit a foul odor that may affect the beauty of the environment (Yang et al., 2006).

Many previous studies have shown the food waste can be treated and recycled as livestock feed ingredients, used in composting to produce organic fertilizer, raw materials used to produce biogas and heat (Wang et. al. 2006). Food waste comprises about 12.7 % of the total municipal solid waste generated in the United States (EPA, 2009) which is about 96 billion pounds of food waste each year (USDA, 1997). The disposal of this organic waste in landfills has environmental consequences ranging from global warming, as a result of gas emissions (Eureka Recycling, N.D) to water pollution (Crawford, 2003) not to mention the energy waste that decomposing food waste without benefit represents. Composting food waste is a sustainable alternative to landfill disposal.

Composting has been used as means of recycling organic matter back into the soil to improve soil structure and fertility. The composting process as receive much attention in recent years because of pollution concern as and the search environmentally sound method for treating waste. Wastes volumes continue to rise, which leads to lose of resources and increased environmental risks. Open dumping and sanitary land field is major method for waste disposal, the land filling of biodegradable wastes is proven to contribute to environmental degradation, mainly through the production of highly polluting leached and methane gas. Composting aim to stabilization, volume and mass reduction of solid waste and retain of organic substance to the natural cycle.

Pace et el. (1995) reported that food waste should be characterized level of moisture content, pH and the ratio of carbon / nitrogen (C / N) for optimum composting. Plants, like all other living things, need food for their growth and development. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organics matter or by organic or inorganic fertilizers.

For plants to utilize these nutrients efficiently, light, heat, and water must be adequately supplied. Cultural practices and control of diseases and insects also play important roles in crop production. Each type of plant is unique and has an optimum nutrient range as well as a minimum requirement level. Below this minimum level plants start to show nutrient deficiency symptoms. Excessive nutrient uptake can also cause poor growth because of toxicity. Therefore, the proper amount of application and the placement of nutrients is important.

Although the environmental benefits of composting are many this section of the literature review will focus on four of the most important benefits of composting. Landfill diversion and pollution, reduction of synthetic fertilizer use, soil enrichment and soil erosion reduction.

3. Methodology

This research is a quantitative and descriptive study. Primary data collection is through the distribution of questionnaires and interviews to respondents in the study area. Sampling of the food waste materials is taken from two locations which is cafeteria B, Politeknik Port Dickson and Port Dickson Market. In this research, the materials involved are soil, fiber and food waste. Composting is done by using a basket of compost according to the type of specimen. Composting period was carried out for 60 days. Laterite soil was bought from Senawang Nursery are used as one of the important material for compost. The food waste was obtained from, Port Dickson Market which is rotten and wilted vegetables (spinach, broccoli and cabbage) and raw fish (mackerel fish and cat fish) while the remaining cooked food was obtained from Café B at Port Dickson Polytechnic. The food waste material is cut into small pieces. The paddy husk was used as fiber material for composting which is planted close to the study area (Kuala Pilah).

3.1 Sampling Method

There are 4 different type of food waste ingredient prepared to determine the nutrient value of the food waste composting together with 2 type of fertilizers in the market for comparison purposes. The ratio for each specimen varied according to soil: fiber: waste (S: F: W). There are four specimen involved with different types of food waste as shown in Table 3.1.

Table 3.1: Ratio of Material / Food Waste Ingredient

Sample	Material / Food Waste Ingredient	Ratio		
		Soil	Fibre	Material / food waste
Sample 1	vegetable waste	2	1	2
Sample 2	fish waste + vegetables waste.	2	1	2
Sample 3	fish waste	2	1	2
Sample 4	cooked food waste	2	1	2
Sample 5	Organic (market) - control	2	1	2
Sample 6	Urea (market) - control	2	1	2

4. Findings

This chapter discusses the data that has been obtained on the main parameters that affect the composting process such as moisture content, pH, temperature, carbon content, nitrogen content, C: N, the nutrients such as nitrate (N03-), phosphate (P04 3-) and potassium (K +). Presentation and discussion of the results is based on the plot a graph showing the change in the trend of each parameter studied. Comparison of the results of composting the best among 6 samples studied can be determined through the plots.

4.1 Factors Affecting Composting Process

4.1(a) Temperature

According to previous study, an increase in temperature in the compost heap is caused by the heat generated by the population of microorganisms through respiration and decomposition of organic materials such as sugar, starch and protein. The increase in temperature is the best indicator of microbial activity in the existence of the mass of the compost where microorganisms more active population, the more heat that will be released.

Table 4.1(a) Temperature

DAYS	TEMPERATURE (°C)			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
1	**32**	**33**	**34**	**34**
3	**54**	**55**	**69**	**54**
5	**55**	**54**	**68**	**54**
7	**55**	**56**	**68**	**59**
9	**56**	**57**	**67**	**58**
11	**58**	**59**	**67**	**58**
13	**57**	**58**	**65**	**57**
15	**56**	**56**	**64**	**55**
17	**54**	**55**	**63**	**54**
19	**54**	**55**	**63**	**53**

21	**52**	**55**	**63**	**53**
23	**52**	**54**	**60**	**50**
25	**52**	**53**	**60**	**50**
27	**51**	**53**	**59**	**49**
29	**51**	**52**	**57**	**47**
31	**48**	**52**	**57**	**46**
33	**47**	**51**	**56**	**46**
35	**46**	**51**	**54**	**46**
40	**42**	**49**	**50**	**43**
45	**36**	**38**	**38**	**36**
50	**31**	**32**	**30**	**32**

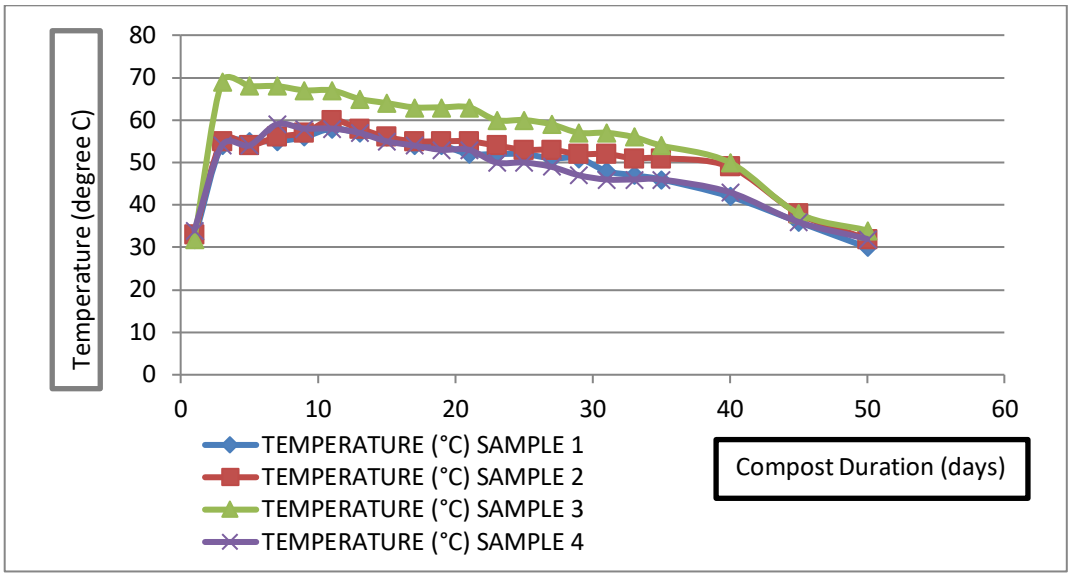

Figure 1: Comparison between temperature changes and duration composting

The optimum temperature allows microorganisms such as bacteria and fungi mesophilic process of decomposition of organic matter found in food waste composting. However, the temperature range recorded for all four samples is still in the optimal temperature range of 30-38 ° C. In the maturation phase, the range of temperatures that were recorded for the sample 3 is between 30 -32 ° C. The value range is lower than the ambient temperature ranges during the maturation phase at 34 ° C. Based on the ability to maintain mesophilic phase during the active phase of composting and compost temperature of lower than ambient temperature, sample 3 seen better compared with other samples.

4.1(b) Moisture Content

Excessive moisture content will invite various problems such as the existence of anaerobic conditions in the compost heap and the loss of nutrients and pathogens in the form of leachate. Meanwhile, the process of cell metabolism of microorganisms will be stopped if the moisture content is 10% or lower than the optimal range.

On average, the moisture content of food waste for the four sampling is 35.47% and this value is still within the range of the recommended moisture content of between 30-80%. If you want to compost food waste, the moisture content is too low can be solved by adding water to stack up to the rest of the park obtained the optimum value range of between 50-60%.

Table 4.1(b) Moisture Content

DAYS	MOISTURE CONTENT (%)			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
1	26	39	85.71	66
3	29	43	88	68
5	36	42	75	61
7	34	45	78	59
9	37	48	72	58
11	35	46	70	59
13	36	45	67	54
15	38	48	69	56
17	34	46	64	51
19	32	45	63	46
21	32	44	62	46
23	31	43	58	45
25	31	42	52	39
27	30	42	49	38
29	29	41	50	37
31	28	42	49	36
33	27	41	47	36
35	24	39	45	35
40	24	37	39	34
45	21	35	38	33
50	21	33	37	35

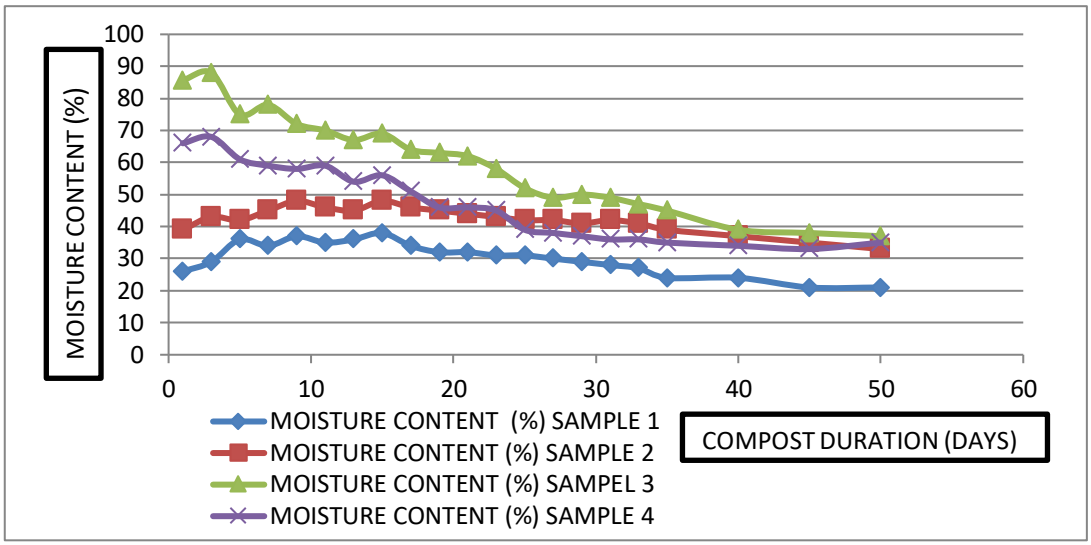

Figure 2: Comparison between moisture content (%) and composting duration (days)

4.1(c) pH Value

The optimum pH value range for the composting process is between 6.5 - 7.5 (Latifah, 2001). Comparison of the average pH value for all samples are shown in Figure 4.2.3. From the graph of the comparison, the range of the average pH of Sample 3 (7.0 - 7.6) during the composting process taking place is much better and is within the range of the optimum pH of 6.5 - 8.5 compared to Sample 4 which has a value range of the average pH is relatively low at between 6.6 -7.1. Meanwhile, the final pH value of the resulting compost for sample 3 after maturation phase is also quite good and approaching the neutral value of 7 compared to Sample 4, is 6.6. However, the resulting compost is also still safe to use on crops as they comply with

the recommended pH range by Day & Shaw (2001) and Sullivan & Miller (2001), respectively 7.5 - 8.5 and 6.0 - 8.0. Overall, it can be concluded that the final pH value of the compost usually depends on several factors such as the organic material used, method of composting, as well as the addition of other materials for pH correction such as calcium oxide and ferric chloride (Sullivan & Miller, 2001). Thus, Sample 3 is better than another based on the pH value of the resulting compost.

Table 4.3(c): pH value

DAYS	pH			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
1	7.7	7.2	7.4	6.9
3	7.5	7	7.3	6.7
5	7.2	7	7.2	6.6
7	7.5	7.2	7.4	6.7
9	7.8	7.6	7.5	6.9
11	7.9	7.8	7.6	7
13	8.1	7.9	7.2	7
15	8.1	7.8	7.2	7
17	8	7.7	7.1	6.9
19	7.9	7.9	7.2	7
21	8	7.6	7.3	7.1
23	8.3	7.9	7.4	6.9
25	8.3	8	7.3	6.9
27	8.2	8.2	7.2	6.8
29	8.1	7.6	7.2	6.9
31	7.9	7.3	7.1	6.8
33	7.9	7.4	7.1	6.7
35	7.9	7.4	7	6.7
40	7.5	7.3	7	6.7
45	7.4	7.2	7	6.6
50	7.4	7.2	7	6.6

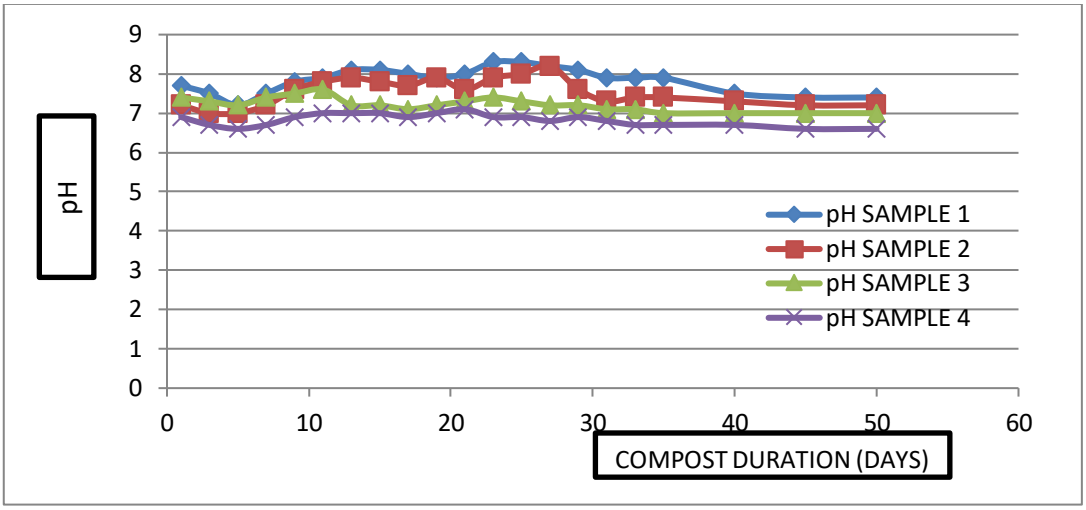

Figure 3: Comparison between pH value and Composting Duration (days)

4.1 (d) C / N Ratio

The ratio of C: N are among the factors that will affect the quality of the compost produced. Previous studies indicated that the ratio of C: N optimal for the survival of the composting process is between 20-25: 1, 25-30 (Huang et.al, 2004) and 26-31 (Latifah, 2001). Figure 4 shows the average ratio of C: N in all samples.

Table 4.1(d): C: N Ratio

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
C : N	36 : 1	34 : 1	26 : 1	43 : 1	32 : 1	39: 1

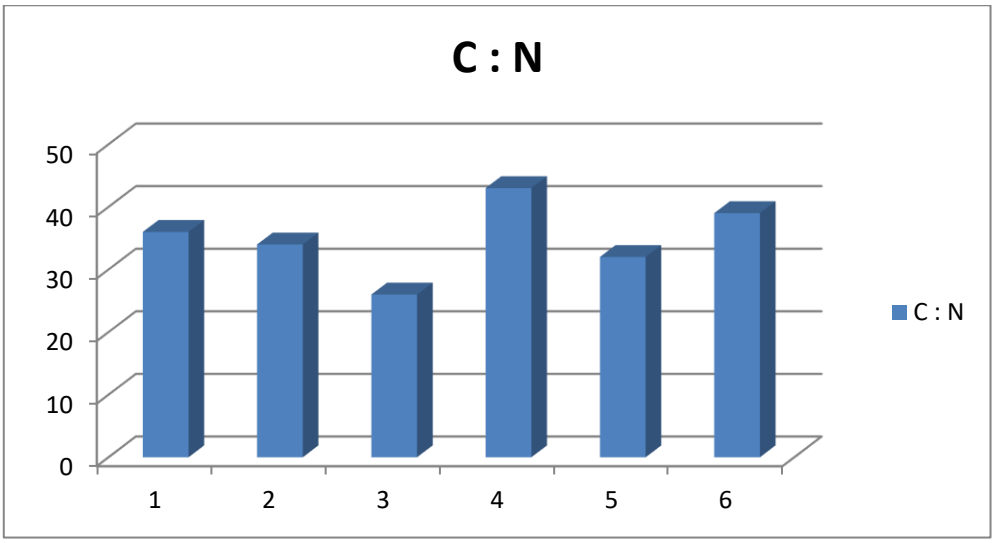

Figure 4: Comparison between C: N ratio and samples

The ratio of C: N high will hinder or slow down the composting process while the ratio C: N low will lead to the production of ammonia that will produce bad odors. From the studies carried out on all samples, was found to range ratio C: N recorded in this study were between 23: 1 -40: 1. Factors such as food waste, which has been shrinking, dry and idle in income causes increased carbon content.

4.2 Nutrient Content Value for Plant Growth

4.2(a) Nitrogen

Microorganisms need nitrogen to synthesize proteins. Figure 4.2.1 shows the nitrogen content in sample 1, 2, 3, 4, 5 and 6 of 1:54%. 1:52%, 2.32%, 0.097% and 4.6% respectively reserving. By comparison, a sample 3 and sample 6 sample seen better than others because there is a higher nitrogen content in the composting process. Although the mechanisms of mixing are performed on all samples, but the loss of nitrogen in the sample is lower than Sample 3. Compost that matured in the open after the active composting process causes a slight decrease in the final phase of maturation.

Table 4.2(a) Nitrogen content

Sample	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Nitrogen(%)	1.536	1.517	2.320	0.097	3.210	4.600

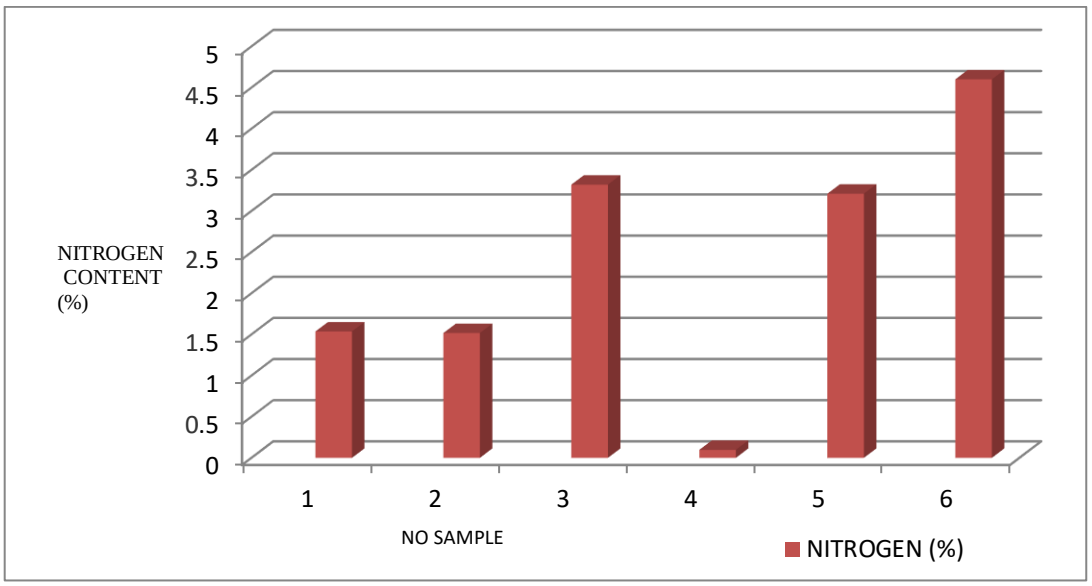

Figure 5: Comparison between nitrogen content (%) and sample.

4.2(b) Potassium

Potassium plays an important role in the growth of root elongation rate of increase, controlling the ion balance, help the synthesis of protein, promotes the enzymatic reaction and help the process of photosynthesis and the formation of food. Figure 6 shows a comparison of the average potassium content of all samples used. In addition, the content potassium in the final compost were also higher in the sample 3 compared to the other samples. By comparison, the sample 3 is viewed better to produce compost end higher potassium content than Samples 1 and 2. Increasing the potassium content may be caused by the aeration mechanism that allows the decomposition of organic materials by aerobic can occur in the compost heap.

Table 4.2(b): Potassium Content

Nutrient	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Potassium (%)	3.23	3.81	6.22	1.45	0.029	0.43

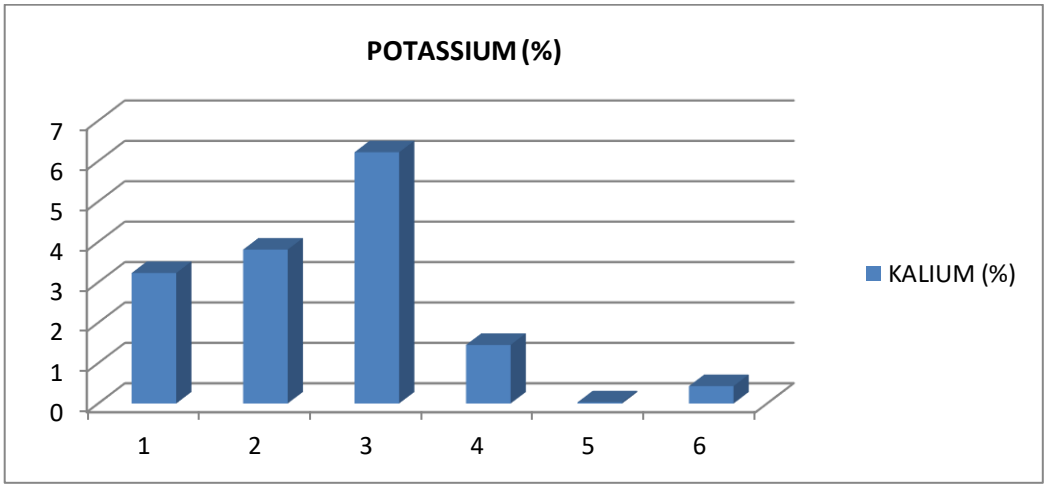

Figure 6: Comparison between potassium (%) and sample

4.2(c) Carbon Content

During the composting process, carbon is a source of energy to the microorganisms necessary for cell growth. Almost most of the absorbed carbon is converted to CO2 by microorganisms during the process of cellular metabolism. Meanwhile, the remaining carbon is converted into a form the cell wall (membrane) and protoplasm. Figure 7 shows the carbon content in the sample 1, 2, 3, 4, 5 and 6, which is 4,426%, 4,426%, 5.218%, 1.413%, 0.003% and 0.036% respectively. Proportionally, Sample 3 seen better from other sample because high carbon content can be observed in the final phase of maturation.

Table 4.2(c) Carbon Content

Nutrient	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Carbon (%)	4.426	4.426	5.218	1.413	0.003	0.036

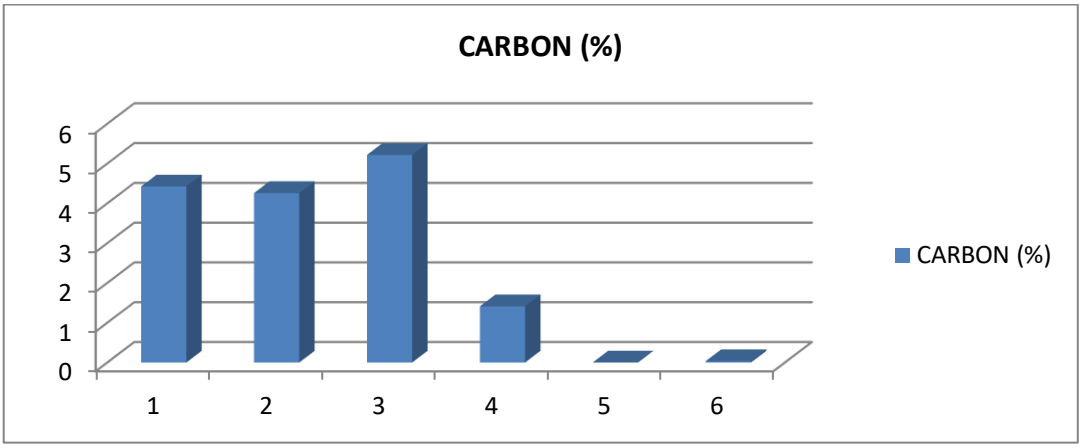

Figure 7: Comparison between carbon content (%) and sample

4.3 Summarize of Nutrient Value

Figure 8 shows a comparison of the nutrient, phosphorus, potassium and carbon against the sample. By comparison, the nutrient value of the sample 3 is higher than the other samples. Based on the final values obtained, found that the value of nutrients in the compost resulting from sample 3 (N = 1,536%, P = 36 934%, K = 6.22%, C = 5.218%) are within the limits of optimum nutrient for use in activities agriculture. This value indicates that the sample 3 is more potent compared to samples 5 and 6, which is a commercially available fertilizer.

Table 4.3: Summarize of Nutrient Value

Nutrient	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Carbon (%)	4.426	4.426	5.218	1.413	0.003	0.036
Kalium / (Potassium) (%)	3.23	3.81	6.22	1.45	0.029	0.43
Phosphorus (%)	16.536	13.623	36.934	11.503	0.96	0.001
Nitrogen(%)	1.536	1.517	2.32	0.097	3.21	4.6

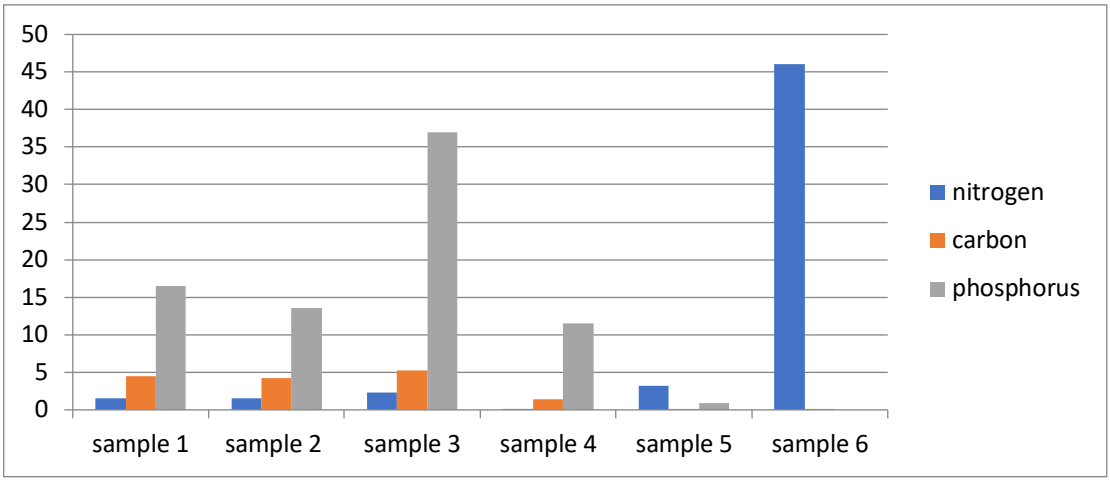

Figure 8: Summarize of Nutrient Value

5. Conclusion

As a conclusion, composting provides nutrients that are good for plant grow which contain a considerable variety of macro and micronutrients. Although often seen as a good source of nitrogen, phosphorous, and potassium, compost also contains micronutrients essential for plant growth. Since compost contains relatively stable sources of organic matter, these nutrients are supplied in a slow-release form. On a pound-by pound basis, large quantities of nutrients are not typically found in compost in comparison to most commercial fertilizers. This research had proven that fish waste is the best material for organic fertilizer because the content of the nitrogen, carbon and potassium in the fish waste are highest reading. Besides, the moisture content in the fish waste is also high. composting also an effective way to reduce greenhouse gasses, save cost and energy use, prolong the landfill life span.

* Nora Ismail. Tel.: +01132555145; fax: 066622026
E-mail address: nora@polipd.edu.my

References

Composting for the Homeowner- University of Illinois Extension a Panikkar et al (2004).
Effects of organic manure and chemical fertilizer on soil fertility and productivity of plant and Raton croops of sugarcane. Archives of Agronomy and Soil Science 51, 325-334 Bokhtiar et al (2005) Bokhtiar, S.M & Sakurai K (2005).
The composting process dairy compost production L Chen (2012)
Sourth Korea food waste solution: you waste, you pay. Common Wealth Mag. (Accessed 22.11.14) Lisa, H, April 2013
A preliminary compative study of three manure composting system. Compost science and utilization. Lopez real, J.and M Baptista (2008)
Manipadma, J 2013. India Food Security Rots in Storage (Accessed 09.09.14).
http:/www.ipsnews.net/2013/06/indias-food-security-rots-in storage.
Review the behaviour and environmental impact of contaminants in fertilizers Mclaughin, M.J, Tiller, K.G, Naidu, R, Steven D.P
Physical and Chemical Characteristic of solid waste Disposel at Taman Beringin Landfill, Kuala Lumpur. Faculty of Environment Studies, Universiti Putra Malaysia (UPM). Mohd Nazeri Salleh and Mohd Nasir Hassan (2005).
Chapter 1: Compost Quality". In Radovich, T; Arancon, N. Tea Time in the Tropics - a handbook for compost tea production and use(PDF). College of Tropical Agriculture and Human Resources, University of Hawaii. pp. 8–16. Radovich, T; Hue, N; Pant, A (2011)
The omnivore's dilemma: A natural history offour meals. New York, NY: Penguin Group. Pollan, M. (2006).
Romania to Develop National Strategy to Reduce Food Waste: Minister. http://news.xinhuanet.com/english/world/2014-04/01/c_133230744.htm (Accessed 03.09.14) Yan, 2014.