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Vermicomposting of Food Waste

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Abstract – The use of food waste recycling concept can be an interesting option to reduce the use of landfill. This strategy is more environmental friendly, cheap and fast if proper management to treat the food waste is applied. Nowadays, the concept of recycling is not well practiced among the community. In this study, vermicomposting is introduced as an alternative of the food waste recycling. Vermicomposting consists of the use of earthworms to break down the food waste. In this vermicomposting treatment, the nightcrawler earthworm are used to treat the food waste. The food was collected from UTHM cafe. The experiment consist of peat soil as a base, earthworms and the food waste. The pH and moisture content of each container were controlled at 7.0 to 7.2 and 60 to 80 % to maintain the favorable environment condition for the earthworms. The mass of the sample will be measured in three days time after exposure to the earthworm. The vermicomposting study was taken about two weeks time. After the treatment, the soil sample wastested for nitrogen (N), Phosphorus (P), and Potassium (K) concentration. Based on the results obtained, it show that vermicomposting has reduced the mass of tested sample and the concentration of N, P, and K for the soil is greater than the chemical fertilizer. Therefore, vermicomposting is a promising alternative treatment of food waste as it is more ecofriendly.

Keywords: food waste,nightcrawler, vermicomposting

1. Introduction

Municipal solid waste (MSW) is a solid waste generated from the household (domestic waste) and also commercial waste which is collected in specific areas. MSW in Malaysia involves the disposal of approximately 98% of the total waste to landfills [1]. The local authorities and waste management consortia have to handle approximately 17,000 tonnes of MSW everyday throughout the country. MSW generation depends on the size of township and level of socio economic, that as low as 45 tonnes daily of MSW are generated in Kluang (a town in the southern part of Peninsular Malaysia) to as high as 3000 tonnes daily in Kuala Lumpur . It is expected that the amount of solid waste generated in Kuala Lumpur reach double in the next twenty years; from 3.2 million tons a year today, to 7.7 million tons a year. The largest sources are household waste followed by industrial and commercial waste [1]. One of the MSW component is food waste.

With a rising level of prosperity in industrialized countries, an increasing number of products and services are being produced and consumed. This development is reflected in the amount of waste generated. Data from the year 1991 up to 2001 shows that the total amount of waste generated in European countries increased from 420 kg/cap/year up to 530 kg/cap/year [2]. Therefore, by a decade, the amount of waste generated had increased up to 20%.

The food waste includes uneaten food and food preparation leftovers from residences, commercial establishments such as restaurants, institutional sources like school cafeterias, and industrial sources like factory lunchrooms. The amount of food waste generated in California was estimated to be about 5.6 million per year of wet tons and 2.2 million per year of dry tons [3]. In Taiwan, food waste is estimated to be about 20-30% of the household garbage [4].

The food waste mostly will be disposed in landfills. However, the disposal of food waste by landfill requires large-scale areas and incineration of wet food waste consumes a lot of energy. Food waste recycling possibly reduces the costs of waste treatments, odors and refuses from landfills, and air pollutants from incineration [4].

With increasing of development, the free space to build the landfill will reduce and in future, there will be no space for landfill. The amount of food waste generated increase as the population size increase. Emissions from municipal landfill sites can potentially be detrimental to both local and global air quality. Landfill gas consists of up to 65% v/v methane and 35% v/v carbon dioxide, both of which are considered to be greenhouse gases contributing to global climate change [5]. Therefore, vermicomposting for food waste recycling is an alternative as it is environmental safely, cost effective and hygienic [6].

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Vermicomposting, or composting with earthworms, is an excellent technique for recycling food waste [7]. Vermicomposting consist of the use of earthworms to break down the food waste particles. The chronological of vermicomposting is the food waste will be stored in a pot together with a soil. The soil will be in base medium. The controlled materials of the vermicomposting are the types of earthworms used as well as the types of food waste. It is observed that when the earthworms have broken down the food waste particles, the mass of the food waste measured after will be much lower than before [6].

Vermicomposting can be used in potting soil mixes for house plants and as a top dressing for lawns. Screened vermicomposting combined with potting soil mixes make an excellent medium for starting young seedlings. Vermicomposting also makes an excellent mulch and soil conditioner for home garden. Red worms in vermicomposting act in a similar fashion, breaking down food wastes and other organic residues into nutrients-rich compost. Table 1 shows the chemical characteristic comparison between garden compost and vermicomposting [8].

Table 1: Chemical characteristic of garden compost and vermicomposting [8]

Parameter*	**Garden compost**	**Vermicomposting**
pH	7.80	6.80
EC (mmhos/cm)**	3.60	11.70
Total Kjeldahl nitrogen (%)***	0.80	1.94
Nitrate nitrogen (ppm)****	156.50	902.20
Phosphorus (%)	0.35	0.47
Potassium (%)	0.48	0.70
Calcium (%)	2.27	4.40
Sodium (%)	<.01	0.02
Magnesium (%)	0.57	0.46
Iron (ppm)	11690.00	7563.00
Zinc (ppm)	128.00	278.00
Manganese (ppm)	414.00	475.00
Copper (ppm)	17.00	27.00
Boron (ppm)	25.00	34.00
Aluminium (ppm)	7380.00	7012.00

* Unit- **ppm** = parts per million **mmhos/cm** = millimhos per centimeter
** EC = electrical conductivity is a measure (millimhos per centimeter) of the relative salinity of soil or the amount of soluble salts it contains.
*** Kjeldahl nitrogen = is a measure of the total percentage of nitrogen in the sample including that in the organic matter.
**** Nitrate nitrogen = that nitrogen in the sample that is immediately available for plant uptake by the roots.

The earthworm species were evaluated based on their ability to tolerate a wide range of environmental conditions and fluctuations, handling and disruption to the worm bed and for their growth and breeding rate. Earthworm species with a short generation time meaning a relatively short life span and rapid growth and reproductive rate have been identified as most effective due in large part to the high concentration of juvenile worms present in their populations. Juvenile worms are voracious consumers, keeping the processing rate of the system high and ensuring an ongoing succession of young worms. The two common earthworms used in the vermicomposting are *Eisenia Fetida / Eisenia Andreii* (common name, Red Worm) and *Eudrilus Eugeniae* (common name, African nightcrawler) [9]. Table 2 shows the characteristics of Red Worm and African nightcrawler respectively. The table shows that both earthworms have different characteristic biologically but both earthworms tolerate with the same range of ideal temperature.

Table 2: The characteristic of *Eisenia Fetida* and *Eudrilus Eugeniae* [9]

Characteristic	*Eudrilus Eugeniae*	*Eisenia Fetida*
Temperature range	Minimum; 45º F, maximum; 90º F, ideal range; 70 º F to 80 º F.	Minimum; 38º F, maximum; 88º F, ideal range; 70 º F to 80 º F.
Reproductive rate	Approximately 7 young per worm per week under ideal conditions.	Approximately 10 young per worm per week under ideal conditions.
Average number of young per cocoon	Approximately two.	Approximately three.
Time to emergence from the cocoon	Approximately 15 to 30 days under ideal conditions.	Approximately 30 to 75 days under ideal conditions.
Time to sexual maturity	Approximately 30 to 95 days under ideal conditions	Approximately 85 to 150 days under ideal conditions

This study is carried out to determine the concentration of nitrogen (N), phosphorus (P), and potassium (K) of the soil after the vermicomposting and to study the capability of soil from vermicomposting as a fertilizer.

2.0 Materials and Methods

Preparation of the favorable environment condition for the earthworms

The earthworm, *nightcrawler* was bought from the commercial representative of vermicomposting. A plastic container with the size approximately 18 cm x 18 cm was used in this vermicomposting process. On top of the container, ventilation was provided for the earthworm. Then, it was covered with a mosquito net to protect from flies and other disturbances. The completed plastic container weigh was measured. The design includes 380 g of peat soil and 10 g of earthworms. The process of substrate was started by putting the 380 g of soil into the plastic container. Then, the non-chloride water was used to get the range between 60 to 80% of moisture content of the peat soil by using the moisture analyzer. The non-chloride water was prepared by leaving the pure water for one to two days. The completed non-chloride water was left for specific days then was put in the spray bottle.

The pH value of the peat soil was determined using pH meter. The pH of the peat soil was adjusted to be in the range of 7.0 to 7.3 using 25% ammonia solution. After the moisture content and the pH value needed were determined, nightcrawler earthworms were put into the plastic container. Once the earthworm penetrates into the soil, a favorable environment condition for the earthworm is reached. Then, the rest of the earthworms are put into the plastic container until it reached 10 g of earthworm. The total weigh of the plastic container including the substrate components were measured and recorded as a day one. This treatment was done for every species of worm and control container. The pH value and the moisture content were controlled over the three days of experiment.

Collection of food waste

The food waste used in this study was taken at the AKED café in the UTHM. A container with the size of 75 x 50 cm was provided to collect the food waste. This collection process only took a day as in this vermicomposting experiment, only fresh food waste was used. The food waste mass was checked until the mass about 2 to 4 kilograms.

The food waste from the container was washed first with normal water. This process to remove excess oils contain in the food waste taken. The oils will prevent the earthworms from eating the food waste by reducing the ventilation for the earthworms in the test container. Besides, the oily food waste will be harmful to the earthworms because it may cause the earthworms to die.

After the washing process was completed, the food waste was separated in tray for drying process. The tray was placed in an oven for drying process at a constant temperature of 60℃. The drying process took 2 to 3 days for a complete dry process. This drying process is needed to remove water in the food waste and to get the food waste which have a constant in mass and volume.

The dried food waste process is cut into small cubes The food provided to the earthworms must be soft and small in size in order for them to be consumed easily.

Preparation of vermicomposting sample

Four containers for vermicomposting were prepared and two containers act as control. For vermicomposting, 100 g of prepared food waste were put into each of the four containers. The food waste added was mixed together with the substrate containing peat soil. The reason for mixing is to provide the homogenity of the components between substrates and the food waste. Therefore, the earthworms will not only focus on specific area in eating process. For the control, no food waste was added.

All containers were covered with the mosquito net to prevent from the insects and flies and put under the roof to protect from rain and the sun. During night, a lamp was provided to give an extra lighting to the earthworms. This process is needed to ensure the earthworms have a favorable environment and will stay in the soil.

Vermicomposting species observation

The observation procedure were done in two phases; the first part is the observation on the mass of each container and the second part is to maintain the pH value and the moisture content of each container. The observation process was done over two weeks time with the checking of mass, pH and moisture content for every three days. For the mass measurement, a same analytical balance was used to get the uniform data. Moisture analyzer was used to check the moisture content and maintained the moisture content around 60 to 80%. The pH value was checked with the pH meter and the pH should be maintained around 7.0 to 7.3.

Chemical analysis

The soil from food waste and control experiment were digested and diluted before chemical analyses process.

Sample Digestion

In the first step of digestion process, the vessels were prepared for microwave digestion. The vessels were washed using ultra purification water to remove any unwanted contaminants. Then, the vessels were dried before the next procedure.

0.5 g of soil from each container was put into the each vessel. 6.0 mL of nitric acid, 3.0 mL of Hydrofluoric acid and 2.0 mL of hydrochloric acid were put in each vessel. For a control pressure vessel, distilled water was put until it is in the same level with the other vessels. All the vessels were capped and tighten by using the key. Then, the entire vessels were put in the vessel holder and transferred to the microwave digestion machine. In the screen, soil was chosen as the type of material that needs to be digested. The machine was set for 40 minutes time reaction period based on the program chosen.

After thistime expired, the microwave was slowly opened and the key was loosen for each vessel to release the pressure in the machine. The released pressure processes took 15 minutes. Then, a beaker was taken together with boric acid powder. The boric acid powder was put with the distilled water until the solution was saturated. The estimation for preparing the boric acid solution was determined by using Equation 3.1:

1.0 mL of Hydrofluoric acid = 6.0 ml of Boric acid solution (3.1)

Then, 18.0 mL of boric acid solution were put into each vessel. The vessels were capped and tighten. The capped vessels were put in the holder and transferred into the microwave. The program was selected for 15 minutes. Once the time expires, the complete digestion was achived.

Test of Nitrogen, Phosphorus and Potassium

DR 5000 spectrofotometer was used to analyze the concentration value of nitrogen (N) and phosphorus (P), while Atomic Absorption Spectroscopy (AAS) was used to get the concentration of potassium (K).

2. Results and Discussions

Reduction of mass

The observation of the reduction of mass in each container had been observed over two weeks. The data of mass collected in each three day observation and is shown in Figure 1. Figure 1 shows that the mass reduction of each container against time period.

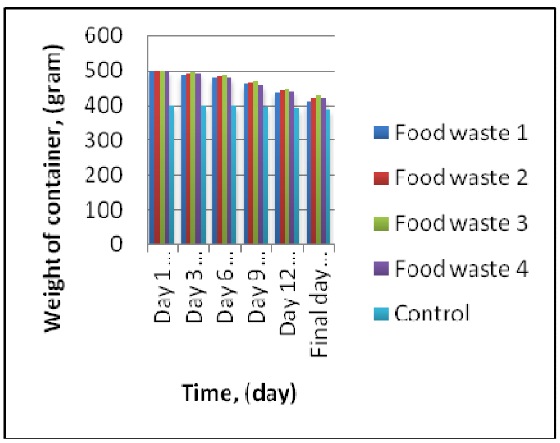

Figure 1: The weight recorded in vermicomposting study

Figure 1 shows that all containers reduced in weight for each of exposure day as compared to control experiments. After two weeks of vermicomposting, the containers show the highest reduction.

Percentage of weight reduction

The percentage of weight reduction shows the pattern of the reduction after treated with vermicomposting from the early stage of the study until the final day. The pattern of the reduction represent as earthworm's eating process. Theoretically, the nutrient that supports microbial activity is potentially suitable food for earthworms. The food waste contains high amount of nutrients as it is an organic base. Figure 2 indicates that the pattern of the reduction of weight.

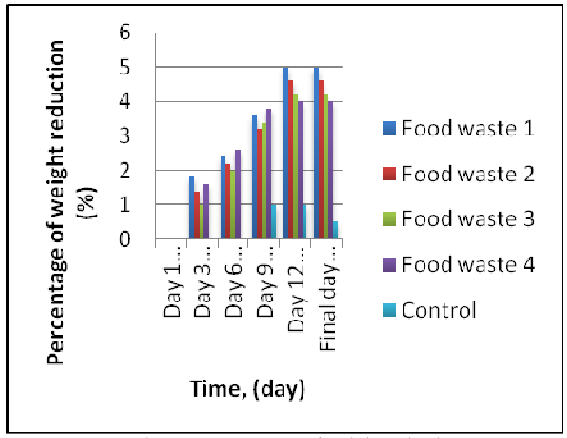

Figure 2: Percentage of weight reduction

The graph in Figure 2 shows that the increment in the percentage of weight reduction in each container. From the analysis, it can be concluded that the mean increment of the percentage of reduction for day one, day three, day six, day nine, day 12, and final day are 0, 1.5, 2.3, 3.5, 4.5, and 4.5 % respectively. The increment shows that this vermicomposting study represent the theory of the mass reduction in vermicomposting [6]. On day one, there is no change in mass. The earthworms remain in the container without doing any eating process. On day three and day six, the mean of the mass reduction are 1.5 % and 2.3 % respectively. At this stage, the food waste treated start to decay and produce the microbe. After the microbes exist in the food waste, the earthworms will start to eat the food waste [6]. As consequences, the reduction of the weight increased.

Requirement of pH value

The pH value recorded during the first day was controlled within the range of 7.0 to 7.3. The pH value needs to be maintained at neutral to provide the favorable environment in each container for the earthworms to live. Favorable environment is important as it help the earthworm to stay healthy in the container and eat the food waste. Sudden change of pH value will forces the earthworms to dormant and sometimes kills them outright, thus reducing the availability of vermicomposting treatment. Figure 3 shows pH value of each container during vermicomposting process.

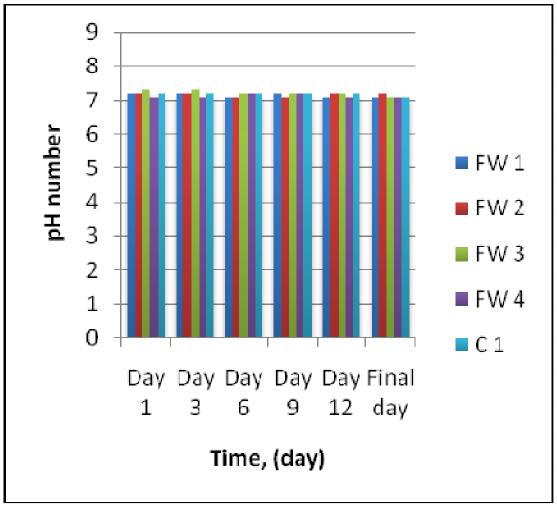

Figure. 3: The pH value recorded during vermicomposting

Requirement of moisture content

The moisture content recorded in the first day will be controlled within the range of 60 to 80 %. Moisture is critical to the survival of all earthworms because the moisture within the earthworm's body that gives the shape enables it to move and aids in the earthworm ability to absorb oxygen. To facilitate the absorption of oxygen, the skin of earthworm should be thin and permeable. Therefore, the moisture within the body cavity eases to evaporate off particularly in dry environments. The moisture range for this type of earthworm, *nightcrawlers* will ensure the absorption of moisture and continue for the vermicomposting treatment process. The data of the moisture content is shown in Figure 4.

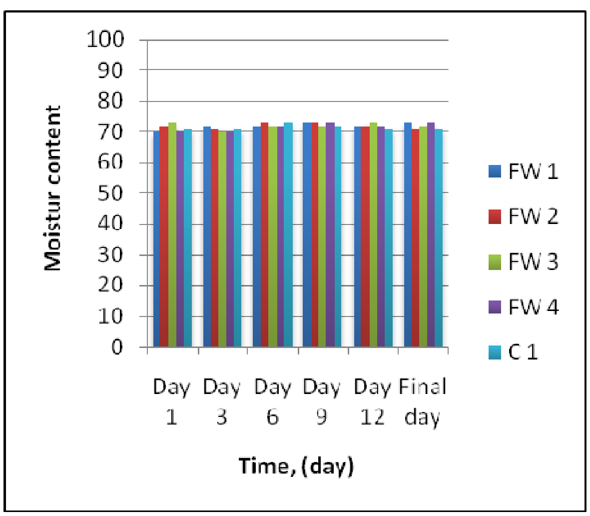

Figure. 4: The moisture content recorded in vermicomposting

Concentration of Nitrogen

Table 3 and Figure 5 show the comparison of concentration of Nitrogen between the food waste containers with the control.

Table 3: Concentration of Nitrogen obtained

Container	Sample No.	N (mg/L)	Mean, N (mg/L) x 100 (dilution factor)
Food waste 1	1	20	1800
	2	16	
	3	18	
Food waste 2	4	17	1733
	5	17	
	6	18	
Food waste 3	7	20	2200
	8	22	
	9	24	
Food waste 4	10	21	2133
	11	23	
	12	20	
Control	13	10	867
	14	7	
	15	9	

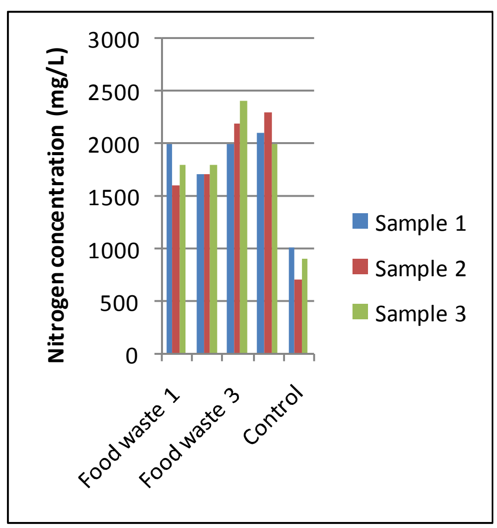

Figure.5: Concentration of Nitrogen

The results show that concentration of nitrogen in vermicomposting process is higher as compared to control experiment. This result show that the decomposition of food waste through vermicomposting provide nitrogen for the soil sample.

Concentration of Phosphorus

Table 4 and Figure 6 show the comparison of concentration of phosphorus between the food waste containers with the control.

Table 4: Concentration of Phosphorus

Container	Sample No.	PO4^{3-} (mg/L)	Mean, PO4^{3-} (mg/L) x 100 (dilution factor)
Food waste 1	1	2.62	260
	2	2.76	
	3	2.43	
Food waste 2	4	2.53	261
	5	2.69	
	6	2.60	
Food waste 3	7	3.00	320
	8	3.26	
	9	3.35	
Food waste 4	10	2.97	297
	11	3.02	
	12	2.93	
Control	13	1.32	129
	14	1.28	
	15	1.26	

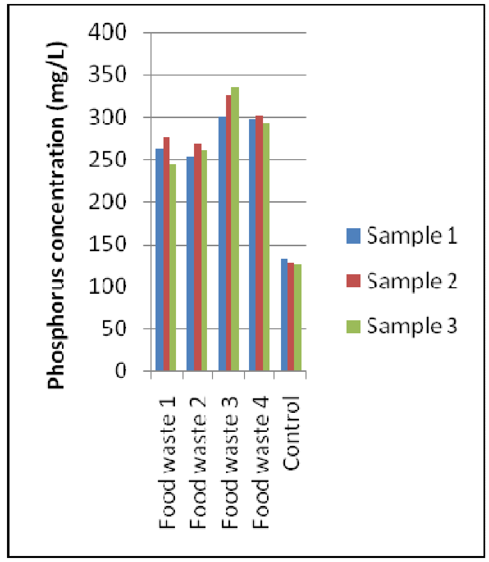

Figure 6: Concentration of Phosphorus

The results show that concentration of phosphorus in vermicomposting process is higher as compared to control experiment. Decomposition of food waste using earthworm resulted in production of phosphorus in the composting process.

Concentration of Potassium

Table 5 and Figure 7 show the comparison concentration of potassium between the food waste containers with the control.

Table 5: Concentration of Potassium obtained

Container	Sample No.	K (mg/L)	Mean, K (mg/L) x 100 (dilution factor)
Food waste 1	1	1.227	117
	2	1.279	
	3	1.003	
Food waste 2	4	1.937	184
	5	1.748	
	6	~~1.514~~	
Food waste 3	7	1.209	140
	8	1.266	
	9	1.719	
Food waste 4	10	1.066	103
	11	1.021	
	12	0.995	
Control	13	0.538	55
	14	0.548	
	15	0.553	

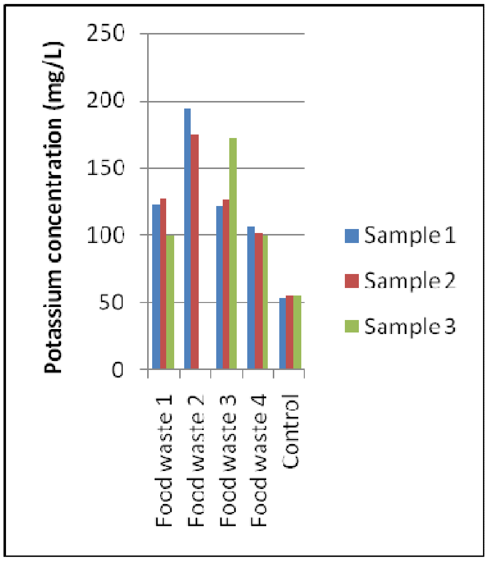

Figure 7: Concentration of Potassium

The results show that concentration of Phosphorus in vermicomposting process is higher as compared to control experiment.

The results show that concentration of nitrogen, phosphorus and kalium in the experiment are higher than the control. During the process of vermicomposting, the earthworms break down the food waste as organic material and use the decomposition product to supply them energy. They also release simple organic (N and P) and inorganic such as mineral salt (K) [10].

Comparison of concentration between food waste and control experiment

Table 6 shows the percentage of the differences between the food waste and control container for each concentration tested. The percentage is between 55 to 60 % indicated the difference amount of the concentration in this vermicomposting research. The difference in concentration occurs as in the food waste container, the content of nutrient is greater than the control container because of the presence of food waste added. When the microbe occurs in the food waste after several days, the microbe will be the food for the earthworm to eat. Therefore, the nutrient of the soil will increase as the earthworms doing the eating process.

Table 6: Comparison of concentrations between food waste and control experiment

Parameter	Food waste	Control	Percentage difference (%)
Nitrogen (N)	1967	867	**55**
Phosphorus (P)	285	129	**56**
Potassium (K)	136	55	**60**

Comparison of previous studies with vermicomposting of food waste study

Two previous studies by Kaviraj & Sharma (2003) [4] and Suthar & Singh (2008) [10] were reviewed and compared with the result obtained in this study. There are three parameters; nitrogen (N), phosphorus (P) and potassium (K) based on each study characteristic as shown in Table 7, 8 and 9 respectively.

Table 7: Previous study by Suthar & Singh (2008)

Unit	**a) *Perionyx sansibaricus***		
	N	P	K
(g/kg)	20.36	6.35	9.60
(%)	2.040	0.635	0.96
	b) *Perionyx excavates*		
(g/kg)	19.26	6.13	9.55
(%)	1.926	0.613	0.955

Table 8: Previous study by Kaviraj & Sharma (2003)

Unit	**a) *Eisenia fetida***		
	N	P	K
(%)	0.39	-	0.22
	b) *Lumbricus mauritii*		
(%)	0.36	-	0.21

Table 9: This vermicomposting of food waste research

Unit	*Nightcrawler*		
	N	P	K
(mg/L)	1967	285	136
(%)	0.197	0.0285	0.0136

Based on the Table 10 and Figure 8, there are differences between each result from both cases study with this research. For the case study one in Suthar & Singh (2008) [10], the difference for nitrogen (N), phosphorus (P) and potassium (K) is about 95 % in the data of concentration. Then, for the case study two in Kaviraj & Sharma (2003) [6], it is estimated that the difference of nitrogen (N) and potassium (K) is about 97 % of the concentration data.

The differences indicated the large margin between the cases study with this research but constant in percentage. Therefore, there are three major factors that give the significant in this result. The first factor is the usage of cow dung in setting up the favorable environment condition for the earthworms. Second factor caused by the type of the earthworms used in each vermicomposting study. Besides, in each vermicomposting studies, the time period takes to run the test is also different. Therefore, time factor also can be as a factor for the difference in result.

Table 10: The comparison of concentration between vermicomposting of food waste study with both previous studies

Parameter	**Suthar & Singh (2008)**		**Kaviraj & Sharma (2003)**		**This research**
	Perionyx sansibaricus	*Perionyx excavates*	*Eisenia fetida*	*Lumbricus mauritii*	*Nightcrawler*
	150 days		**42 days**		**14 days**
Nitrogen (%)	2.04	1.926	0.39	0.36	0.197
Phosphorus (%)	0.635	0.613	-	-	0.0285
Potassium (%)	0.96	0.955	0.22	0.21	0.0136

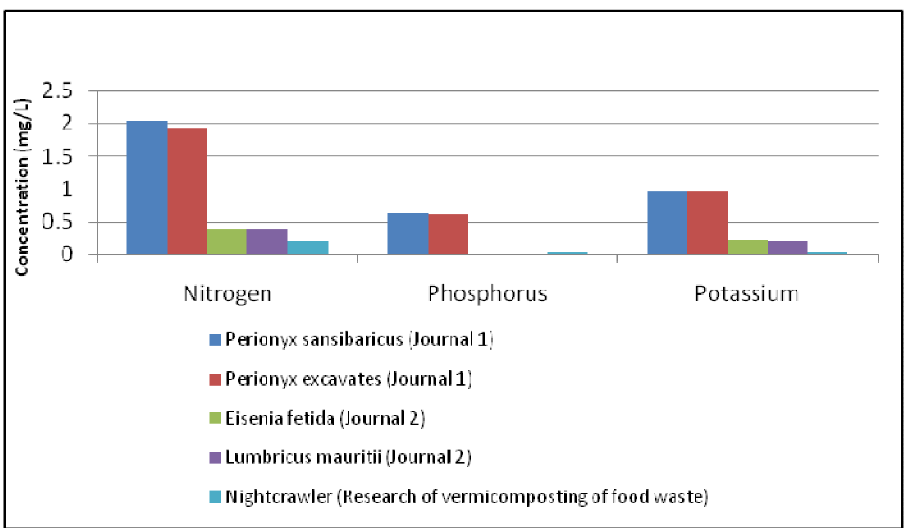

Figure. 8: The comparison of concentration between vermicomposting of food waste study with both previous studies

The use of cow dung

Cow dung is a nitrogen rich material and is of economic importance as fertilizer, feed supplement or as energy sources. Besides, cow dung also high in carbon and nitrogen (C:N) ratio. Adding the cow dung in the process of vermicomposting set up will provide an extra supplement in nitrogen, phosphorus and potassium to the vermicomposting test itself. Therefore, the use of cow dung in both previous studies gives the additional concentration value of nitrogen, phosphorus and potassium by 95% and 97%.

Type of earthworms used

The earthworms used in the both cases studies are in the group of Red Worm. Red Worm is the most common group in vermicomposting treatment as it provided the best for the treatment. Besides, the Red Worm are also known as versatile vermicomposting earthworms as It has a very wide temperature tolerance, will happily consume a wide variety of organic waste materials, has a relatively high rate of reproduction, and is just generally a highly adaptable worm. Therefore, the difference in the concentration of nitrogen, phosphorus and potassium between both previous study and this research because of the Red Worm used is versatile to the surrounding where it can match with high and low range of temperature. Thus, it provides the rapid process in the vermicomposting.

Time period for vermicomposting experiment

The time taken to run the vermicomposting for case study one and two are 150 days and 42 days. On the other side, in this research, it only takes about 14 days which is in two weeks time period. Therefore, the time factor can be considered as one of the factor that affect the differences in concentration result as longer time period taken provide a long treatment process. As a consequence, the concentration value for nitrogen, phosphorus and potassium will increase perpendicular to the time. Thus, for a longer time taken in vermicomposting, a greater value of nitrogen, phosphorus and potassium concentration will obtained.

Comparison of concentration of Nitrogen, Phosphorus and Potassium with chemical fertilizer

Table 11 shows the ratio of nitrogen, phosphorus and potassium in this vermicomposting. From the calculation made, we can see that the Nitrogen, Phosphorus and Potassium composition (N-P-K composition) is 14-2-1. The Table 12 and Figure 9 shows the comparison of N-P-K composition between this vermicomposting studied with the chemical fertilizer.

Table 11: This vermicomposting of food waste research

Unit	*Nightcrawler*		
	N	P	K
Milligram per liter, (mg/L)	1967	285	136
Percentage, (%)	0.197	0.0285	0.0136

Table 12: Comparison of N-P-K composition between vermicomposting of food waste and chemical fertilizer

Type of N-P-K composition	**N-P-K composition**		
	N	**P**	**K**
Vermicomposting	14	2	1
Chemical fertilizer	1	1	1

From Table 17 and Figure 9, there is a difference between vermicomposting and chemical fertilizer for nitrogen, phosphorus and potassium with 93%, 50% and 0% of N-P-K composition ratio respectively. The results, show that the vermicomposting contains of greater in nitrogen and phosphorus but remains the same number for the potassium.

Nitrogen has traditionally been considered as one of the most important plant nutrients. It is an essential component of the proteins that build cell material and plant tissue. Of all the major plant nutrients, N is often the most important determinant of plant growth and crop yield. Plants lacking N show stunted growth and yellowish leaves. Plant growth and crop yield usually increase when N is added, despite the presence of N in soils. This is because most of the N in soils is stored within the soil humus in forms that plants cannot access. The quantity of nitrogen supplied by the soil is determined by the quantity of nitrogen released from the soil organic matter, that released by decomposition of residues of the previous crop, any nitrogen supplied by previous applications of organic waste, and any nitrogen carried over from previous fertilizer application. Therefore, we can see that the soil from the vermicomposting is better in terms of fertilizer usage as it contains the greater number of nitrogen for plants to growth.

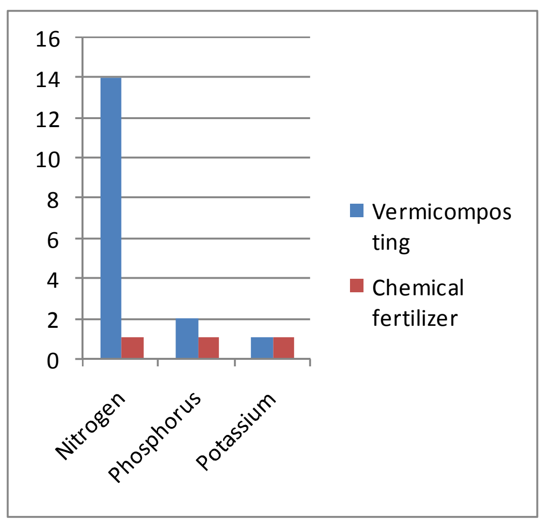

Figure 9: Comparison of N-P-K composition between vermicomposting of food waste and chemical fertilizer

Phosphorus is an essential nutrient both as a part of several key plant structure compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants. Phosphorus is noted especially for its role in capturing and converting the sun's energy into useful plant compounds. Phosphorus is a vital component of ATP (Adenosine Triphosphate), the "energy unit" of plants. ATP forms during photosynthesis, has phosphorus in its structure, and processes from the beginning of seedling growth through to the formation of grain and maturity. Thus phosphorus is essential for the general health and vigor of all plants. Some specific growth factors that have been associated with phosphorus are: stimulated root development, increased stalk and stem strength, improved flower formation and seed production, more uniform and earlier crop maturity, increased nitrogen N-fixing capacity of legumes, improvements in crop quality, and increased resistance to plant diseases. Therefore, the increment of 50% in Phosphorus composition ratio in vermicomposting shows that the soil is better to be as an organic fertilizer for plants growth.

3. Conclusion

In this vermicomposting study, the concentration of nitrogen, phosphorus and potassium for food waste container is greater than the control container. The difference between food waste and control container obtained for nitrogen, phosphorus and potassium are 55%, 56% and 60% of concentration.

The differences of the concentration indicated that presence of food waste added increase the amount of nitrogen, phosphorus and potassium. Food waste provides microbial activity that produce microbes. Microbes will be eaten by the earthworms to sustain its life. From the result of reduction of weight, we can conclude that the presence of microbes happen in several days. The increment in percentage of reduction weight shows that vermicomposting study can be one of the methods for food waste treatment. Then, from this feeding process, it can be concluded that the increase of the concentration of nitrogen, phosphorus and potassium is due to the earthworms feeding activity.

The results show that there is about 55 to 60 % concentration of nitrogen, phosphorus and potassium between food waste and control container. The concentrations indicated the composition in fertilizer. Therefore, there is probability the soil from this vermicomposting study can be as a fertilizer as the concentration of nitrogen, phosphorus and potassium for food waste container is greater than the control container.

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