# An Evaluation on Compost Quality Produced in UTP Campus

By

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**CERTIFICATION OF APPROVAL**

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Civil Engineering Programme
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Approved by,

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**CERTIFICATION OF ORIGINALITY**

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

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# ABSTRACT

UTP is producing compost or organic fertilizer from the food waste that generated by cafeterias in UTP. A few tests have to be carried out to analyze the content of the compost and to determine the quality of the compost, whether it is suitable and safe to be used as fertilizer. Compost quality standard documents from Canada and United States are the main references in determining the quality of compost produced in UTP. There are 6 criteria that being considered in determining the quality of compost produced in UTP which are maturity of the compost, heavy metal content, foreign matter content, pathogens content, constituents of the compost which indicates the percent of CHNS, NPK (Nitrogen, Phosphorus, Potassium) content of the compost and moisture content. Maturity of compost is determined based on the germination of radish seeds and bean sprout seeds in the compost and C/N ratio of the compost. Germination of those two types of seeds is carried out in three different conditions which are in 100 % soil, 100 % compost and in 50 % soil and 50 % compost. The content of seven types of heavy metal which are lead, cadmium, copper, chromium, zinc, nickel and boron were tested on the compost. Any matters that are greater than 2 mm in dimension that results from human intervention and having organic or inorganic constituents such as metal, glass and synthetic polymers (plastic, rubber) are considered as foreign matters. Quanti-Tray / 2000 are the device that being used to determine the amount of bacteria in 100 ml of compost sample using IDEXX-d substrate reagent. NPK content is determined by carrying out powder pillow test. Moisture content of the compost is determined using the moisture analyzer. For maturity aspect, germination of both types of seeds only occurred in 100% soil. C/N ratio of the compost is 17.67. The content of heavy metal in the compost are within the allowable limit. For foreign matter analysis, compost produced in UTP contains no man-made foreign matter such as glass, plastic, metal and stones. For pathogens analysis, the compost does not contain *E.coli*. The amount of NPK in compost produced in UTP is low compared to the standard and moisture content of the compost is 54.65 %.


Keywords: compost, food waste, compost quality standard, maturity, heavy metal, pathogen

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Compost obtained from the organic fraction of municipal solid waste such as food waste, can sometimes is used effectively as an organic fertilizer on agricultural soil. The high content of stabilized organic matter and the presence of nutrients of good quality compost are a guarantee of agronomic advantages and at the same time, the use of compost makes the reuse of organic wastes possible and has numerous advantages (F. Pinamonti, 1997). An increase in soil organic matter and nutrient availability after compost application has been observed by many. The use of compost is also beneficial for the soil's physical properties: increased porosity, structural stability, available water content and reduction of erosion (Guidi G, 1988).

Currently Universiti Teknologi PETRONAS (UTP) is generating more than one (1) tone of food waste daily which is sent to a dumping site at Tanjung Tualang, Perak for disposal. The disadvantages of uncontrolled waste disposal are aesthetically displeasing, unsanitary and providing breeding place for fly and rats. On the other hand, uncontrolled disposal of solid waste has been discouraged by the Local Authorities and Department of Environment, Malaysia. Therefore, composting which is biological decomposition of organic waste into a usable product (humus) is proposed to be applied in the campus. Composting is a natural process that occurs when there is sufficient oxygen and an optimum range of moisture contents. The final product will be used as a soil amendment in the campus green area to reload the rich organic matter in the soil. Compost not only can improve crop growth, it also has many roadside applications such as erosion control, or backfill. Landscapers, topsoil blenders and many other fields look for quality compost to use in businesses. Thus, the surplus is sold to public.

Universiti Teknologi PETRONAS (UTP) purchased a composting machine which is known as 'Compostech' from a company by the name of Sumber Handal Sdn. Bhd., a Malaysian based entity, created to bring ecologically sounds solutions for waste disposal especially food waste. It has come up with the Compostech machine, claimed to be able to decompose or degrade food within 24 hours. Compostech technology consists of mixing bacteria with food waste materials inside the specially designed and tailor-made compostech machine. The food waste is converted into organic compost / animal feed. The food waste is processed in a chamber inside the machine, at specific and controlled temperature and humidity levels (Sumber Handal Sdn.Bhd., 2010).

This machine functions in a controlled environment where it has ability to produce and control internal heat. The fan blade facilitates the mixing process of the content in the machine. Microbial inoculums contained in a combination of saw dust and charcoal carrier is used to enhance the decomposition process. The compostech machine is fully automatic and run 24 hours per day and 7 days a week. The machine stops automatically during rest times that can vary according to the size of the machine. The mixing process of food waste and effective microbes produces a small sound and a very light smell but not a bad smell. In UTP, the machine is being placed at the sewage treatment plant area where all the food waste is being collected. The daily production capacity of the organic compost fertilizer is around 150 kg (Sumber Handal Sdn.Bhd., 2010).

Compostech uses effective microbe (bacteria) to decompose the food waste. Sumber Handal supplies the bacteria in 60 kgs bags. After the bacteria are loaded inside the compostech, its efficiency will last for few months, depending on the size of the machine. For a 250 kg compostech machine, 60 kg of bacteria loaded (in one time) can last 3 months, provided that a small volume of compost, approximately 50kg, is left everyday inside the machine after the compost has been collected. The bacteria that remain in the compost left inside the chamber will decompose the next food waste to be loaded. Figure 1 shows the Compostech machine purchased by UTP

**Figure 1.1**: Compostech machine placed in sewage treatment plant, UTP


There are several reasons for this composting of food waste project must be carried out in UTP which are:

i) UTP is producing around 1000 kg food waste every day.

- Calculation based on Municipal Solid Waste (MSW) generation rate.
  - 6000 persons
  - 1.3 kg per capita per day of MSW
  - 40% food waste
  - Total food waste = 3120 kg/day
  - 1/3 suitable for composting ≈ 1.04 ton/day
- Estimated amount of food waste produced daily from all cafeterias in UTP:

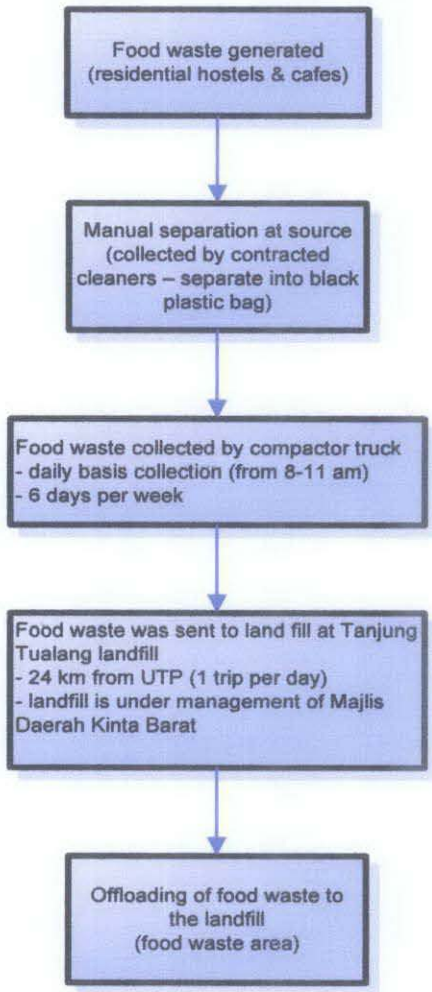
**Table 1.1**: Food waste production rate in UTP

| Sources | V1 | V2 | V3 | V4 | V5 | V6 | USM | Pocket C | Pocket D | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Amounts (kg/day) | 200 | 200 | 200 | 200 | 300 | 200 | 150 | 50 | 100 | 1500 |

Source: Health, Safety and Environment (HSE) Department of UTP

ii) Produced food waste sends to a dumping site at Tanjung Tualang. This method is messy, smelly, unhealthy, unhygienic and discouraged by Malaysian Government and Department of Environment.

**Figure 1.2**: Transportation of food waste from UTP to Tanjung Tualang landfill




Source: En Wan Tarmizi Wan Ismail ,Manager of HSE, UTP

iii) UTP pays around RM 60 000 yearly for the purchasing of fertilizers which is included in the Landscape Services contract (refer appendix 2).

iv) UTP pays around RM 58 000 yearly for the management and disposal of food wastes at landfill (refer appendix 3).

Collection of food waste from all cafeterias in UTP is twice a day which are at 9 a.m. (for midnight wastes & breakfast wastes) and 4 p.m. (for lunch wastes).Then, separation is carried out on the food waste to remove the non-organic matter such as, plastics, nylons, and etc. The food waste is loaded into the 'in-vessel' composting machine. Special bacteria are added as inoculums to decompose the food waste and to convert it into organic compost within 24 hours. Figure 3 shows the microbial inoculums which is the combination of saw dust and charcoal that being placed in the Compostech machine to enhance the composting process.

**Figure 1.3**: Microbial inoculums, combination of saw dust and charcoal carrier to enhance decomposition process

Source: Health, Safety and Environment (HSE) Department of UTP

Composting process brings a lot of benefits. Firstly, it is fast, simple and easy to operate. Secondly, no waiting for garbage disposal, thus reduce smell and potential flies breeding. Thirdly, reduce the volume of waste to be sent to landfill. Fourthly, food waste is converted into organic feed which can be used to enrich plants or for landscape. Fifthly, it is cost saving for landscape maintenance. Sixthly, it is environmentally friendly (using bio-technology solution) and lastly it provides opportunity for research (e.g. developing microbes)

## 1.2 Problem Statement

Compost produced in UTP needs to be analyzed for level of quality. Tests and analysis have to be carried out to analyze the content of the compost and to determine the quality of the compost, whether it is suitable and safe to be used as fertilizer. In Malaysia there is no compost quality standard document that had been produced so far. Hence, compost quality standard document produced by other countries such as Canada and United States have to be considered as main references. Sample of compost was sent to Malaysian Agricultural Research and Development Institute (MARDI) for testing. The test was carried out in the Agriculture Chemical Analysis Laboratory and the test report was issued on September 20, 2010 by the quality manager of MARDI upon completion of the test. Unfortunately, there a few data that was not included in the report such as the percentage of Carbon in the compost and pathogens content (refer appendix 1). It is quite difficult to determine the quality of the compost produced by Compostech by only referring to insufficient data. A few other tests have to be carried out in order to determine the quality of the compost.

## 1.3 Objectives

The objectives of this project, an evaluation on compost quality produced in UTP campus are:

1. To produce a guideline which indicates the criteria of good compost
2. To determine the quality of produced compost in UTP

## 1.4 Scope of study

In producing a guideline on compost quality standard, valid sources on compost quality standard documents were gathered from all over the world as reliable references. Two main references on compost quality standards are Support Document for Compost Quality Criteria - National Standard of Canada (CAN/BNQ 0413-200) The Canadian Council of Ministers of the Environment (CCME) Guidelines and Agriculture and Agri-Food Canada (AAFC) and United States Compost Quality Standards & Guidelines prepared by New York State Association of Recyclers. Experiments were carried out based on the compost quality standards document. There are 6 criteria that being considered in determining the quality of compost produced in UTP which are maturity of the compost, heavy metal content, foreign matter content, pathogens content, constituents of the compost which indicates the percent of CHNS, NPK (Nitrogen, Phosphorus, Potassium) content of the compost and moisture content.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Food Waste

Food waste has a moisture and organic matter content, which is easily decomposed by microbes. It produces odor that harmful to environmental quality. Direct landfill of food waste has created various problems such as bad smells and leachate polluting ground and surface waters (Yang, 2002)(Yun, 2000). Recycling food waste can benefit the environment by reducing the amount of garbage disposed, promoting the fertility of soil and improving the physical and chemical properties of soil (Pak, 2002).

Recycling of food wastes reduces the unpleasant odors of garbage, benefits the sanitation of the environment and decrease garbage collection-related spending. Food waste is less harmful to the environment than industrial waste. Thus, composting of food waste is attracting considerable attention because it would significantly reduce the amount of waste and the product can be used as compost or biofertilizer which can be handled, stored, transported and applied to the field without adversely affecting the environment (Debosz, 2002).

Although various composters are currently commercially available or several types of in-vessel composting systems have been developed for installation in food service establishments to manage food waste as a recyclable resource, it is difficult to maintain steady degradation due to the instability of the microflora within the composter due to the raw material, pH, temperature and other environmental conditions (Choi, 1998)(Aoshima, 2001)(Shu Hsien Tsai, 2006).

## 2.2 Composting

Composting is an aerobic microbial driven process that converts solid organic waste into a stable, sanitary, humus-like material. Composting process reduces the bulk considerably and returns safely the final product to environment. Almost all the widely used composting systems are aerobic, with the main products being water, carbon dioxide and heat. The most important operational factors are: aeration, temperature, moisture. C:N ratio and pH level (Chmielewska, 2003). Compost (humus) contains nutrients and organic carbon which are excellent soil conditioners. The optimum conditions for composting are with moisture content of about 50 %, carbon to nitrogen ratio of about 25 to 30 and temperature of 55 °C.

The composting process occurs in two major phases. In the first phase, microorganisms including bacteria and fungi decompose the composting feedstock into simpler compounds, producing heat as a result of their metabolic activities. In second phase, the compost product is completed where microorganisms depleted the supply of readily available nutrients in the compost. As a result, heat generation gradually diminishes and the compost becomes dry and crumbly in structure (Composting: Yard and Municipal Solid Waste, 1995).

Composting is an environmental-friendly method to tackle the disposal problem of sewage sludge and municipal solid waste. With appropriate nutrients, porosity, density and moisture content during composting, pathogens such as *Salmonella typhi*, *Escherichia coli* etc. will be destroyed and the organic matter will be stabilized producing a compost product that can contribute directly to soil fertility and conditioning (Razak, June 2003). Composting is a biological decomposition process during which microorganisms convert raw organic materials into relatively stable humus-like material. During decomposition, microorganisms assimilate complex organic substances and release inorganic nutrients (Metting, 2003).

Various factors affect the composting processes and determine the level of biological activities. The main factors are moisture, temperature, pH, initial recipe C/N ratio and oxygen (Pace MG, October 1995).

The composting mixtures should be maintained within a range of 40% to 65% moisture and preferably 50%-60%. The raw compost mixture should have water content of approximately 55% because microbes absorb nutrients in molecularly dissolved form through a semi permeable membrane. At moisture content under 20%, no biological processes are possible (Bilitewski, 1997). Temperature is generally a good indicator of the biological activity. Temperature above 60°C -65°C should be prevented because the more sensitive microorganisms may be killed and the decomposition process may be slowed. Nevertheless, a continuing high temperature of 55°C -60°C, lasting beyond 5 to 6 weeks, indicates an abnormally prolonged decomposition and a delayed transition to the stabilization stage (Legg, December 1990).

For optimum microbial activity during composting, a neutral to slightly alkaline pH range is required for optimal microbial growth. Generally, the pH level drops at the beginning of the composting process as a result of the acids formed by the acid-forming bacteria which initialize the process by breaking down complex carbonaceous materials. The later break down of proteins account for the rise in pH (Bilitewski, 1997). The preferred range of pH is 6.5 to 8.0. The ranges of pH for optimum growth of microorganisms during composting process are suggested by various researchers.

The C/N ratio insures the necessary nutrients for the synthesis of cellular components of microorganisms. For an active aerobic metabolism, a C/N ratio of 15 to 30 is suggested that the C/N ratio of the microbial cell be about 10. Raw materials blended to provide C/N ratios of 25 to 30 are ideal for active composting although initial C/N ratios of 20 to 40 consistently give good composting results. A C/N ratio below 20 produces excess ammonia and unpleasant odors while a C/N ratio above 40 does not provide enough N for microbial growth and a fast composting process. Once completely composted, the treated waste should offer a C/N ratio ranging between 15 and 20, to be used as a balanced soil amendment. If the C/N ratio exceeds 20, N becomes deficient in the soil (Bilitewski, 1997)

Composting is a natural process which provides several benefits: the process can be inexpensive; it addresses over 50 percent of a city's waste stream; it reduces one of the world's largest contributors to Greenhouse gases; it enhances related recycling and incineration activities; and it can produce a beneficial end product with unlimited marketing potential. It simply recycles organic material back to the topsoil from where it is mined through typical agricultural practices (Hoornweg, 1999). Among other benefits of composting are as follows:

- Enhances recycling and incineration operations by removing organic matter from the waste stream.
- Produces a valuable soil amendment—integral to sustainable agriculture.
- Promotes environmentally sound practices, such as the reduction of methane generation at landfills.
- Enhances the effectiveness of fertilizer application.
- Can reduce waste transportation requirements.
- Flexible for implementation at different levels, from household efforts to large scale centralized facilities.
- Addresses significant health effects resulting from organic waste, such as reducing Dengue fever.
- Provides an excellent opportunity to improve a city's overall waste collection program.

Figure 4 shows the schematic of composting process. Carbon, chemical energy, protein and water in finished compost are less than that in the raw material; the finished product has more humus. The volume of the finished compost is approximately 50% less than that of the raw materials (Rynk, 1992).

**Figure 2.1**: Schematic diagram of composting process

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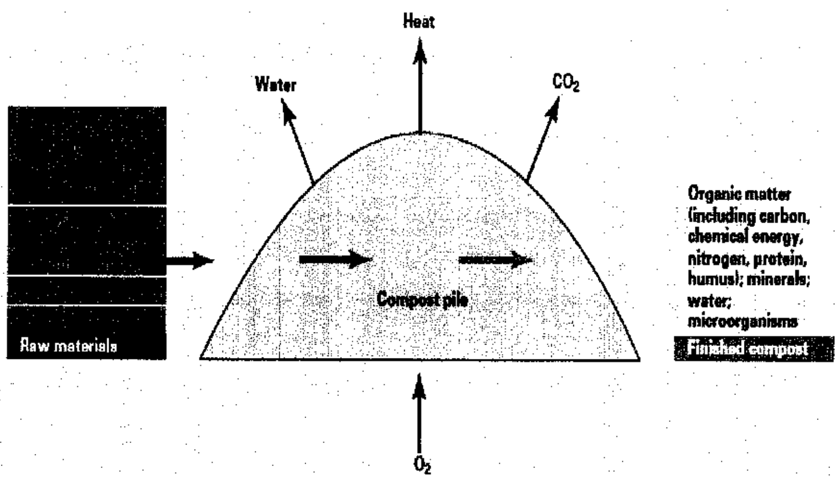


Source: Rynk R. On-Farm Composting Handbook, Agriculture and Engineering Service, Cooperative Extension; 1992:1-186.

## 2.3 Compost Quality

Compost quality is difficult to define and often elusive term, meaning different things to different people according to their professional background and national legislations. Nevertheless, compost quality lies at the core of the issue of composting and biological treatment in general, as it defines the marketing potential and the outlets of the product and in most cases, the viability of the treatment plant, but also the long-term acceptability of biological treatment as a valuable option in the waste hierarchy (Lasaridi, Compost Stability: A Comparative Evaluation of Respirometric Techniques, 1998).

Compost quality refers to the overall state of the compost in regard to physical, chemical and biological characteristics, which indicate the ultimate impact of the compost on the environment. The quality of compost is determined by the sum of its different features and properties (de Bertoldi, 1993). The criteria that are relevant to the evaluation of quality depend on what purpose the compost is used for, the relevant environmental protection policies and the market requirements (Gillett, 1992)(Kehres, 1992). For example, composts intended as growing media should meet more stringent quality criteria compared to composts that will be used as landfill cover.

A number of characteristics determine compost quality, such as particle size distribution, moisture, organic matter and carbon content, concentration and composition of humus-like substances, nitrogen content and forms of N, phosphorus and potassium, heavy metals, water holding capacity, porosity and bulk density, pathogens, and state of maturity or stability (Lasaridi, Compost Stability: A Comparative Evaluation of Respirometric Techniques, 1998).

However, the most important, from the point of view of standards for the protection of public health, the soil and the environment in general, are those relating to pathogens, inorganic and organic potentially toxic compounds (heavy metals, PCBs, PAHs, phthalates etc.) and stability, the latter determining compost nuisance potential, nitrogen immobilization and leaching (Brinton W. , 2000)(Deportes, 1995)(Hogg, 2002).

In addition to ensuring a safe product, compost standards provide a valuable marketing tool. The consumer can be satisfied with the knowledge that the product quality is consistent and suitable for the desired application. This is important for commercial and agricultural operations where a relationship exists between predictable results and repeated sales. The supply of compost must also be reliable since inability to meet market commitments affects customer relations and reflects poorly upon the credibility of the program (Albrecht, 1989).

During the past few years, the Canadian composting industry has been expanding, which has meant an increase in the number of composting sites and, consequently, in the quantity of compost produced from organic waste of diverse origins. In Canada, many organizations are involved in the development of standards and regulations. In the area of compost and composting, Agriculture and Agri-Food Canada (AAFC) (through the Plant Products Division), the provincial and territorial governments (through the Canadian Council of Ministers of the Environment (CCME)), and the Standards Council of Canada (SCC) (through the BNQ) are all concerned with developing quality criteria. The necessity and feasibility of establishing safety criteria for compost have led AAFC, the CCME and the BNQ to collaborate in developing uniform criteria while retaining sufficient flexibility for the different organizations to work within their mandates and reach their objectives (Daniel Lefebvre, 2000).

### 2.3.1 Compost Quality Criteria - National Standard of Canada

The five categories of quality criteria for compost considered in Support Document for Compost Quality Criteria - National Standard of Canada (CAN/BNQ 0413-200) The Canadian Council of Ministers of the Environment (CCME) Guidelines and Agriculture and Agri-Food Canada (AAFC) are:

- maturity
- foreign matter
- trace elements
- pathogenic organisms
- organic contaminants

*Maturity:* The maturity of compost is an important characteristic to consider when evaluating the quality of the product, given the harmful effects of immature compost use on plant growth. Maturity can be measured using the following criteria:

- a C/N ratio < *25;*
- an oxygen uptake < *150* mg 02/kg volatile solids per hour; and
- a germination and growth test using cress *(Lepidium sativum)* seeds and radish *(Raphanus sativus)* seeds, which demonstrates an absence of phytotoxic effects.

*Foreign matter:* When developing an industry standard for compost quality, the presence of foreign matter in compost should be taken into consideration since it has a negative impact on consumers and on the composting industry in general. Foreign matters can be defined as any matter over a 2 mm dimension that results from human intervention and having organic or inorganic constituents such as metal, glass and synthetic polymers (e. g., plastic and rubber) that may be present in the compost but excluding mineral soils, woody material and rocks.

*Trace elements:* It is defined as a chemical element present in compost at a very low concentration. The considered trace elements include those that are essential to plant growth (particularly Cu, Mo, Zn) and heavy metals which, depending on their concentration in the soil, could be harmful to human health and to the environment.

*Pathogenic organisms:* The pathogenic organism content must not exceed the following limits:

- faecal coliforms < 1000 most probable number (MPN)/g of total solids calculated on a dry weight basis, and
- *Salmonella* sp. <3 MPN/4g total solids calculated on a dry weight basis

*Organic contaminants:* The Committee decided that, at the present time, there is no valid reason for including organic contaminant criteria in the standard. This stance can be reconsidered and modified should any information or scientific findings justify a review.

*Water content:* Compost water content is a criterion that was adopted by the standardization committee for the following reasons. By not establishing a critical limit for water content in compost, it is possible that compost would be sold containing high levels of water. This, in turn, would lead to a deterioration of the image of superior quality compost and thus appears undesirable from a standardization viewpoint. Moreover, it is desirable to limit the water content so the consumer does not buy (by weight) more water than dry matter (compost). Therefore, the maximum acceptable water content – expressed as a percentage of the compost's humid mass - must not exceed 60 percent.

*Nitrogen, Phosphorus and Potassium (NPK) concentrations:* The concentration of major fertilizing elements in compost is also a criterion to be taken into consideration when evaluating the agronomic value of compost. However, it is extremely difficult and arbitrary to establish reference values for Nitrogen, Phosphorus and Potassium for each compost type, since the fertilizing role of compost, although not negligible, seems of secondary importance. Therefore, compost with *0.5* percent Nitrogen, Phosphorus and Potassium is not as rich as compost with 1 percent of those elements.

### 2.3.2 United States Compost Quality Standards and Guidelines

Based on the United States Compost Quality Standards and Guidelines prepared by New York State Association of Recyclers, the following standards are being considered:

*Heavy metal allowable levels:* Of all potential quality standards, heavy metals have been the focus of most attention. Thus it is useful to explore the details of these standards, beginning with an overview of the range of standards (Brinton W. , 2000). Table 3 shows the heavy metal allowable limits that being accepted in United States.

**Table 2.1**: Heavy metal allowable levels

| Metal | Limits (mg/kg) |
|---|---|
| Cadmium | 39 |
| Chromium | 1200 |
| Copper | 1500 |
| Mercury | 17 |
| Nickel | 420 |
| Lead | 300 |
| Zinc | 2800 |

Source: United States Compost Quality Standards & Guidelines by New York State Association of Recyclers

*Physical composition and inert contamination:* The acceptable quantities of foreign matter in compost have been a subject of some debate, but generally there is greater agreement on these standards. Normally, stones are distinguished from non-decomposable "foreign matter" which includes glass, plastic and metal (Brinton W. , 2000). Table 4 shows physical standard and the maximum foreign matter particles allowed in compost.

**Table 2.2**: Maximum Foreign Matter Particles Allowed in Composts

| Stones % of dry weight | Man-Made Foreign Matter glass, plastic, metal, as% of dry weight |
|---|---|
| must be < 5% of >5mm size | < 0.5% for >2mm fraction |
| must be < 3% of > 11 mm size | < 2% of > 2mm fraction |
| < 2% | no visible contaminant, max 0.5% >2mm |

Source: United States Compost Quality Standards & Guidelines by New York State Association of Recyclers

# CHAPTER 3

# METHODOLOGY

## 3.1 Maturity

### 3.1.1 Germination

Radish seeds and bean sprout seeds were selected based on the recommendation in the Support Document for Compost Quality Criteria - National Standard of Canada. Both seeds are available in Malaysia and easy to grow and quick to mature. Each type of seeds was germinated in three different conditions which were in 100 % soil, 100 % compost and in 50 % soil and 50 % compost. The baskets were placed under sunlight and the seeds were watered daily for 5 weeks. Figure 3.1 and Figure 3.2 show both types of seeds being planted in 3 different conditions.

**Figure 3.1**: From left to right, bean sprout seeds in 100 % soil, 100 % compost and in 50 % soil and 50 % compost

**Figure 3.2**: From left to right, radish seeds in 100 % soil, 100 % compost and in 50 % soil and 50 % compost

### 3.1.2 Carbon, Hydrogen, Nitrogen, Sulfur Determination

2 mg of Sulfamethazine is being used as standard and being wrapped in silver capsules before being placed in the CHNS-932. CHNS-932 is a machine manufactured by LECO Corporation in St. Joseph, Michigan, United States, which it can detect carbon, hydrogen, sulfur and oxygen by means of individual, highly selective, infrared detection systems. 2 mg Sample (compost in solid form) are being wrapped with tin capsules and then placed in CHNS-932, to determine the percent of CHNS.

**Figure 3.3**: CHNS-932

## 3.2 Heavy metal content

### 3.2.1 Digestion of compost for heavy metal analysis

Compost samples were oven dried at 105° C to a constant weight and sieved through a non-metal sieve to a size of 2 mm. 10 ml of concentrated nitric acid ($HNO_3$) was added to 1 g of each dry sample and was allowed to stand overnight, and then heated for 4 hours at 125° C on a hot plate. The mixture was then diluted to 50 ml with double distilled water and filtered through filter paper No.1.

Concentrations of Cadmium (Cd), Chromium (Cr), Copper (Cu), Zinc (Zn), Lead (Pb) and Nickel (Ni) were determined using 12-CV-EVL-01 Atomic Absorption Spectrophotometer (AAS), country. Prior to determine the concentration of heavy metal using AAS, standard solution was prepared for each type of heavy metal in order to produce the calibration curve in the standard concentration range. Three standard solutions with different concentration were prepared for each type of heavy metal in 50 ml volumetric flask. To prepare the standard solution, the calibration standard solution for each type of metal is filled in 50 ml volumetric flask and topped it up with distilled water based on $M_1V_1 = M_2V_2$ principle. Concentration of calibration standard solution, $M_1$ is 1000 mg/l and volume of standard solution, $V_2$ is 50 ml for all types of metals. Table 8 shows the concentration of standard solution and measuring conditions for each type of metal that being analyzed.

**ble 3.1**: Concentration of standard solution and measuring conditions for each type of metal that being analyzed

| oncentration of standard solution and measuring conditions | | Cadmium (Cd) | Chromium (Cr) | Copper (Cu) | Zinc (Zn) | Lead (Pb) | Nickel (Ni) |
|---|---|---|---|---|---|---|---|
| Volume of calibration std. olution, $V_1$ (ml) | Std. 1 | 0.02 | 0.025 | 0.025 | 0.01 | 0.05 | 0.025 |
| | Std. 2 | 0.03 | 0.05 | 0.05 | 0.02 | 0.2 | 0.05 |
| | Std. 3 | 0.04 | 0.1 | 0.1 | 0.03 | 0.4 | 0.1 |
| oncentration of td. solution, $M_2$ (ppm) | Std. 1 | 0.4 | 0.5 | 0.5 | 0.2 | 1.0 | 0.5 |
| | Std. 2 | 0.6 | 1.0 | 1.0 | 0.4 | 4.0 | 1.0 |
| | Std. 3 | 0.8 | 2.0 | 2.0 | 0.6 | 8.0 | 2.0 |
| Current (mA) | | 8.0 | 10.0 | 6.0 | 8.0 | 12.0 | 12.0 |
| Wavelength (nm) | | 228.8 | 357.9 | 324.8 | 213.9 | 217.0 | 232.0 |
| Slit width (nm) | | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.2 |
| Lighting mode | | BGC-$D_2$ | BGC-$D_2$ | BGC-$D_2$ | BGC-$D_2$ | BGC-$D_2$ | BGC-$D_2$ |
| Burner height (mm) | | 7.0 | 9.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Burner angle (degree) | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fuel gas flow (L/min) | | 1.8 | 2.8 | 1.8 | 2.0 | 2.0 | 2.2 |
| Type of oxidant | | Air | Air | Air | Air | Air | Air |

Source: AAS Cookbook Section 3 by Shimadzu Corporation

Concentration of Boron (Br) was determined through powder pillow test using the BoroVer 3 reagent powder pillow and 75 mL concentrated sulfuric acid. Equipment that being used are 50 mL and 100 mL graduated cylinders, 125 mL and 250 mL conical flasks, 2.0 mL pipette and 1-in. square 10 mL sample cells. Figure 7 shows the AAS machine that available in the lab and being used to determine the content of metal in the compost.

**Figure 3.4**: 12-CV-EVL-01 Atomic Absorption Spectrophotometer (AAS)

### 3.3 Foreign matter content

Sieve analysis had been carried out to determine the percent of matter that are greater than 2mm in dimension. Figure 8 shows the sieve plate with 2.0 mm sieve size that being used to separate any foreign matter that greater than 2.0 mm in the compost while figure 9 shows the sieve machine that gives vibration to the plate in separating the foreign matter.

**Figure 3.5**: 2.0 mm sieve

**Figure 3.6**: Sieve machine

## 3.4 Pathogens content

The equipment that used is 'Quanti-Tray' / 2000. This device is designed to count the amount of bacteria in 100ml sample using IDEXX-d Substrate reagent product. 20 g of compost samples were mixed with 200 ml of distilled water in a conical flask and was put on orbital shaker for 24 hours. The samples then filtered using the filter paper. Quanti-Tray/2000 is used to count the amount of bacteria (*E.coli*) in 100 ml sample using IDEXX-d Substrate reagent product. One snap pack of colilert powder is used for 100 ml sample. The reagent (colilert powder) was added to the filtered sample in a sterile, transparent, non-fluorescent vessel. The vessel was sealed and shakes until sample reagent mixture dissolved. The sample reagent mixture was poured directly into the tray avoiding contact with the foil tab and sealed the tray. Incubated for 24 hours at 35° + 0.5° and after incubation for 24 hours, the sample was examined under fluorescent light, number of positive wells were counted and referred to MPN table to determine the Most Probable Number (MPN) of total coliforms (yellow wells) and *E.coli* (fluorescent wells) in sample.

## 3.5 NPK value determination

### 3.5.1 Nitrate (N)

The content of nitrate was determined through powder pillow test where NitraVer® 5 reagent powder pillow was used. 20 g of compost samples were mixed with 200 ml of distilled water in a conical flask and was put on orbital shaker for 24 hours. The samples then filtered using the filter paper. 10 ml of the filtered sample was filled in a square sample cell. One sachet of NitraVer® 5 reagent powder pillow added to the sample and the sample shake for 1 minute followed by 5 minutes reaction. A blank sample of 10 ml was prepared in the square sample cell and was used together with the previously prepared sample to obtain nitrate reading using the DR 2800 Spectrophotometer.

### 3.5.2 Phosphorus (P)

The content of phosphorus was also determined through powder pillow test. 5 ml of filtered sample was pipette into a Total and Acid Hydrolysable Test Vial. Then, one sachet of potassium persulfate powder pillow was added to the vial. The vial then capped tightly and shakes to dissolve. The vial was heated up in DRB200 Reactor, which is in 150°C, for 30 minutes. After 30 minutes, the vial is cooled down to room temperature. Then, 2 ml of 1.54 N Sodium Hydroxide Standard Solution was added to the vial and mixed. The vial then being insert into the DR 2800 Spectrophotometer and pressed ZERO. The vial being took out from DR 2800 Spectrophotometer and one sachet of PhosVer 3 powder pillow was added into the vial and was shake for 30 seconds to mix followed by 2 minutes reaction. The vial then being insert once again into DR 2800 Spectrophotometer to obtain the reading of phosphorus. The content of potassium was determined using the 12-CV-EVL-01 Atomic Absorption Spectrophotometer (AAS) where the preparation of the sample is the same with sample preparation in heavy metal analysis.

### 3.5.3 Potassium (K)

The content of potassium was determined using the 12-CV-EVL-01 Atomic Absorption Spectrophotometer (AAS) where the preparation of the sample is the same with sample preparation in heavy metal analysis. Table 9 shows the measuring conditions and concentration of standard solution that being prepared prior to the process of determining the content of potassium by using the AAS machine.

**Table 3.2:** Concentration of standard solution and measuring conditions for potassium

| Concentration of standard solution and measuring conditions | | Potassium (K) |
|---|---|---|
| Volume of calibration std. solution, $V_1$ (ml) | Std. 1 | 0.01 |
| | Std. 2 | 0.02 |
| | Std. 3 | 0.04 |
| Concentration of std. solution, $M_2$ (ppm) | Std. 1 | 0.2 |
| | Std. 2 | 0.4 |
| | Std. 3 | 0.8 |
| Current (mA) | | 10.0 |
| Wavelength (nm) | | 766.5 |
| Slit width (nm) | | 0.5 |
| Lighting mode | | HCL |
| Burner height (mm) | | 7.0 |
| Burner angle (degree) | | 0.0 |
| Fuel gas flow (L/min) | | 2.0 |
| Type of oxidant | | Air |

Source: AAS Cookbook Section 3 by Shimadzu Corporation

### 3.6 Moisture content

Moisture content of the compost was determined using the Precisa moisture content analyzer model XM 60 made in Switzerland, where the compost sample is placed directly onto the weighing pan and placed inside the analyzer. The moisture analyzer is used as a quick and reliable means of determining the moisture content in powders and liquids by the thermo gravimetric process. In this process, the sample is weighed before and after heating so as to determine the moisture content from the difference. Sample being distributed evenly and thinly on the weighing pan in order to achieve reproducible results. If it is applied unevenly, this causes an inhomogeneous distribution of heat in the sample, resulting in incomplete drying or an extension to the measuring time. If the sample is piled up, it heats up with greater intensity in the upper layers, causing combustion or encrustation to occur. The high layer thickness or possible formation of a crust prevents the moisture from escaping from the sample.

**Figure 3.7**: Precisa moisture content analyzer model XM

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Maturity

### 4.1.1 Germination

After 5 weeks of germination, for both radish and bean sprout seeds, only seeds in 100 % soil are germinated. Seeds are not germinated at all in 100 % compost and in 50 % soil and 50 % compost. Based on the compost quality standard, germination of seeds in 100% compost must be greater than 90 % of germination rate of control sample. This shows that compost produced in UTP are not fulfilling the germination of seeds standard. Figure 10 and figure 11 show the result of germination for both types of seeds after 5 weeks. All the seeds being watered daily and received sufficient amount of lights during that 5 weeks.

**Figure 4.1**: Radish seeds after 5 weeks of germination in 100 % soil, 100 % compost and in 50 % soil and 50 % compost

**Figure 4.2**: Bean sprout seeds after 5 weeks of germination in 100 % soil, 100 % compost and in 50 % soil and 50 % compost

### 4.1.2 C/N ratio

C/N ratio of the compost is 17.67 meaning that the compost has 17.67 times as much carbon as nitrogen. Based on the compost quality standard from Canada, C/N ratio of good compost should be less than 25. Organisms that decompose organic matter use carbon as a source of energy and nitrogen for building cell structure. They need more carbon than nitrogen. If there is too much carbon, decomposition slows when the nitrogen is used up and some organisms die. Other organisms form new cell material using their stored nitrogen. In the process more carbon is burned. Thus the amount of carbon is reduced while nitrogen is recycled. When the energy source, carbon, is less than that required for converting available nitrogen into protein, organisms make full use of the available carbon and get rid of the excess nitrogen as ammonia. This release of ammonia to the atmosphere produces a loss of nitrogen from the compost pile and should be kept to a minimum (Lindsey, 2005).

## 4.2 Heavy metal content

Heavy metals content of the compost produced in UTP are found to be below compare to those have been mentioned in Support Document for Compost Quality Criteria - National Standard of Canada (CAN/BNQ 0413-200) The Canadian Council of Ministers of the Environment (CCME) Guidelines and Agriculture and Agri-Food Canada (AAFC) and United States Compost Quality Standards & Guidelines prepared by New York State Association of Recyclers. This shows that the compost is fulfilling the criteria of good compost. Heavy metal content of the compost is very low because the main source of compost is only food waste. Excessive content of heavy metal can cause hazardous health complication to consumers. For example, cadmium may accumulate in human body and induce kidney dysfunction, skeletal damage and reproductive deficiency. Lead can cause liver, brain and central nervous system dysfunction while Nickel can cause respiratory problem. A research carried out in Taiwan on heavy metal content in compost made from food waste had produced a result of heavy metal analysis of Cd, Cr, Cu, Br, Ni, Pb and Zn. The method used is concentrated nitric acid digestion which is the same method used in this project. The concentrations of Cd, Cr, Cu, Br, Ni, Pb and Zn in the final solutions were determined by an atomic absorption spectrometer (AAS) (Hitachi Z-8100, Japan) (Hseu, 2004). Table 10 below shows heavy metal content in compost produced in Taiwan.

**Table 4.1**: Heavy metal analysis of compost produced in Taiwan

| | Content in compost produced in Taiwan (mg/L) |
|---|---|
| Lead (Pb) | 77.2 |
| Cadmium (Cd) | 0.49 |
| Copper (Cu) | 488 |
| Chromium (Cr) | 90.3 |
| Zinc (Zn) | 623 |
| Nickel (Ni) | 64.3 |
| Boron (Br) | 14.2 |

Source: Zeng-Yei Hseu in "Evaluating heavy metal contents in nine composts using four digestion methods", Taiwan, 2004.

The heavy metal content in compost produced in UTP is very low compared to heavy metal content in compost produced in Taiwan. Table 11 below shows the heavy metal content in compost produced in UTP.

**Table 4.2**: Heavy metal analysis of compost produced in UTP

| | Content in compost produced in UTP (mg/L) | Compost Quality Criteria from Canada & US (mg/L) |
|---|---|---|
| Lead (Pb) | 0.53 | < 150 |
| Cadmium (Cd) | 0.00 | < 5 |
| Copper (Cu) | 4.57 | < 500 |
| Chromium (Cr) | 0.46 | < 300 |
| Zinc (Zn) | 0.41 | < 900 |
| Nickel (Ni) | 0.00 | < 50 |
| Boron (Br) | 7.00 | < 100 |

### 4.3 Foreign matter content

Based on the physical observation and sieve analysis result, compost produced in UTP contains no man-made foreign matter such as glass, plastic, metal and no stones. This is good because compost must be virtually free of foreign matter that may cause nuisance, damage or injury to humans, plants or animals, during or resulting from intended use. The compost must not contain any sharp foreign matter measuring over 3 mm in any dimension or any foreign matter greater than 25 mm in any dimension. Figure 12 shows compost that had gone through sieve process where any matter that larger than 2 mm in size are trapped in the sieve plate.

**Figure 4.3**: Compost in 2.0 mm sieve plate

### 4.4 Pathogens content

Quanti-Tray being observed under fluorescent light and there are no blue wells formed. That means, no *E.coli* being observed from compost. Based on the compost quality standard from Canada, *E.coli* in compost must be less than 1000 MPN. *E. coli* not available in the compost produced in UTP because the source of the compost is only food waste from the cafeterias. It is important to produce hygienic compost because the compost usually handled by human.

### 4.5 NPK content

Germination of radish seeds and bean sprout seeds did not occur because of low content of Nitrogen, Phosphorus and Potassium (NPK) and also micronutrients in the compost. Table 11 shows the amount of NPK in the compost produced in UTP. The values are compared with the recommended content of NPK in the compost by United States Compost Quality Standard & Guideline.

**Table 4.3**: Amount of NPK in compost compared to standard

| | Content in compost produced in UTP (mg/L) | United States Compost Quality Standard & Guideline (mg/L) |
|---|---|---|
| Phosphorus | 2.81 | 6.0 |
| Nitrate | 9.80 | 17.0 |
| Potassium | 8.30 | 12.0 |

The amount of NPK in compost produced in UTP is low compared to the standard. This is not good for the plant because NPK are macronutrients, which are essential elements used by plants in relatively large amounts for plant growth (Rynk, 1992). NPK are necessary for the basic building blocks of amino acids, cell membranes and ATP. Amino acid contains nitrogen. Molecules that make up the cell membrane contain phosphorus and so does every molecule of ATP which is the main energy source of all cells.

Potassium makes up 1 percent to 2 percent of the weight of any plant and, as an ion in cells, is essential to metabolism (Hoornweg, 1999).

To enrich the content of macronutrients and micronutrients in the compost, the following organic material can be added (Ann Whitman, March 2009):

1. Chicken and fish bones.

   A popular source of phosphorous (11 percent) and calcium (22 percent), bone meal is derived from animal or fish bones. It also contains 2 percent nitrogen and many micronutrients.

2. Coffee grounds.

   Coffee grounds can be added to compost piles to increase nitrogen balance. Coffee grounds contain about 2% of nitrogen, which is released quickly into the soil. This nitrogen gives energy to the bacteria that naturally break down the items in a compost pile, thus increasing the speed with which compost is produced. Coffee should be added to compost piles with high carbon content such as those with grass, leaves or vegetables. It is not harmful to compost paper filter (tea beg) along with the coffee. Coffee grounds can bring compost to a neutral level when they are added to compost and also can subdue fungal problems that sometimes found in compost.

3. Egg shells

   Crushed egg shells make a great addition to the compost pile because it adds valuable nutrients, which is calcium, to soil. Calcium is essential for cell growth in all plants and important for fast growing plants because they quickly deplete the surrounding soil of calcium.

### 4.6 Moisture content

Moisture content of the compost is 54.65 %. Based on the standard, good compost should have moisture content less than 75 %. It is well known that correct moisture management is the key to successful composting. If the moisture in the compost is too low, microbial processes are slowed and compost does not reach its optimum temperature. If it is too high, processes become anaerobic and the compost pile becomes an air pollution hazard. Moisture content of the compost is 54.65%, is in the optimal range which is between 45% and 65%.

Table 4.4 below shows the summary of compost quality produced in UTP.

**Table 4.4**: Summary of compost quality produced in UTP

| Experiments | Details | | |
|---|---|---|---|
| 1. Maturity | i) Germination<br>After 5 weeks of germination, for both radish and bean sprout seeds, only seeds in 100 % soil are germinated. No germination occurred in 100 % compost and in 50 % soil and 50 % compost.<br><br>ii) C/N ratio = 17.67 | | |
| 2. Heavy metal content | | Content in compost produced in UTP (mg/L) | Compost Quality Criteria from Canada & US (mg/L) |
| | Lead (Pb) | 0.53 | < 150 |
| | Cadmium (Cd) | 0.00 | < 5 |
| | Copper (Cu) | 4.57 | < 500 |
| | Chromium (Cr) | 0.46 | < 300 |
| | Zinc (Zn) | 0.41 | < 900 |
| | Nickel (Ni) | 0.00 | < 50 |
| | Boron (Br) | 7.00 | < 100 |
| 3. Foreign matter content | Compost contains no man-made foreign matter such as glass, plastic, metal and no stones. | | |
| 4. Pathogens content | No *E.coli* being observed from compost. | | |

| | | | |
|---|---|---|---|
| 5. NPK content | | Content in compost produced in UTP (mg/L) | United States Compost Quality Standard & Guideline (mg/L) |
| | Phosphorus | 2.81 | 6.0 |
| | Nitrate | 9.80 | 17.0 |
| | Potassium | 8.30 | 12.0 |
| 6. Moisture content | Moisture content is 54.65, which is in the optimal range of 45% to 65%. | | |

After completed the tests and analysis on compost produced in UTP, a set of compost quality standards and guidelines of our own had been produced. Table 4.5 below shows the compost quality standards and guidelines produced by UTP based on the tests and analysis carried out in this project.

**Table 4.5**: Compost Quality Standard & Guideline by UTP

| Experiments | Details | |
|---|---|---|
| 1. Maturity | i) Germination<br>Germination of radish and bean sprout seeds in 100% compost must be greater than 90 % of germination rate of control sample. Control samples consist of two conditions which are seeds in 100 % compost; seeds in 50 % soil and 50 % compost.<br><br>ii) C/N ratio must be less than 25. | |
| 2. Heavy metal content | | Compost Quality Standard & Guideline by UTP (mg/L) |
| | Lead (Pb) | < 150 |
| | Cadmium (Cd) | < 5 |
| | Copper (Cu) | < 500 |
| | Chromium (Cr) | < 300 |
| | Zinc (Zn) | < 900 |
| | Nickel (Ni) | < 50 |
| | Boron (Br) | < 100 |
| 3. Foreign matter content | The compost must not contain any sharp foreign matter measuring over 3 mm in any dimension or any foreign matter greater than 25 mm in any dimension and also must not contain man-made foreign matter such as glass, plastic, metal stones. | |
| 4. Pathogens content | *E.coli* in compost must be less than 1000 MPN. | |

| | | |
|---|---|---|
| 5. NPK content | | Compost Quality Standard & Guideline by UTP (mg/L) |
| | Phosphorus | 6.0 |
| | Nitrate | 17.0 |
| | Potassium | 12.0 |
| 6. Moisture content | Moisture content must be in the optimal range of 45% to 65%. | |

# CHAPTER 5

# ECONOMIC BENEFITS

UTP Compost Quality Standards & Guidelines produced based on this project is one way of saving cost in analyzing the compost produced in UTP. The compost does not have to be sent to MARDI for analyzing of its quality. The quality can be analyzed in our own laboratory here in UTP. The effort of composting the food waste in UTP using the 'Compostech' machine can also be seen as one way of saving money for food waste disposal and the purchase of fertilizer. UTP spent approximately RM 60 000 per year for the purchasing of fertilizer and another RM 60 000 per year for food waste disposal process. This is considered a very high cost for UTP to cope with. The compost also can be marketed as UTP is producing approximately 29 400 kg of compost per year and only 12 000 kg of compost are used for landscape in UTP. The compost can be up for sale to any potential buyers especially nurseries around Perak.

# CONCLUSION

Compost produced by Compostech machine in UTP is lack of Nitrogen, Phosphorus and Potassium (NPK) which are the macronutrients. These elements are what the plants uptake the most. To enhance the content of NPK, there are a few recommended organic materials can be added into the Compostech during the process of composting. Chicken and fish bones are the popular source of phosphorus. Coffee grounds can also be added to compost piles to increase nitrogen balance and crushed egg shells make a great addition to the compost pile because it adds valuable nutrients, which is calcium, to soil. Further research should be carried out to observe the improvement of NPK content in the compost when the above mentioned organic materials added into the compost. In terms of other aspects such as C/N ratio, heavy metal content, foreign matter content, pathogens content and moisture content, compost produced in UTP is fulfilling the criteria of good compost based on the Support Document for Compost Quality Criteria - National Standard of Canada (CAN/BNQ 0413-200) The Canadian Council of Ministers of the Environment (CCME) Guidelines and Agriculture and Agri-Food Canada (AAFC) Criteria and United States Compost Quality Standards and Guidelines prepared New York State Association of Recyclers.

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# APPENDICES

## APPENDIX 1

Test report by MARDI on compost produced in UTP.

| Major and Trace Element | |
|---|---|
| Al | 0.00 ppm |
| CaO | 0.62 % |
| $K_2O$ | 0.49 % |
| MgO | 0.10 % |
| Na | 11 977.19 ppm |
| $P_2O_5$ | 0.76 % |
| S | 0.00 % |
| Nitrogen | 2.37 % |

## APPENDIX 2

Characteristics of Compostech machine.

Size of the machine:

| Model | L (cm) | H (cm) | W (cm) |
|---|---|---|---|
| CT250kg | 129.8 | 156.8 | 101.2 |

Features:

1. Stainless steel
2. Fully automatic - runs by motor , low speed & low sound
3. Auto-stop safety switch
4. 1 hr rest time every 8 hrs operation

Price of the machine and electricity consumption:

| Model | Price (RM) | Electrical power (kW) | Electricity cost/day (RM) |
|---|---|---|---|
| CT250kg | 74, 450 | 3.5 | 4.8 |

Volume of compost produced by 'Compostech':

| Model | per day (kg) | per month (kg) ,20 working days | per year (kg) |
|---|---|---|---|
| CT250kg | 175 | 3, 500 | 42, 000 |

** Source – En Wan Tarmizi Wan Ismai ,Manager of HSE, UTP*

## APPENDIX 3

| | Company / Contractor | Number of bags of chemical fertilizer used ( 50kg/bag, RM 120/bag) | Number of bags of organic fertilizer used for grass (22.5kg/bag, RM 200/bag) |
|---|---|---|---|
| 1 | Liveline S/B | 10 | Nil |
| 2 | Azar Enterprise | 12 | Nil |
| 3 | Semaian Seri Iskandar | 10 | 5 |
| | Total | 32 | 5 |

Cost:

1. Chemical Fertilizer (Type: NPK) - 32 x RM 120 = RM 3840
2. Organic Fertilizer (US imported) - 5 x RM 200 = RM 1000

Cost per month – RM 4840

Total cost per year = RM 58,080 @ **RM 60 000**

** Source – En M Azizi A Wahab, Landscape Executive, UTP*

## APPENDIX 4

Food waste collection = 6 days (exclude Sunday) .More on Monday and Thursday.

Present Costs:

Management + Workers + dumping at **non-sanitary landfill**

= RM 29,070/semester*

* Source – Study by Mr Mzolisi Gulwa (FYP) supervised by Dr. Amirhossein Malakahmad, Civil Eng, UTP

# APPENDIX 5

**Study 1: Restaurant Food Waste decomposition using Compostech Machine**

***Materials***

Food waste, starter culture (microbial inoculums mixed with saw dust and charcoal), water, Compostech Machine and Thermometer.

***Methodology***

1. 2.4kg of food waste were hand mixed with 500ml water and 500 g of inoculums which consist of saw dust, bacteria and charcoal.
2. The mixture was left in the Compostech Machine to be automatically mixed and decomposed for 24 hours.
3. Two other batches of food waste of 2.0 kg each were added at 24 hr and 48 hr later.

***Results and Discussion***

Table 1: Food waste recovery rate

| Duration | Food Waste Weight Before Treatment (Kg) | Weight After Treatment (Kg) | Weight Recovery % | pH |
|---|---|---|---|---|
| 24 hours | 2.4 | 1.2 | 50.0 | 6.2 |
| 48 hours | 4.4 | 1.7 | 38.6 | 6.1 |
| 72 hours | 6.4 | 2.1 | 32.8 | 5.8 |

| Chemical Analysis | Before Composting | After Composting |
|---|---|---|
| Total Carbon % | 49.57 | 43.55 |
| Nitrogen % | 1.72 | 2.02 |
| C : N | 28.8 | 21.6 |
| Kalium % | 0.34 | 0.37 |
| Phosphorous % | 0.18 | 0.33 |
| Calcium % | 0.31 | 0.61 |
| Moisture Content | Na | Na |
| Temperature | 45°C | 45°C |
| pH Value | 6.5 | 5.8 |
| Smell | Strong Smell | Mild Smell |
| Texture | Bulky, moist | Loose, dry |
| Total Weight (Kg) | 6.4 | 2.1 |

## APPENDIX 6

Project planning (Gantt chart)

| No | Details/Week | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Finalize the methodology for experiment | | | | | | | Mid-Semester Break | | | | | | | | | |
| 2 | Take sample (compost) from STP of UTP | | | | | | | | | | | | | | | | |
| 3 | Sieve analysis of compost | | | | | | | | | | | | | | | | |
| 4 | Germination of seeds | | | | | | | | | | | | | | | | |
| 5 | Heavy metals analysis on compost | | | | | | | | | | | | | | | | |
| 6 | Pathogens analysis on compost | | | | | | | | | | | | | | | | |
| 7 | Determine CHNS content of compost | | | | | | | | | | | | | | | | |
| 8 | Submission of progress report | | | | | | | | | | | | | | | | |
| 9 | Determine moisture content of compost | | | | | | | | | | | | | | | | |
| 10 | Determine nitrogen and phosphorus content | | | | | | | | | | | | | | | | |
| 11 | Prepare poster | | | | | | | | | | | | | | | | |
| 12 | Pre- EDX presentation | | | | | | | | | | | | | | | | |
| 13 | Dissertation preparation | | | | | | | | | | | | | | | | |
| 14 | Submission of dissertation (softbound) | | | | | | | | | | | | | | | | |
| 15 | Submission of dissertation (hardbound) | | | | | | | | | | | | | | | | |
| 16 | Viva | | | | | | | | | | | | | | | | |