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Composition of Solid Waste in a University Campus and its Potential for Composting

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***Abstract*— The aim of this research is to study the solid waste generation at Universiti Kebangsaan Malaysia (UKM). The study areas were divided to four categories; offices, dormitories, faculties, and student affairs. This study is to quantify waste generation and composition, which was separated into organics, papers, plastics, glass, metals, e-waste and others. Waste characteristics studies were done to estimate the moisture content, density, pH and carbon/nitrogen ratio (C/N ratio). The average solid waste generation (on monthly basis) at UKM is 137.57 ton. The compositions of solid waste generated are paper (15.9%), glass (0.7%), plastic (12.2%), metal (1.2%), organic (54.8%), e-waste (0.2%) and others waste (15.0%). From the laboratory results, the average moisture content, density, pH and C/N ratio values from the solid waste generated are 43.16%, 273.5 kg/m^3, 5.76, and 7:1 respectively. Composting methods would be one most sustainable method to convert organic waste into valuable compounds and reduce the waste to be disposed into landfills.**

***Keywords*— Solid Waste, Waste Generation, Waste Characteristics.**

I. Introduction

Open dumping and sanitary landfill is a major method for waste disposal in Malaysia. In total there are 290 landfill sites to manage the waste disposal and around 176 sites still on process [1]. The problems are that the lifespan of existing landfill sites are nearing its end, whereas new landfill areas are scarce due to rapid urban development [2]. Composting could be a one of the options to manage the solid waste.

Waste management in Malaysia is still facing the following problems such as (i) Inadequate resource mobilization; (ii) Over-reliance on imported equipment; (iii) Inappropriate methods of finance; (iv) Use of inappropriate technology; (v) Inequity in service provision; and (vi) Lack of technical expertise [3]. And comprehensive data is not available such as generation rates, physical and chemical composition and particularly the heating value of the waste of campus [2]. Hence, Universiti Kebangsaan Malaysia (UKM) could be a role model to establish proper waste management in Malaysia.

As mentioned above, waste generation and composition is particularly important to determine the management of waste because successful solid waste management (SWM) requires a complete understanding of the flow stream of waste generated as well as the activities that determine first place its generated [4]. Hence, this paper will present the waste composition and generation in UKM and a potential of composting methods to manage waste for higher education campus.

II. Materials and Methods

The study was done at UKM campus in Bangi. The samples were obtained from four categories which is offices, dormitories, student affairs and faculties. Sampling was carried out for a week starting from 24th February 2009 till 2nd March 2009. The sampling and segregation adopted referred to the American Society of Testing and Material standard [5], where solid wastes are sorted into two main groups; recyclable and non-recyclable materials.

Solid wastes were collected in a 660 litre MGB container outside the buildings. This is to ensure the total daily generation waste is collected together before the segregation process. Next, daily solid waste generation were weighed with

analogy weighing machine and data were recorded. The solid wastes were separated according to plastic, paper, aluminium, glass, e-waste, food waste and others. Then, each category of the waste are weighed and recorded while samples were taken for further analysis at the laboratories.

The determination of the total moisture content was done according to [6], hence, once the waste were sorted, the samples were weighed and sent to the laboratory for further analysis. For the moisture content analysis, once the samples reached the laboratory, the samples were weighed initially to determine if there was any moisture lost during the compactor truck unloading the sample during sorting session. If there is moisture lost/gained then it will be accounted for in the total overall moisture content of the sample.

The analysis to determine the pH value was referred to Carnes [7]. At least 10 gram sample of organic waste is poured into 500 ml distilled water and stirred vigorously for 3 to 5 minutes. Then, when the mixture is settled pH measures with a pH meter (Model *Sension1*) was taken. Density of solid waste is done according to "*Standard Metode Pengambilan dan Pengukuran Contoh Timbunan dan Komposisi Sampah Perkotaan"* [8]. Firstly, a 50cm×50cm×50cm box was prepared. Then, the weight of the box was measured and recorded. After that, a refuse bag of refuse was selected from the research area. All refuse was poured from the bag to the box. The waste from the refuse bag was ensured to occupy almost the designated height of the box (50cm). Then, the box was free dropped from the height of 20cm from the ground level for 3 consecutive times. Next, the volume of the box was measured (after 3times free drop). The weight of the box was measured together with the compacted waste. Finally, the density of waste was calculated.

C/N ratio analysis was carried out using the CHNS-O analyzer (Model EA 1108), which was in accordance to the procedures as required by [9] and [10]. This method gave results for carbon, hydrogen, oxygen, nitrogen, and sulphur content in the waste. Analysis of the samples was done not only for the individual components but also for the commingled samples. This approach allows for comparison of results from the individual component analysis, calculated overall characteristics of the MSW based on a weighted average and also on a commingled sampling basis.

III. Results and Discussions

The results of the waste composition study are shown in Table I. The observation could be concluded that food waste is the highest portion i.e. dormitories (51.6%), faculties (57.8%), student affairs (56.4%), and offices (53.7%). Followed by plastic items i.e. dormitories (11.8%) and faculties (12.7%) except student affairs (13.3%) and offices (10.9%). At student affairs and offices, the second highest amount is papers which (17.7%) and (25.5%) respectively.

TABLE I
SUMMARY WASTE COMPOSITION OF SEGREGATION AT SOURCES METHOD

Categories	Dormitories	Faculties	Student Affairs	Offices	Avg.
Papers	8.3%	12.0%	17.7%	25.5%	15.9%
Plastics	11.8%	12.7%	13.3%	10.9%	12.2%
Metals	1.9%	0.9%	0.4%	1.5%	1.2%
Glass	0.2%	0.6%	1.8%	0.1%	0.7%
Food Waste	51.6%	57.8%	56.4%	53.7%	54.8%
e-Waste	0.1%	0.2%	0.3%	0.3%	0.2%
Others	26.2%	15.8%	10.1%	7.9%	15.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

In terms of recyclable materials, it was found that in overall about 30.0% of major recyclable materials were disposed of from the campus, this includes mainly papers (15.9%), plastics (12.2%), glass (0.7%), and metals (include ferrous metals, non-ferrous metals and some aluminium) (1.2%). Offices areas generated the highest percentage of recyclable items, followed by student affairs, faculties and dormitories.

However, it should be noted that some recyclable materials were being retained in the campus instead of disposing it into the waste bins, especially used newspapers and aluminium cans. In summary of the study of waste composition, it could be said that UKM campus could restructure the waste management in the campus because almost 55% is compostable components (Fig. 1). There is a high potential for converting the waste into fertilizer that can be used for landscaping at UKM rather than dumped into landfill. Hence, implementation of composting method is a way to reduce the amount of food waste disposed at landfills. Besides, the high portions of paper waste generated can be decreased by implementing programs to recover the recyclable items from offices, such as having paper recycling boxes in offices to recover papers items and so forth.

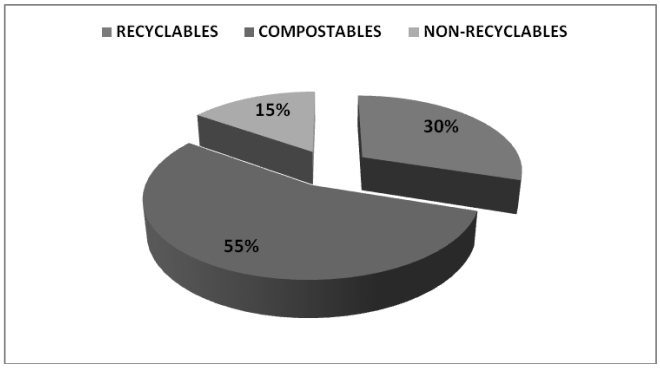

Fig. 1 Waste percentages (by weight) according to the recycling category

Reducing waste disposal into landfill option by composting methods

Composting method is useful to convert organic waste to useful products and that would otherwise have been landfilled [11]. There are several composting techniques such as windrow composting, aerated static pile composting, and in-

vessel composting systems [12]. Table II shows some advantages and disadvantages about the composting techniques.

TABLE II
VARIOUS COMPOSTING METHODS

Techniques	Descriptions
Passive piles	• Require relatively low inputs of labour and technology. • Require turning usually once a year. • Disadvantages: - Slow process - Formation of anaerobic conditions (odour problem) due to infrequent turning and - Potential to overheat and burn.
Turned Windrows	• Elongated composting piles that are turned frequently to maintain aerobic composting conditions • Can be placed under shelters to control composting conditions • The ideal height is from 1.5-1.8m and the width is generally twice the height • Need 3-12 months to complete composting process
Aerated static piles	• A relatively higher technology approach when space is a constraint and composting must be completed within 3-6 months
In-vessel systems	• A high-technology method in which composting is conducted within a fully enclosed system • Warranted if, - Composting must be completed quickly - Odour and leachate control - Limited space - Sufficient resources are availabe

(Sources: Lim Poh Eng, 2005)

Table III shows that the laboratory analysis of waste disposal in UKM. Moisture content in UKM is lower compared to Kuala Lumpur because the sample in UKM is obtained from compactor truck which compresses out the moisture in the samples. Hence, moisture content in UKM is 26% which is lower compared to MSW of Kuala Lumpur which is 55.01% [2]. The C/N ratio (7.51) is lower compared to standard value for composting which in the range of 20 to 35 is best [13]. If organic waste sample C/N ratio is low, which means high nitrogen content, this could be adjusted by adding carbon rich items such as leaves or shredded paper. Hence, composting method could be established in the system of waste management in UKM.

TABLE III
LABORATORY ANALYSIS DATA IN CAMPUS UKM, 2009

Laboratory Analysis	UKM, 2009
Proximate analysis (Wet Basis)	
Mositure Content, % Volatile matter content, % Ash Content, %	26 48 26
Elementary Analysis (Dry Basis)	
Carbon (%) Nitrogen (%) C/N ratio	39.48 5.26 7.51

For waste management technologies options, composting is an environmentally friendly method rather than directly dumped into earth. Benefits of composting [14] are as shown below:-

a) Reduce landfill space
b) Reduce surface and groundwater contamination
c) Reduce methane emissions
d) Reduce transportation costs
e) Reduce air pollution from burning waste
f) Provide more flexible overall waste management
g) Enhance recycling of materials
h) Can be carried out with little capital and operating costs

As indicated above, campus UKM generates a high proportion of organic waste which is more than half of total waste. Besides that, this waste disposed into landfill will be impacts to the environment such as leachate contamination, pest problem and other [15]. Hence, waste diversion is needed and could be converted into valuable components (fertilizers) in more sustainable ways.

In the literature published in Malaysia, a research was carried out to study for vermicomposting method which is combination of 67% organic waste and 33% of vermicompost will be the best combination for compost because the process will complete in 21 days [15]. The result also shows that vermicomposting method could reduce at least 35% of generation waste rather than directly disposal into landfill [15]. Fig. 2 and Table IV shows the optimal vermicomposting structure and function of the materials to organic waste.

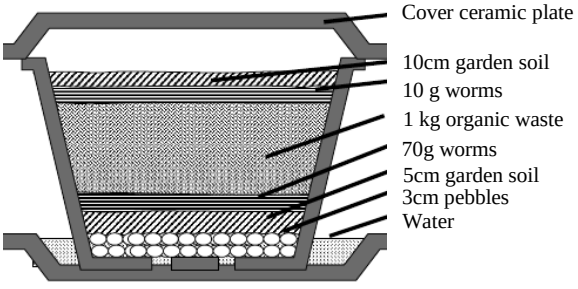

Fig. 2 Optimal vermicomposting by layering method

(Source: Fauziah et al., 2009)

TABLE IV
DETAILED FUNCTION OF EACH MATERIALS IN THE VERMICOMPOSTING SET-UP

Materials	Functions
Pebbles	To act as drainage material to collect excess water from the system
Garden soil (bottom)	To provide bedding material for worms prior to complete adaptation to new system
Garden soil (top)	To cover worms and waste materials, to reduce light penetration and prevent offensive odour from escaping the system
Bottom plate with water	To trap worms that escape from the opening of the flower pot base
Cover plate (top)	To prevent worms from getting preyed, to avoid insect from getting into the system, to totally remove the source of light

(Source: Fauziah et al., 2009)

From the study [15], the vermicomposting method has been done successfully in the Malaysian climate by local method with lab-scale experiment. Hence, UKM may consider using vermicomposting method to manage the high proportion of organic waste generated in UKM campus.

IV. CONCLUSIONS

The study has been successful in highlighting the composition and characteristics of the solid waste in selected location at UKM. The main components of the waste are food, paper and plastics, which is more than 80% of the total solid waste. The organic content is about 54.9% and the moisture content is around 26%. Major problem occurred at UKM is the management of organic waste. Hence, vermicomposting method can be considered as an option for UKM waste management because the result shows that at least 35% of total waste disposal can be diverted.

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