Municipal Solid Waste Characterization and Quantification as A Measure Towards Effective Solid Waste Management in UniMAP

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Abstract. The most common environmental problems in Malaysia is increasing in solid waste generation. Solid waste generation and composition knowledge is compulsory as a benchmark for the decision making in managing municipal solid waste management strategy. The objective of this study was to measure solid waste generation and compare solid waste composition at cafeterias of UniMAP. Three different cafeterias had been chosen as a sampling location. Waste was sorted out into several components such as food waste, plastic, papers, metal, glass, and other types of waste. There is significance difference in data collection between the three locations where the organic waste was the main component in waste composition. Solid waste sampling and laboratory analysis were carried out based on random sampling method by using American Standard Test Method (ASTM) standards for proximate analysis (moisture content, ash content, volatile matter and fixed carbon). Ultimate analysis which is C:N ratio was carried out. Results showed that total municipal solid waste generated during two weeks of collection at School of Manufacturing, Tuanku Tengku Fauziah Residential College (PFI 2) and Tan Sri Aisyah Ghani Residential College (KKTAG) were 459.9 kg (0.1452 kg/p/day), 709.0 kg (0.0292 kg/p/day) and 201.90 kg (0.0163 kg/p/day). Based on this information, a proper waste management can be introduced to treat organic waste such as food waste and paper including inorganic waste efficiently.

1. Introduction

In Peninsular Malaysia, daily municipal solid waste generation exceeds 19000 tonnes [1]. Food waste, yard wastes and miscellaneous inorganic waste or durable and non-durable goods, packaging and containers that comes from residential are known as municipal solid waste (MSW). In order to keep the city neat and clean, the wastes are operated by environmentally friendly manner where the wastes are stored, collected, transported, processed and disposed [2]. In order to enhance the effectiveness of management of solid waste, an act has been gazetted in 2007 which The Solid Waste and Public Cleansing

Management Act 2007 [1] where it has become the main principle for assisting strategies, policies and plan for solid waste management. Material that is no longer use which is produced from the activities of residential, commercial or industrial is known as solid waste [3] Usually, generation of municipal solid waste is generated from the sources of residential, commercial, institutional, and industrial.

2. Experimental

2.1. Sample collection

Three different location of generation had been chosen and the collection is conducted for 2 weeks where each week is collected for 3 days. Two plastics bags are provided, one for organic waste and another one for inorganic waste. The waste collected and segregated according to its component. The waste weighed of each composition are recorded. A statistical through graph and chart used to analyze the result of the study where the data analyzed based on waste composition, comparing the generation of each cafeteria. The waste is presented by food waste generation with the quantity of food waste generated per person per day (kg/capital/day).Organic waste such as food waste and mixed papers are collected for further lab analysis to obtain moisture content, ash content and fixed carbon content, volatile matter content, pH value and C/N ratio content.

2.2. Moisture content

For each organic waste sub-component will be determined by oven drying at temperature of 105°C. The oven drying is for the weight loss stabilizes. The time taken for the oven drying is 1 to 3 hours. The moisture contents of the food waste are calculated as follows [4]:

$$\text{Moisture content (MC\%)} = \frac{Wet\ weight - Dry\ weight}{Wet\ weight} \times 100 \quad (1)$$

2.3. Ash content and fixed carbon

Non-combustible residue is left after the waste is burnt in determination of ash content. It represents the natural substances after carbon, oxygen, sulfur and water. The samples are dried at 750 °C for 1 hour (ASTMD 3174). Next is fixed carbon where the carbon that is found in the material which is left after volatile test. Fixed carbon is determined by removing the mass of volatile from the original mass of the sample [5].

$$\text{Fixed carbon (Wt\% wet basis)} = 100 - (\text{Wt\% moisture content} + \text{Wt\% Ash} + \text{Volatile matter}) \quad (2)$$

2.4. Volatile matter

It is determined by ignition method of the sample at 950°C. The triplicate samples of organic waste used in the moisture content determination is weighed. Then, it is placed in the furnace for 7 minutes at 950 °C (ASTMD3175). The samples are weighed in order to get the ash dry weight with volatile solids being the difference between the dried solids after the combustion [6]. The equation is:

$$\%VS = [(\text{Dry sample weight} - \text{Ash Weight}) / \text{Dry Sample Weight}) 100\%] - MC\% \quad (3)$$

2.5. pH value

Ten grams of the sample is diluted with 100 ml of distilled water. The electrode is rinsed with distilled water. It is rinsed before and also after measurements. The readings are taken three times in order to gain average pH value .

2.6. Carbon to nitrogen (C/N) ratio

Carbon to nitrogen ratio is determined according to standard of ASTM E 777-87 and E 778-87. The organic waste is prepared and baked in 70°C oven for 24 hours. The sample is allowed to cool and was ground into a powder. Two grams of the samples is placed in a small aluminium cone. Then, it is tested by using CHNS-O analyzer instrument [7].

3. Results and Discussions

3.1. Waste Generation

Figure 1 shows the waste generation of each cafeteria for 6 days where it represents two consecutive weeks. Total municipal solid waste generated during two weeks of collection at School of Manufacturing, PFI 2 and KKTAG were 459.9 kg(0.1452 kg/p/day), 709.0 kg (0.0292 kg/p/day) and 201.90 kg(0.0163 kg/p/day) respectively.

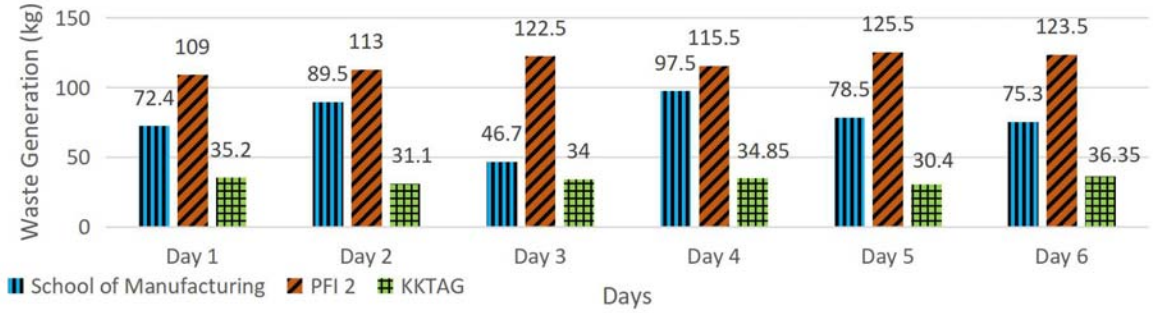

Figure 1. Waste generation of each cafeteria for 6 days collection.

3.2. Waste composition

Figure 2 (a) shows the waste composition of School of Manufacturing where food waste is the highest generation (85.19%), followed by plastics (7.02%), papers (5.85%) and metal (1.96%). As for glass and other component is zero generation. As for figure 2 (b) shows the waste composition of PFI2 cafeteria where food waste is highest generation(83.22%), followed by plastics (7.02%), papers (5.83%), metals (1.96%) and glass including other waste has zero generation. Figure 2 (c) illustrated food waste (59.14%) also the highest generation, followed by plastics (25.26%), papers (11.14%), metal (4.46% and glass including other waste also has zero generation at the cafeteria.

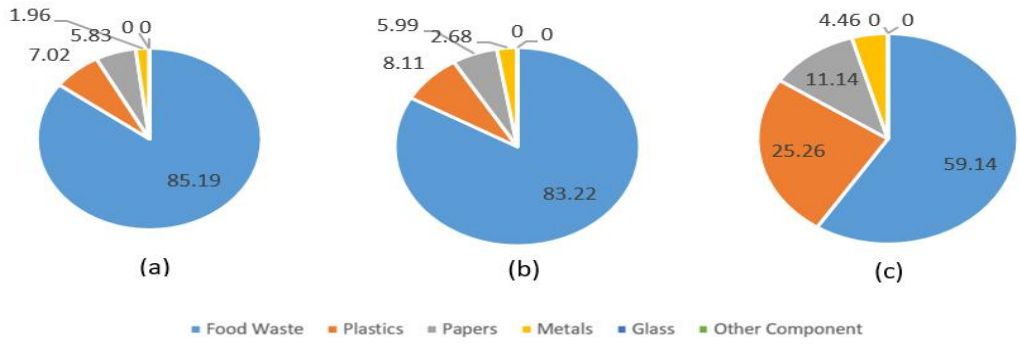

Figure 2. Waste composition for 2 weeks a) School of Manufacturing cafeteria; b) PFI 2 cafeteria; c) KKTAG cafeteria.

3.3. Chemical properties of organic waste

Table 1 shows the results of chemical properties of food waste and paper waste that carried out based on ASTM standards for knowing the suitable method for recycling of organic waste.

Table 1. Chemical properties of organic waste at each cafeteria.

	School of Manufacturing		**PFI 2**		**KKTAG**	
Waste Component	**Food Waste**	**Paper Waste**	**Food Waste**	**Paper Waste**	**Food Waste**	**Paper Waste**
Moisture Content (%)	59.7	5.52	81.00	4.06	77.16	4.45
Ash Content (%)	7.67	34.97	1.51	35.05	2.22	30.83
Volatile Matter (%)	3.73	51.75	3.26	55.79	5.04	57.04
Fixed carbon (%)	28.89	7.77	14.22	5.10	15.58	7.68
pH Content (%)	7.147	6.644	7.102	6.547	7.275	5.941

Table 1 shows the results of chemical properties of food waste and paper waste. Organic waste recycling usually undergoes composting process whether aerobic composting or anaerobic composting. The best moisture content when composting was within the range of 50% to 60% [8]. The content of moisture could be adjust by blending the component. Paper waste is not suitable for composting since it has lower moisture content where it could slow down the microbial growth for composting process. The ash range should between 0.49 to 12.58% [6]. It was the fastest increment the nutrient quality of a compost when ash content is low. Next, the range of volatile matter was 20% to 35%. Paper waste is not suitable for composting since it can lead burst into flame. When the volatile content was higher, it was easier to be ignited at low temperature [9].

Based on table 1, food waste at the three location had higher fixed carbon compared to paper waste with the value 28.89%, 14.22 % and 15.58 % respectively. High percentage of fixed carbon showed that fixed carbon need a longer detention time of the surface. This is because to achieve complete combustion compared to paper waste [10]. In addition, the optimum range of pH composting was between 7 and 8 [7]. Thus, food waste meets the requirement of pH value. Table 2 shows the results of carbon to nitrogen ratio.

The carbon to nitrogen (C:N) ratio was 7.23 for food waste while paper waste had 27.38. The C:N ratio of food waste was low compared to the C:N ratio for active composting. The range of C:N ratio of active composting was 10:1 including 15:1 [7]. However, the C:N ratio could be increased by adding more meat, fruits and vegetables at the feed stock [5]. Paper waste are not suitable for composting since the values are out of the range from composting criteria.

Table 2. Carbon to nitrogen ratio (C/N) ratio.

Waste Component	**Food Waste**	**Paper Waste**
C/N ratio	7.23 **:** 1	27.38 **:** 1

4. Conclusions

This project provides an opportunity to study on municipal solid waste characterization and quantification at three cafeterias which are School of Manufacturing, PFI 2 and KKTAG cafeteria at Universiti Malaysia Perlis. Organic waste which is food waste dominated the solid waste composition. The increasing amount of organic waste specify the necessary for collection including removal frequently. Hence, added-value products efficient to be generated such as compost or biogas. Therefore, Universiti Malaysia Perlis should develop a policy where each cafeterias in UniMAP is compulsory to separate their recyclable wastes. As for disposing of organic waste which is the food waste, UniMAP should propose to buy the composting machine where organic fertilizers can be produced. Organic waste such as papers and inorganic waste such as plastics, metal, glass and other composition that has value can be sent to recycling centre for recycle.

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