Baseline for food waste generation – A case study in Universiti Tun Hussein Onn Malaysia cafeterias

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Abstract. Increasing population and economy status have contributed to the increasing volume of solid wastes produced in Malaysia and it creates problems on the existing solid waste management system. Ineffective waste management system was one of the issues that often discussed. The purpose of this study was to suggest the best method for managing food waste in Universiti Tun Hussein Onn Malaysia (UTHM) cafeterias. The scope of the study was to identify the type and quantity of waste generated in each cafeteria. The study area was carried out at six cafeteria in UTHM including residential college cafeteria which are Tun Dr.Ismail (TDI), Tun Fatimah (TF) and Tun Syed Nasir (TSN), G3’s cafeteria, Arked, and Dr. Munie’s cafeteria located at the Faculty of Civil and Environmental Engineering (FKAAS). In this study, food waste was quantified in unit of kilogram (kg). Results of the study showed that total food waste in selected UTHM’s cafeterias was 6197.5 kg for two months. Food waste generated in G3’s cafeteria was the highest value with 1823.5 kg among another cafeteria. This is due to strategic location for students and staff to take meals, the variety of food sold and reasonable price were major factors of generating food waste. Meanwhile, the Dr. Munie’s cafeteria located in FKAAS recorded the least total production of food waste as staffs and students take their meals at others cafeterias. Through literature review, there are list of methods on waste management were identified and composting method was suggested for food waste management in UTHM since the waste was produce in very large quantity.

1. Introduction
The amount of solid waste generated was directly proportional to the population growth [1]. Solid waste or garbage and all kinds of waste materials generated by human activity refers to materials that are not useful and no longer required [1]. Solid waste was one of three major environmental problems faced by most Local Authorities (PBT) in addition to the problem of air pollution and water pollution [2]. In Malaysia, food wastes make up 45 percent of the total 29,000 tons of solid waste generated within a day [3]. By 2020, an estimated 30,000 tons of solid waste will be generated within a day due to the increasing number of a population exceeding 28 million people [3]. This development resulted in curtailment lifespan of 176 landfills operating in Malaysia [3]. UTHM allocated about one million a year to pay contractors for picking up trash from campus to landfill and this cost was excluding the cost of waste management from cafeterias and residential colleges. Cafeteria operators pay another private contractor for the collection of solid waste generated in their cafeterias. Therefore, a suitable solid waste management method for food waste in UTHM will be proposed in this paper to reduce cost of waste management. This method hopefully will assist UTHM in sustainable waste management for food waste and generate new income for UTHM.
2. Literature review

Solid waste management was one of the main problems faced by society, particularly in urban areas [4]. The process of urbanization and rapid industrialization led to an increase in solid waste [4]. The cost of solid waste management from the stage of collecting, transportation, and disposal was very high [4]. Therefore, the quantity of solid waste, especially domestic solid wastes should be reduced in order to reduce government spending [4]. Municipal Solid Waste (MSW) was known as the waste generated from the area around the city, residential, commercial, institutional and industrial [5]. Municipal solid waste produced containing material which is durable and non-durable material that is deemed to be heterogeneous [5]. MSW can be classified into two major categories of organic waste and inorganic waste (table 1). Organic waste consists of plant and animal waste, where the waste was easily decomposed by soil microbial reactions produced a foul odor and harmful gases such as methane. While, non-organic waste takes a long time to decompose [5].

Table 1. Sources of municipal solid waste (MSW) generation

| Classification | Composition | General |
|---------------|-------------|---------|
| Organic waste | Food        | Beef, chicken, vegetables |
|               | Garden wastes | Dried leaves, twigs |
|               | Textile / rubber | Leathers, clothes, carpet |
|               | Paper product | Newspaper, box, paper cups |
|               |              | Polyethylene terephthalate (1) *
|               |              | High density polyethylene (2), |
|               |              | Polyvinyl chloride (3), |
|               |              | Low-density polyethylene (4), |
|               |              | Polypropylene (5), Polystyrene (6), |
|               |              | Multilayer plastic (7) |
| Non-organic waste | Plastic | Glass plates, glass windows, light bulbs |
|               | Glass       | Glass, aluminium, zinc, chromium |
|               | Metal       | Ferrous, aluminium, zinc, chromium |

* Plastic coding system, Society of the Plastics Industry, Inc.[5]

The problem of solid waste management and disposal sites in Malaysia has increased its landfill management system and became inefficient. These include weaknesses in the system of waste collection and management of waste in landfills [6]. The daily amount of solid waste generated reaches approximately 30,000 tons and about 70 percent will be collected and reported about 95 percent of waste collected will be disposed of in a landfill with only about 5 percent recyclable [7]. Table 2 shows the number of existing landfills in Malaysia.

Table 2. Total disposal site in Malaysia

| Country | Landfills that operated | Landfills that not operated | Total |
|---------|-------------------------|----------------------------|-------|
|         |                         |                            |       |

2
Based on table 2, total landfills were 296 but only 165 operated. In Johor, total landfills were 37 and only 14 landfills operated. Solid waste management continues to be a major challenge in urban areas around the world, especially in towns and villages where the increase of solid waste at an alarming rate, especially in underdeveloped countries [8]. The steady economic growth and low unemployment are driven by the political situation and there are a number of resources to make Malaysia a developed country on a par with [9]. Table 3 shows the methods of solid waste management.

Table 3 indicates the waste management practiced in Malaysia. According to Periathamby [10], in 2006, sanitary landfill produces 30.9% from total waste disposed. In 2020, landfill will target becoming high percentage of waste disposed with 44.1% follow by 22.0%, recycling, 16.8% for incineration, inert landfill, 9.1% and composting 8.0%. Referring to Jabatan Pengurusan Sisa Pepejal Negara [15], construction of the landfill will have an effect on greenhouse gas emissions to 50% by 2020. In Japan, from the 1960s and up to now, solid waste was beginning to dispose by incinerator. Japan has the world's leading incinerator facility. In 2011, a total of 1211 incinerator facilities is provided for managing the waste generated. Features of this high-technology combustion were promoted as a safe technology and risk of contamination of the population can be reduced [11].

In Singapore, 90% of solid waste was disposed by using incinerators and only 10% disposed in sanitary landfills. The resulting energy recovered from incineration was for electricity generation in which 980 million kWh of electricity could be generated each year [12]. While in India, Refuse Derived Fuel (RDF) is defined as the heat generated from the waste materials that have been processed to be used as a secondary or substitute fuel in industrial solid fuel. RDF is used as a replacement for coal (fossil fuels) in high-energy industrial processes such as power production, cement kilns, steel making where the use of RDF can be optimized to improve economic performance. In waste management, RDF placed under aerobic composting as waste-to-energy incineration to generate electricity. RDF method is different because the goal is to increase the thermal processing of fuels [13].

| Country       | Method | Article |
|---------------|--------|---------|
| Johor         | 14     | 23      | 37     |
| Kedah         | 8      | 7       | 15     |
| Kelantan      | 13     | 6       | 19     |
| Melaka        | 2      | 5       | 7      |
| Negeri Sembilan | 7  | 11      | 18     |
| Pahang        | 16     | 16      | 32     |
| Perak         | 17     | 12      | 29     |
| Perlis        | 1      | 1       | 2      |
| Pulau Pinang  | 2      | 1       | 3      |
| Sabah         | 19     | 2       | 21     |
| Sarawak       | 49     | 14      | 63     |
| Selangor      | 8      | 14      | 22     |
| Terengganu    | 8      | 12      | 20     |
| WP Kuala Lumpur | 0 | 7       | 7      |
| WP Labuan     | 1      | 0       | 1      |
| Total         | 165    | 131     | 296    |
Furthermore, the methods used to manage solid waste in Thailand are sanitary landfill, composting, open burning, and incineration. There were 97 disposal facilities in which 91 sanitary landfills, 3 incinerators, and 3 integrated facility system that is designed to be placed. Open dumping of solid waste remains an option for some areas because of its low cost and performance effective in getting rid of a large amount of waste. However, this method is not appropriate as it may cause the area to become unsanitary and potential to environmental disaster [14].

3. Methodology
The research process was described in details which each level begins with the initial survey stage to analyze the data. In this study, the primary data collected by manual in each cafeteria. While, there are some obtained through literature review. This review process includes four phases that describe the flow of the study. The first phase refers to the beginning of the study and literature review, the second phase refers to the collection of data and information, third phase and fourth phase refers to data analysis and conclusion and recommendation respectively. Figure 1 shows a flow chart of the study.

| Malaysia |         |         | [10] |
|----------|---------|---------|------|
|          | i. Landfill |         |      |
|          | ii. Recycling |      |      |
|          | iii. Composting |      |      |
|          | iv. Incineration |      |      |
|          | v. Inert landfill |      |      |
|          | vi. Sanitary landfill |      |      |
| Japan    |         |         | [11] |
|          | i. Incinerator |      |      |
|          | ii. Technology biomass |      |      |
|          | iii. Landfill |      |      |
| Singapore| i. Landfill |         | [12] |
|          | ii. Incinerator |      |      |
| India    | i. Composting |         | [13] |
|          | ii. Landfill |      |      |
|          | iii. Refuse Derived Fuel (RDF) |      |      |
|          | iv. Incinerator |      |      |
| Thailand | i. Landfill |         | [14] |
|          | ii. Incinerator |      |      |
|          | iii. Composting |      |      |
|          | iv. Open burning |      |      |
In this paper, the method proposed was composting that seen suitable with high generation produced by all cafeteria in UTHM.

4. Data Analysis

4.1. Total of food waste generated in UTHM

The analysis was performed to determine the quantity of food waste generated in each cafeteria located at the Universiti Tun Hussein Onn Malaysia (UTHM). From the data collected in each cafeteria located at UTHM, food waste generation schedule has been created as shown in table 4.

Table 4 shows the amount of food waste generated in each cafeteria located in the UTHM. It was found that 390.4 kilograms (kg) of food waste generated on Thursday (March 9, 2017) and was the highest weight of food waste collected. On the other hand, only 35.9 kg of food waste generated on Sunday (April 2, 2017). The drastic reduction of food waste was due to mid-sem holiday for students at the University. Total food waste collected can for two months was 6197.5 kg where 3738.8 kg in March and 2458.7 kg in April.

4.2. Comparison of food waste in March and April

Figure 2 shows a comparison of food waste collected in each cafeteria in March and April respectively.

Referring to figure 2, more food waste was collected in March. Food waste collected at G3’s cafeteria was the highest compare to others cafeteria because many students come to have meals. This was due to many types of food sold and students have many choices of food to eat. The strategic location, diversity of food sold and reasonable price were also among factors in the generation of food waste in the cafeteria. In contrast, the result shows the total food waste generated in the Cafeteria Dr. Munie’s produced the least because most of the staff and students take meals in another cafeteria. This was due to food prices are less affordable and the location of the cafeteria was not strategic.

Table 4: Table of food waste generated in each cafeteria located at UTHM (Kg)

| Date | Day  | Faculty | Total  |
|------|------|---------|--------|
|      |      |         |        |
| Date       | Day     | FKAAS | TDI  | TF   | TSN  | ARKED | G3   |
|------------|---------|-------|------|------|------|-------|------|
| 5-March    | Sunday  | 4.3   | 28   | 32.5 | 18.7 | 68    | 140.8| 292.3|
| 7-March    | Tuesday | 5.8   | 43.5 | 51.7 | 52.5 | 72.5  | 132.1| 358.1|
| 9-March    | Thursday | 0    | 54.4 | 80.4 | 63.2 | 107.2 | 85.2 | 390.4|
| 12-March   | Sunday  | 6.4   | 40   | 43.4 | 38   | 92    | 112  | 331.8|
| 14-March   | Tuesday | 11.2  | 60   | 54.8 | 55.1 | 101.3 | 93.8 | 376.2|
| 16-March   | Thursday | 4.2  | 45.9 | 23.2 | 47.1 | 73.2  | 68.8 | 262.4|
| 19-March   | Sunday  | 6.3   | 48.7 | 38.9 | 17.1 | 70.4  | 108  | 289.4|
| 21-March   | Tuesday | 7.1   | 32.4 | 34   | 25   | 81    | 67.7 | 247.2|
| 23-March   | Thursday | 5.2  | 43.2 | 45.3 | 41.3 | 82.7  | 78.4 | 296.1|
| 26-March   | Sunday  | 5.3   | 51.4 | 42.1 | 33   | 82    | 117.4| 331.2|
| 28-March   | Tuesday | 7.2   | 14   | 36   | 21   | 144   | 122  | 344.2|
| 30-March   | Thursday | 6.3  | 17   | 21   | 15.9 | 68.3  | 91   | 219.5|
| 2-April    | Sunday  | 0     | 6.7  | 4.2  | 5.1  | 8.3   | 11.6 | 35.9 |
| 4-April    | Tuesday | 0     | 7.2  | 3.9  | 4.3  | 5.1   | 28.3 | 48.8 |
| 6-April    | Thursday | 0    | 10.8 | 8.2  | 9.8  | 10.1  | 15.8 | 54.7 |
| 9-April    | Sunday  | 3     | 78   | 42   | 23.3 | 35.8  | 38.6 | 220.7|
| 11-April   | Tuesday | 4     | 29   | 21   | 14   | 32    | 68   | 168  |
| 13-April   | Thursday | 3.2  | 24.5 | 33.1 | 35.5 | 41.3  | 55   | 192.6|
| 16-April   | Sunday  | 0     | 36   | 45   | 41.2 | 52.4  | 53   | 227.6|
| 18-April   | Tuesday | 0     | 63.3 | 68.5 | 32   | 66    | 51   | 280.8|
| 20-April   | Thursday | 5    | 46   | 32   | 64   | 86    | 68   | 301  |
| 23-April   | Sunday  | 4.1   | 48   | 37.2 | 24.6 | 55    | 58   | 226.9|
| 25-April   | Tuesday | 2.9   | 25.3 | 41.8 | 57   | 72.5  | 61   | 260.5|
| 27-April   | Thursday | 5.3  | 32   | 33   | 43   | 56    | 51   | 220.3|
| 30-April   | Sunday  | 0     | 32   | 38   | 37.9 | 66    | 47   | 220.9|
| **TOTAL**  |         | **96.8** | **917.3** | **911.2** | **819.6** | **1629.1** | **1823.5** | **6197.5** |

**Figure 2.** Comparison of food waste in March and April

**4.3. Amount of food waste generated in each cafeteria at UTHM**
Figure 3 shows the total amount of food waste generated in March and April. 1823.5 kg of food waste collected in the G3’s cafeteria was the highest in two months. The percentage of food waste collected at cafeteria Dr. Munie’s was the least with only 96.8 kg. The study showed that students and staffs who come to take meals at the cafeteria Dr. Munie's was the least crowded. Based on the analysis carried out for two months, the overall amount of food waste generated in UTHM was 6197.5 kg. The total food waste generated at G3’s cafeteria was the highest because a lot of students who come to take meals. Thus, much of the food produced in the cafeteria. Strategic places, diversity of food sold and reasonable price was also an among factors in generated of food waste in cafeterias. Next, the study also found that total amount of food waste generated in the Cafeteria Dr. Munie's produces was the least because most of the staff and students take meals at another cafeteria.

5. Conclusion
In conclusion, disposal of waste food in March was higher than in April. G3’s cafeteria has recorded the most number of waste generated with the amount of 1823.5 kilograms (kg). While only 96.8 kilograms (kg) of waste generated in the cafeteria Dr. Munie's. Next, the data collected found that the overall amount of food waste generated by all six cafeterias for two months was 6197.5 kilograms (kg). With these data, other studies can be carried out in more detail and used as a reference. Based on previous studies, some methods of solid waste management have been identified including landfill, recycling, composting, incineration, inert landfill and sanitary landfill. According to waste generation waste produced in UTHM, composting method has identified the best and efficient method to manage food waste in six cafeterias in UTHM. This method was recommended as the best solid waste management for the recovery of organic waste. Further, this method cannot completely solve the problem of solid waste, but it will be able to move a number of waste mainly organic waste from landfill and thereby reduce the problem of organic waste. By using this propose a baseline figure for food waste generation in UTHM cafeterias, UTHM can save cost of waste management and also can generate new revenue.

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