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Comprehensive Characteristics of the Municipal Solid Waste Generated in the Faculty of Engineering, UKM

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***Abstract*—**The main aims in this research are to study the solid waste generation in the Faculty of Engineering and Built Environment in the UKM and at the same time to determine composition and some of the waste characteristics likewise: moisture content, density, pH and C/N ratio. For this purpose multiple campaigns were conducted to collect the wastes produced in all hostels, faculties, offices and so on, during 24th of February till 2nd of March 2009, measure and investigate them with regard to both physical and chemical characteristics leading to highlight the necessary management policies. Research locations are Faculty of Engineering and the Canteen nearby that. From the result gained, the most suitable solid waste management solution will be proposed to UKM. The average solid waste generation rate in UKM is 203.38 kg/day. The composition of solid waste generated are glass, plastic, metal, aluminum, organic and inorganic waste and others waste. From the laboratory result, the average moisture content, density, pH and C/N ratio values from the solid waste generated are 49.74%, 165.1 kg/m^3, 5.3, and 7:1 respectively. Since, the food waste (organic waste) were the most dominant component, around 62% from the total waste generated hence, the most suitable solid waste management solution is composting.

***Keywords*—**Solid Waste, Waste Management, Characterization and Composition

I. Introduction

THE rapid urbanization and industrialization has brought about many changes in the quantity and quality of the Municipal Solid Waste (MSW) generated. As a consequence of this, the management of the MSW needs to be revamped to accommodate the changes in the quantity and quality to ensure the longevity of the environment [1]. Inhabitants of any type of communities need to realize the importance of recycling and reuse, whereas the city council should rethink the management style from solely dumping to the recovery of energy from the waste by incinerating and only dumping the inert ash into the landfill. This action would take time and effort but has to be put into action for the welfare of the city dwellers [2]. An important point for the success of a waste management plan is the need for accurate and up to date data on the quality and quantity of the waste that is generated in the area. With this data, proper management strategies can be planed and put into action, not withstanding the fact that this data could also be used to predict the future trends in the quantity and quality of the MSW. Thus allowing the authorities to take anticipating measures so that the MSW generated will be managed in a proper manner [1], [2].

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II. Location Background

University Kebangsaan Malaysia (UKM) main campus is located in Bangi, Selangor. The Physical facilities that are existing on the campus includes residential colleges, unit guest house, 12 faculties, administration blocks, main library, Pusanika, Health center, canteens and cafeterias, research centers, and finally sporting fields and UKM stadium. Currently the population of students and staff in UKM is about 24800 comprising of about 17500 undergraduate students, 5500 postgraduate students and about 1800 staff. A wide and diverse range of activities and large number of campus populations creates the need for managed and proper waste disposal system.

Faculty Engineering and Built Environment is one of the earliest established faculties in UKM. The location of canteen and faculty of Engineering, the studied sites are near the UKM Lake on eastern part of UKM campus. Versus the canteen which is comprised of one building only, the faculty of engineering consists of three different building connected to each other, each one 3 floors. Currently the population of all the students and staffs in the faculty of engineering is estimated about 3000 which is about 8.5% of the whole UKM population.

For this purpose that is, investigating the waste generation rate and characteristics, multiple campaigns were conducted to collect the wastes produced in all hostels, faculties, offices and so on, during 24th of February till 2nd of March 2009, measure and investigate them with regard to both physical and chemical characteristics leading to highlight the necessary management policies.

A short term study survey was carried out in the faculty of engineering and the nearby canteen to determine the waste

generation and also some of the physio-chemical characteristics of the waste generated daily. Here are the items investigated during the survey:

- Waste generation
- Waste composition
- Waste characterization

In this survey the generation of all kind of solid waste generated in the faculty of engineering and canteen nearby is assessed. Table 1 shows the waste generation and composition in the faculty of engineering and the canteen nearby that.

TABLE I
WASTE GENERATION AND COMPOSITION IN THE FACULTY OF ENGINEERING

Dates of Sampling	Day	Recyclable solid wastes			Non-recyclable solid wastes					Daily Generation (kg)
		Paper (kg)	Plastic (kg)	Aluminum (kg)	Glass (kg)	Food Waste (Organic) (kg)	Inorganic Waste (kg)	e-Waste (kg)	Others (kg)	
23 Feb 2009	Monday	41	51.5	1	2	115	3	1	1	215.5
24 Feb 2009	Tuesday	46	48.9	1	1.2	126.8	8	1	1	233.9
25 Feb 2009	Wednesday	31.6	32.9	1	1	132	6	1	1	206.5
26 Feb 2009	Thursday	26.8	42.5	1	1.5	190	6.5	1	1	270.3
27 Feb 2009	Friday	28	31.3	1	2	140	7	1	1	211.3
28 Feb 2009	Saturday	-	-	-	-	-	-	-	-	-
1 Mar 2009	Sunday	-	-	-	-	-	-	-	-	-
	Total Waste	173.4	207.1	5	7.7	703.8	30.5	5	5	1137.5

As it is shown in the Table 1, the waste generation has an almost constant rate during the week and reaches a peak in Thursday. There is some ignorable fluctuation in the waste generation that might have reasons like population fluctuation in those days. Waste generation is not announced for the weekend as there were no collection happening at those days and also the generation has almost a very small portion in the mentioned days. The waste generated in the weekend is considered as the waste generated in Monday.

This study was initiated to help with the identification and also characterization of the waste that is generated in the UKM campus and specifically faculty of Engineering and built Environment. The study will give a complete characteristic of the waste from all the different sources. The characterization will include composition, density, and proximate analysis, elemental analysis including heavy metals and also Moisture content and pH. It is envisaged that this data base will be able to answer most if not all the questions put forward before this.

The bar graph below better illustrates the amount of waste generated in the faculty of Engineering and Built Environment.

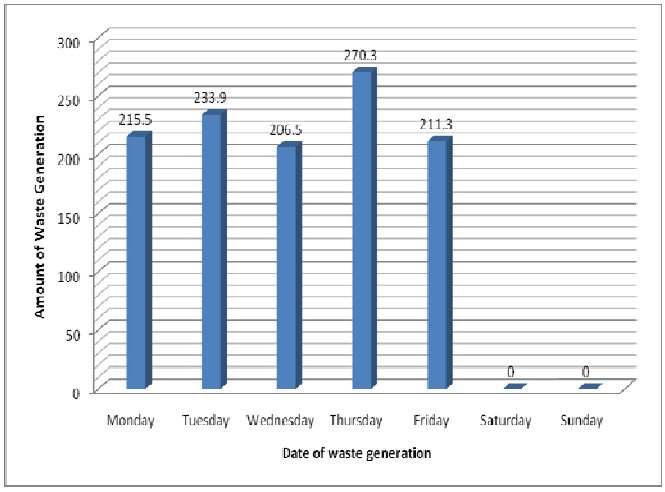

Fig. 1 Daily waste generations (Kg)

The solid waste generated in faculty of engineering contains a very high concentration of organic waste and consequently has high moisture content. The waste composition study (Figure 2) found that the main components of the waste found in the faculty of engineering were food,

paper, and plastic respectively, which comprise almost 95% of overall weight.

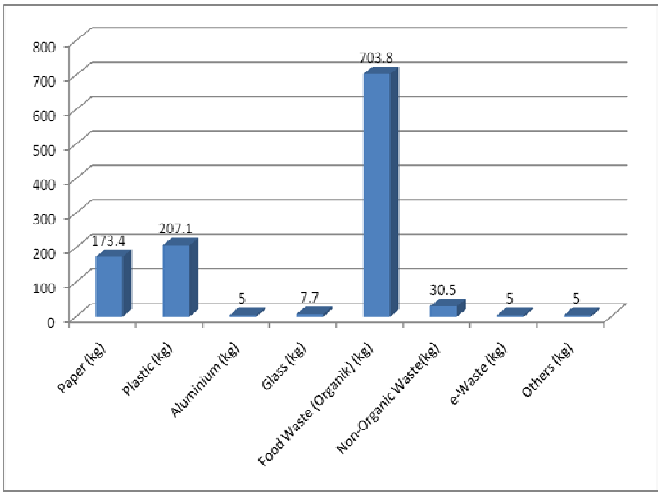

Fig. 2 The composition of the solid waste in the faculty of engineering

III. Materials and Methods

Samples for this study were obtained from the municipal solid waste (MSW) generated in the faculty of engineering and the canteen nearby that. This was done according to the American Society of Testing and Material standard [3], where solid wastes are sorted into two main groups; recyclable and non-recyclable materials.

The solid wastes were separated according to plastic, paper, aluminum, glass, e-waste, food waste and others. Solid wastes were collected in a 660 MGB container outside the buildings. This is to ensure that the total daily generation waste is collected together before the segregation process. Moreover, daily solid waste generation was weighed with weighing machine and recorded. After that, each category of the waste are weighed and recorded while samples were taken for further analysis at the laboratories [4].

The determination of the total moisture content was again done according to ASTM [5], so, once the waste was sorted, the samples were weighted and sent to the laboratory for further analysis. For the moisture content analysis, the amount of moisture lost during the experiment means 24 hours in oven with the temperature of 75-76 was considered as total moisture content of the samples. Once the samples reached the laboratory, the samples were weighted initially to determine if there was any moisture lost during the transportation.

The method we used here for the determination of density was based on "Standard Metode Pengambilan dan Pengukuran Contoh Timbunan dan Komposisi Sampah Perkotaan". This method is a well known method in eastern Asia. A box with the dimension of 50 cm eachside was selected and a mixture of waste was poured into it. No compaction was applied unless the box was fully filled with solid waste. Afterward for three time only, the box was lifted to the height of 20 cm and droped. The density now was calculated by deviding the weight of the box over its new height [6].

For the Carbon to Nitrogen ratio (C/N) experiment the food wastes are supposed to be already dried. For this purpose as described earlier for moisture content experiment, the food wastes should be kept in the oven for 24hrs but not with the same temperature as of the moisture content, but in the 70 c. After that the food waste residues need to be smashed in order to get the solid waste in powder form. About 2 grams of this smashed and powder formed solid waste is needed to be burned in the CHNS-O analyzer machine (Model EA 1108) to determine the amount of carbon, nitrogen, oxygen and other similar parameters. Ultimate analyses were carried out using the CHN analyzer (Model EA 1108), which was in accordance to the procedures as required by ASTM [7], [8].

The determination of pH value analysis was referred to Carnes et al. 1970 [9]. About 10 gram sample of organic waste is poured into 500 ml distilled water and stir vigorously for 3 to 5 minutes. Then, let the mixture settle and measure pH via pH meter.

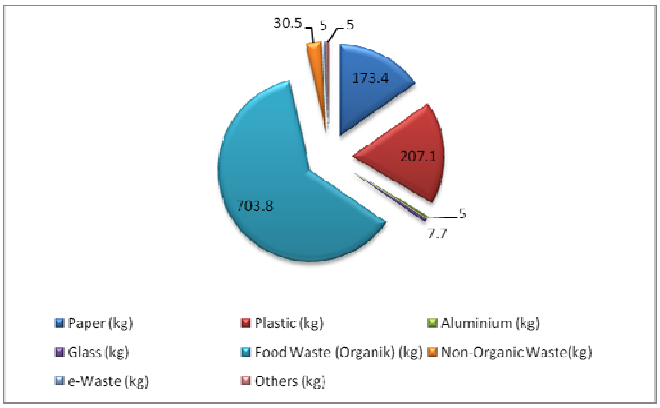

Fig. 3 Solid Waste Composition in the Faculty of Engineering

IV. Results and Discussion

This pie graph better illustrates the composition of solid waste in the Faculty of Engineering. According to this graph Food waste (organic waste) comprises more than 62% of all the waste generated during the sampling period.

Aluminum cans and e-waste placed last in this comparison made between wastes generated in the faculty. According to this graph, the plastic category placed second with 207.1 kg of generation which is about 18% of the whole waste generated is the faculty of engineering. Paper wastes were also of a great portion compare to the other categories. This category form the 15% of the whole waste generated in the faculty. Aluminum cans, glasses, non-organic wastes, e-wastes and other wastes all together constitute about the 5% of all waste generated in the faculty of engineering. Figure 3 better illustrates the composition of solid waste in the faculty of engineering. As it is quite clear from this bar graph, the inimitable category is the food waste category with about 62%

of all the amount of solid waste generated in the faculty of engineering.

At the laboratory, the determinations of the total moisture content, pH, Carbon to Nitrogen and bulk density were carried out. These experiments were carried out as prescribed by the American Society for Testing and Materials (ASTM). Table 2 shows the moisture content results.

TABLE II
THE AMOUNT OF MOISTURE CONTENT FOR BOTH FOOD WASTE AND OTHER WASTES (%)

	Sample 1	*Sample 2*	*Sample3*	*Average*
Paper	8.5	26.6	4.5	13.2
Aluminum	3.2	25.0	0.0	9.4
Plastic (Bottle)	5.1	0.9	9.8	5.3
Drinking box	7.5	8.7	11.5	9.2
P.S (Inorganic)	22.7	33.3	66.7	40.9
Plastic Bag	20.7	8.3	20.0	16.3
Food waste	75.6	70.0	66.2	70.6

P.S stands for Polystyrene.

According to the method that was discussed in Materials and Methods for the measurement of density and what the standard method states [6], the density is calculated for three different samples of food waste and three different samples of other wastes. Table 3 shows the results.

TABLE III
SOLID WASTE DENSITY (KG/M$^{3)}$

	Sample 1	*Sample 2*	*Sample3*	*Average*
Food wastes	549.74	458.00	530.12	512.62
Other wastes	42.2	38.94	22.3	34.48

For pH measurement just like the other parameters, three samples were taken from the solid wastes in three different days. As the raining days might affect the pH results, the three mentioned samples were taken in three different days to remove the probable raining problems. Samples were taken mostly from food wastes and paper wastes. Here, just the results are announced.

TABLE IV
SOLID WASTE PH

	Sample 1	*Sample 2*	*Sample 3*	*Average pH*
Day 1	4.7	4.4	4.5	4.5
Day 2	5.4	5.1	5.7	5.4
Day 3	5.8	6	6.3	6

Ultimate analysis were carried out using the CHN analyzer (Model EA 1108), which was in accordance to the procedures as required by ASTM [7], [8]. This method gave results for Carbon, Hydrogen, Oxygen, Nitrogen, and Sulphur content in the waste. Here in this survey only the amount of Carbon and nitrogen and also their proportion are given. Table 5 shows the results for C/N ratio. For this experiment only, 5 samples were provided for achieving more accurate results.

TABLE V
C/N RATIO RESULTS

	Carbon (%)	*Nitrogen (%)*	*C/N ratio*
Sample 1	50.0166	7.7729	6.43:1
Sample 2	42.9839	5.9073	7.28:1
Sample 3	49.3133	7.6388	6.46:1
Sample 4	45.8577	2.7789	16.50:1
Sample 5	50.5949	9.8079	5.16:1
Average	47.75328	6.78116	7.04:1

V. CONCLUSION

The results showed that the amount of food waste (organic waste) is almost 62% of the whole waste generated in the faculty of engineering and the canteen nearby that. As the most kind of organic wastes are not recyclable, it seems for this huge percentage of the waste most suitable approach is to use them for composting. As the food wastes are very high in nutrient content the compost resulting from them would be high in nutrient content as well. Moreover, As the C/N ratio here is in high levels too, the compost will heat up well but the amount of the Nitrogen is not in a very satisfaction range that might make the compost become hot and somehow odorous.

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