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Solid wastes characterization in University of Science and Technology of Southern Philippines, Cagayan de Oro Campus

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Key words: Characterization, Composition, Generation rate, Population, Solid waste

Abstract

The study on waste characterization was prioritized to obtain the salient data to improve the waste management in the university. This study was conducted in University of Science and Technology of Southern Philippines, Cagayan de Oro City campus to find out the composition of solid waste generated in a building per day, to correlate the population and the waste that was generated in the university and to predict how much waste the university would generate in the future. Results have shown that among the waste composition, paper has the highest percentage of weight (Weight% = 28.42) and volume (Volume% = 23.57%). Statistical analysis showed that at 5 percent level of significance and p-value ((p =0.104> 0.05), there is no significant relationship between population density and waste generation rate in the university. Based on existing data, the researchers predicted the future generation rate of the university to be more than 10,000kg or 200,000,000cm^3 of waste in five years. It is recommended that the administration of this university should strictly implement the rules and regulation relating to solid waste management. The administration together with the unit heads of the colleges / departments should conduct an information, education, and campaign to give awareness to the students, faculty and staff of this university in the proper waste segregation.

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Introduction

City authorities in developing countries are facing a major challenge which is the Solid Waste Management (SWM) mainly due to the increase of waste generation rate the burden posed on the municipal budget as a result of the high costs associated to its management, the lack of understanding over a diversity of factors that affect the different stages of waste management and linkages necessary to enable the entire handling system functioning (Guerrero *et al*., 2013).

The enactment of the Ecological Solid Waste Management Act prompted higher education institutions including State Universities and Colleges (SUCs) to incorporate ecological waste management in the school system (Gequinto, 2017). Nowadays, management and recycling of waste materials is one of the important economic and environment issues that must be considered by policy makers to attain sustainable development of a society. Effective management of solid wastes requires a complete understanding of composition of wastes as well as activities involved in its generation (Farmer *et al*., 1997). According to Robles (2015), Solid Waste Management is a way of controlling waste production, it is associated with storing, collecting, transporting, processing and disposing of solid waste that is in agreement with the codes of conservation, public health, engineering, economics and other environmental concerns.

The implementation and enforcement of the provisions of this Act shall be the primary responsibility of the Local Government Units (LGUs) within their respective jurisdictions as stipulated in the Republic Act 7160, otherwise known as the Local Government Code of 1991. According to Gequinto (2017), it was stated in the law that segregation and collection of solid waste shall be conducted at the barangay level while collection of non-recyclable materials and special wastes shall be the duty of the municipality or city.

The City Local Environment and Natural Resource Office (CLENRO) encourages the residents of Cagayan de Oro City to participate in the proper waste segregation, since the old dumpsite in Zayas was already closed last April 2017. The wastes that were collected by the garbage collector are deposited into the sanitary landfill located in Barangay Pagalungan since they are only collecting residual waste. The closure of Zayas Landfill in Cagayan de Oro City last April 2017 obliged the people in Cagayan de Oro to explore more alternative waste management options to begin overcoming its primary reliance on landfilling for waste disposal. Thus, University of Science and Technology of Southern Philippines (USTP-CDO campus) is planning to make its own Material Recovery Facility (MRF) to ensure that only residual waste is the only waste coming out from the campus. Waste segregation does not only limit in reducing the production of wastes but it can also be a source of income. University of Science and Technology of Southern Philippines is one of the fastest growing state universities in the country. However, researchers found that there was limited research study related to solid waste characterization conducted in this university. Thus the study determined the composition, weight and volume of wastes generated by the university. Specifically the research study focus on the following objectives: To determine the composition and proportion of solid wastes generated from selected building, assess the relationship between the population and the waste generation rate, and make future projection with the generation of solid wastes in five (5) year time.

Materials and methods

Research Design

A descriptive-comparative type of research was used in this study since it determines the waste composition that was generated in the university. A comparative method was used in the study since the researchers also determined which of the solid wastes has the highest percentage of generation rate.

Description of Study Area

The University of Science and Technology of Southern Philippines, Cagayan de Oro Campus is located at Claro M. Recto Avenue, Lapasan, Cagayan de Oro City (see Fig. 1). The University has a total of 43 buildings,

however, there were only 22 buildings which are being used. The University has approximately 10,000 individuals including students, faculty and other personnel. The test was conducted in order to determine the wastes present in the area and to quantify the weight and volume of wastes per building in a day. The building with yellow mark are the selected sampling sites.

Fig. 1. A map of University of Science and Technology of Southern Philippines-CDO campus showing the five sampling sites.

Data Collection Method

Collection of the Sample

The collection of waste started at 5:30pm. Unsorted wastes were taken from each floor of the selected sampling sites. The wastes from each trash bins were collected using trash bags and brought it to the sorting station (building 35). The initial weight and volume of the entire sample was recorded, before sorting.

Determination of Weight and Volume before Air dry

An empty container was used to measure the volume of the collected waste samples. The researchers measured the height and the diameter of the container before placing the waste inside. A 20kg weighing scale was used to measure the weight of the collected sample.

Waste Characterization

In waste characterization, a total of 10 containers were provided to properly segregate the collected waste samples. The researcher's sort the waste samples according to its composition whether paper and other paper products, plastic products, food waste, sanitary waste and other wastes.

Air Drying Process

After the collected wastes have been properly segregated according to its type, the segregated wastes were subjected to air drying for 12 hours. Its purpose is to reduce the amount of water content on the collected solid wastes.

Determination of Weight and Volume after Air dry

After subjecting the segregated wastes to air drying, the researchers measured the wastes again to determine its final weight and volume.

Statistical Analysis

The researchers calculated the percentage of the waste collected in order to determine the highest generated composition of waste in USTP-CDO campus. The researchers also correlate the population of the university to the waste generation rate produced in the campus using Pearson correlation. Linear regression was also used by the researchers in projecting the future waste generation rate that University of Science and Technology of Southern Philippines-CDO campus will produce in five years.

Results and discussion

The study on waste characterization was conducted in University of Science and Technology of Southern Philippines, Cagayan de Oro City (USTP-CDO) campus. The data presented (see Table 1) was gathered during the 12-day sampling period. Table 1 showed the composition of solid wastes generated in the university.

Table 1. The composition and proportion of solid wastes generated in the selected buildings of University of Science and Technology of Southern Philippines – Cagayan de Oro Campus.

Waste Composition	Percentage of Waste Composition (12 days sampling period)	
	Weight (%)	Volume (%)
Paper	28.42	23.57
Paper cups	5.05	13.15
Plastic bottles	10.43	22.35
Plastic wrappers	8.1	15.51
Disposable cups/ spoon/ fork	4.42	8.07
Food waste	22.17	4.57
Sanitary waste	6.11	5.09
Bottles	2.46	1.58
Polystyrene foam	0.13	0.96
Other waste	11.79	5.15

In total, 10 types of wastes were identified; paper, paper cups, plastic bottle, plastic wrappers, disposable cups/spoon/fork, food waste, sanitary waste, polystyrene foam and other wastes (rubber, CDs). Results also showed that paper has the highest percentage both in weight and in volume. The waste stream in schools is characterized by higher amounts of paper and other paper products, compared to food wastes. The main reason for this is that paper and other paper products are the main academic tools for learning and documentation. The paper and other paper products category is prominent in the academic institutions, reflecting the large amounts of stationery used in the learning process. Paper is also used in the packaging of various types of items used in the academic and training institutions (Zohur-uz-Zaman 2014). Meanwhile food waste ranked as second highest percentage of generated waste among other waste composition in terms of weight. However for volume, plastic bottle comes second after paper wastes since it occupies more space due to its varying size.

Fig. 2 illustrates the proportion of the generated wastes in the university. It shows the weight percentage of each composition from the highest down to the lowest generated composition. Based on the gathered data, the composition of waste generated as shown in Fig. 3, paper predominates among all other waste composition both weight and volume. Paper has a percentage of 28.42% (Kg) and 23.57% (cm^3). According to Arazo (2015) this dominated the waste stream from this source considering that students and school personnel spent most of their office hours in these areas. Followed by food waste 22.17% for weight and plastic bottle 22.35% for volume. Other plastic products are still in higher percentage compared from other waste composition since plastic waste is composed mainly of packaging, plastic products, hard and flexible plastic household items, PET bottles, plastic can, etc. Plastic waste especially packaging materials does not decompose and compact easily which is why it significantly affects transportation cost and landfill life (Phuntsho *et al.,* 2010). Polystyrene foam acquires the lowest percentage for both weight and volume. Polystyrene is a versatile plastic used to make a wide variety of consumer products. Polystyrene also is made into a foam material, called expanded polystyrene (EPS) or extruded polystyrene (XPS). Expanded polystyrene is used to manufacture foam cups, and polypropylene is used to manufacture plastic cups.

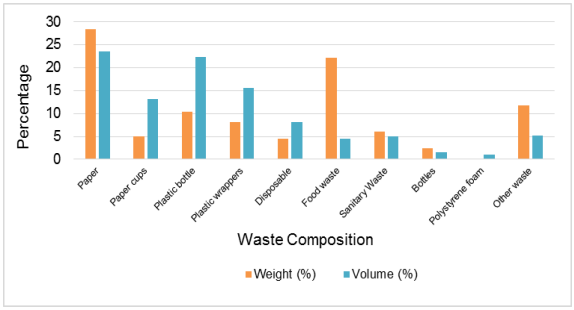

Fig. 2. Percentage weight and volume of wastes generated.

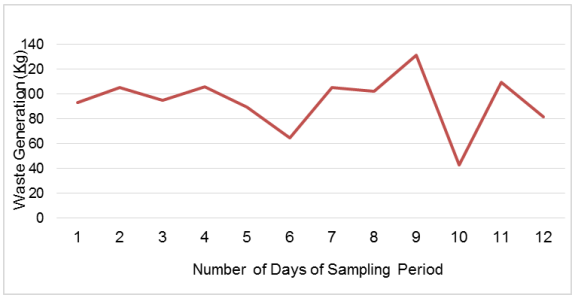

Fig. 3. Waste generated (weight) during the 12-day sampling period.

According to Nnaji (2015) & Kofoworola (2007), Emerging kinds of waste including e-waste and polythene/cellophane materials are presenting an enormous challenge to the already overwhelmed waste management authorities. The quest to maximize profit and ease conveyance has given rise to a new tradition of disposable packaging. Nowadays, consumable products come in disposable packs which end up as waste. Unfortunately many of these packages are non-biodegradable and at the same time, of little interest to scavengers. The need for waste disposal has given rise to the proliferation of open dumps which constitute a grave environmental and health hazard. Table 2 showed the relationship of the population in the university and the generation rate of solid wastes. Results showed ($p = 0.104 > 0.05$) that there is no significant relationship between

population and solid wastes generation. This result is in contrast with the study of Lacang *et al.,* 2019, which showed that the population density is directly proportional to the solid wastes generation of the barangay. Other sources of solid wastes in the university like residuals from trees and construction materials could contribute to the increase in solid wastes generation.

Table 2. Showing the relationship between the population and the solid wastes generated in USTP-CDO campus.

	Population	
Waste Generation	0.340 0.104	Pearson Correlation of C1 and C2 p-value

Thus, number of people does not affect the solid waste generation rate. Though there are floors in a building that numerous numbers of students stayed but that does not mean majority of them generates wastes. However, there are other buildings that few students stayed but they generate more wastes. Based on the result, it showed that population does not really affects the generation rate of solid wastes in the university (see appendix J). According to Saeed (2009), Ezeah & Roberts, (2012) as compared to residential and industrial areas, academic institutions generate relatively small amounts of solid waste. According to Bandara *et al.,* (2007), Daven & Klein (2008) & Lemma (2014) their study also showed that as the number of people in a household increases, there is a reduction in the per capita waste generation rate, thereby establishing the fact that waste generation parameters are considered. The number of employed people in a household also appears to be a contributing factor to waste generation. The average amounts of waste generated per households of different income levels can be used to predict. In Sri Lanka, since municipalities in the country maintain a database of property assessment tax values, the study findings can be extrapolated to other municipalities to estimate waste generation and composition. In addition, other factors may affect the amount and composition of waste. These are climate, living habits, level of education, religious and cultural beliefs, and social and public attitudes. Solid waste generation rate and waste composition based on field surveys and to determine the related socio-economic factors (Bandara *et al.,* 2007). The quantity of MSW generated depends on a number of factors such as food habits, standards of living, degree of commercial activities and seasons (Sharholy *et al.,* 2008). Table 3 presented the future generation rate of solid wastes that USTP-CDO campus would produce in five years.

Table 3. Waste Generation Rate in five (5) years.

Days	Weight (Kg)	Volume (cm^3)
12 days	126.01	2374336
24 days	196	3748672
48 days	335.98	6497344
96 days	615.94	11994688
192 days	1175.86	22989376
384 days	2295.70	44978752
768 days	4535.38	88957504
1536 days	9014.74	176915008
1825 days	10700.34	210013600

Based on the data provided, linear regression was used to predict the waste generation rate that USTP-CDO campus would generate in five years. It shows that, the generation rate of waste increases as the number of year increases. There are several factors that affects the increasing number of wastes, such as the behavior of students, faculty and staff when it comes to waste reduction and increasing quantities of waste being generated. Due to changing lifestyles and consumption patterns, the quantity of waste generated has increased with quality and composition of waste becoming more varied and changing. Industrialization and economic growth has produced more amounts of waste. There is a growing realization of the negative impacts that wastes have had on the local environment (air, water, land, human health etc.) Complexity, costs and coordination of waste management has necessitated multi-stakeholder involvement in every stage of the waste stream. This calls for an integrated approach to waste management (Troschinetz & Mihelcic, 2009). Therefore, it is difficult to assess the land requirement and select appropriate treatment/disposal techniques (Joshi & Ahmed, 2016).

Fig. 4 is the graphical representation of the future generation rate of USTP-CDO campus. As shown in Fig. 4, rate fluctuation occurs. The weight of wastes collected from the selected sampling sites varied as

the number of days passed. From the first day of collection until to the fourth day, the waste collected was constantly increasing and decreasing. It started to decrease dramatically in the sixth day but increase or decrease in the following days that followed. This fluctuations is observed to happen when there are no classes, as can be observed in the ninth, tenth, eleventh and twelve day of sampling. The increased of solid waste generated in the last two days of sample collection was due to events such as program and activities that were held in the campus, making of requirements or projects and weather condition. This factors can change the consumption behavior of many individual.

As shown in Fig. 4, the volume of waste collected from selected buildings varies. The lowest volume of waste that has been collected during the sampling was in the fourth, sixth and tenth day. While the highest volume collected was in the third day of collection. These changes in the volume of wastes during the sampling indicates that the generation of University differ according to its activities during the day. Increasing quantities of waste being generated due to changing lifestyles and consumption patterns, the quantity of waste generated has increased with quality and composition of waste becoming more varied and changing (Zurbrugg, 2003; Gbekor, 2003).

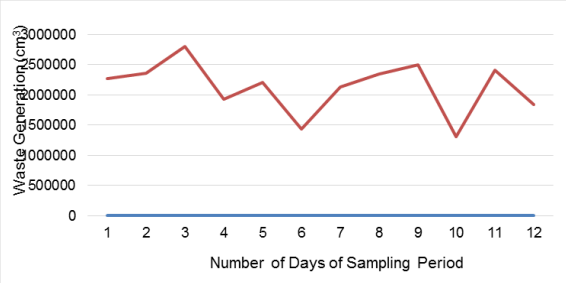

Fig. 4. Waste generated (volumecm^3) during the 12-day sampling period.

Conclusion and recommendations

Based on the findings drawn from the study, the highest waste generated in the campus was paper with a percentage of 28.42% in weight and 23.57% in volume Results shown that there was no significance relationship between the population and the waste generation rate in the university. Moreover, current trend and the future regression is the reliance upon the school administration and the student in minimizing the amount of wastes destined for final disposal. The trend is prompted, by an awareness of the need to waste minimization.

Based on the gathered data, the researchers were able to come up with a facilitative recommendation that would help in reducing the waste generation of this university and in maintaining the cleanliness of the campus. The researchers recommend that the administration of this university must be strict in implementing the rules and regulation relating to solid waste management. In addition, the administration together with the department heads should conduct an Information, Education, and Campaign to give awareness to the students, faculty and staff of this university in the proper waste segregation.

The student leaders must encourage the students and to be the role model in practicing proper waste segregation and in recycling technique. The researchers also recommend that there should be a separate garbage bin for special wastes such as bulb and other electronic wastes, and there should be another garbage bin for food wastes. It should be separated from other biodegradable wastes.

The researchers also strongly recommend that the school must have its own functional Material Recovery Facility (MRF) with a personnel assign to minimize problem in solid wastes. However, it will take time, money and a combined effort on the part of many people. Organized university program should be imposed such as: strengthening and strict implementation of R.A. 9003 better known as Ecological Solid Waste Management act of 2000.

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