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Solid waste characterization and reducing potential at Faculty of Engineering, University of Surabaya

T L Simangunsong^{1*}

¹Chemical Engineering Department, Center for Environmental and Renewable Energy Studies, University of Surabaya

tuani@staff.ubaya.ac.id

Abstract. Reducing solid waste generation is one of the green campus achievement programs at the University of Surabaya (Ubaya). It is essential to determine the quantity and composition of all faculty's solid waste generation. The Faculty of Engineering significantly contributes to the amount of waste generation in Ubaya. Research related to the Faculty of Engineering solid waste characteristics needs to be conducted. The purposes of the study were estimating the quantity of solid waste generation and observing the composition of solid waste at the Faculty of Engineering. The method of this research was a survey of waste generation. The estimation of waste generation was taken for 12 (twelve) days during April 2018. The study results showed that the average solid waste generation faculty of engineering was to be 19.26 kg/day, and the percentage of solid waste was found to be food waste 27%, plastic 25.8%, food packaging 17.6%, Paper 9.8%, and Residue 19.8%.

1. Introduction

Higher education institutions can decrease solid waste generation that has to be disposed to landfills by implementing the green campus concept. University of Surabaya (Ubaya) has applied the concept to develop a sustainable campus. One of the green campus performances is reducing solid waste generation. This can be achieved by engaging solid waste management. The success of the University's solid waste management system can give models of 'best practice' and by that render directions that other campuses can study from and adopt [1]. It is crucial to discover the origins of solid waste generation in any institution to act upon the following management options of the wastes, of which minimization and sorting have been significant [2]. Solid waste management has to consider the composition or characteristics of waste. It is urgent to calculate the amount and composition of all faculty's solid waste generation. Waste characterization must provide complex fractions of the solid waste generation rate or the number of materials before any treatment. Information of the composition and volume of waste is an essential part of selecting the most appropriate system for sustainable waste management systems [3]. Data of the compositions of the waste stream in the campus provides many benefits. Efficient wastebins for each classification of waste such as biodegradable, non-biodegradable, and recyclables can be prepared to cater to the anticipated volume of waste between collection periods. Volume can also be quantified in knowing the frequency or interval of collection, especially when each type of waste is collected in disparate schedules [4].

The increasing number of students, faculty members, and non-teaching personnel have directly increased the University's solid waste [5]. The rapid growth in waste generation presents the implication



of sustainable waste management programs in higher education institutions. The primary aim of integrated solid waste management is to handle community waste in conformity that fulfills public health and environmental concerns, and the public expect to reuse and recycle waste materials [6]. The faculty of Engineering significantly contributes to the amount of waste generation in Ubaya. Estimation of organic solid waste at Engineering Faculty that had conducted before presents 9.78 kg/day but no detail of the composition of the waste. The insufficiency of waste characterization studies in higher education proposes the need to investigate and record waste composition as a means to collect the essential data to suggest better treatment and management alternatives for solid waste [3]. Waste characterization is an important activity of any solid waste management program, and it is a required permanent function contributing to better short, medium, and long solid waste management planning. The waste characterization survey describes what types of components consist of significant parts of Ubaya waste generation. It also discovers the origin of the materials and serves the information required to arrange the priority of recycling and other waste reduction actions. The results of a waste characterization report represent the information required to set up redirection programs effectively, and the study supplies some of the baseline data needed to evaluate a program's improvement over time. The initial point for planning functional waste management systems is to count per capita waste generation and its characterization [6]. An effective and efficient integrated solid waste management system can only successfully begin with understanding on characteristics and generation rate of solid waste [7]. Research related to the Faculty of Engineering solid waste characteristics needs to be conducted. The purposes of the study were estimating the quantity of solid waste generation and observing the composition of solid waste at the Faculty of Engineering. There is a new study of waste characterization at the University of Surabaya. The study is essential for further waste management planning.

2. Methodology

2.1. Sampling area

The study was conducted at the Faculty of Engineering University of Surabaya in April 2018. The research comprised of four main steps as below:

- a. Quantifying the amount of daily generated solid wastes
- b. Solid waste sampling
- c. Identifying waste composition
- d. Data compilation and analysis of the quantities and types of wastes

Three buildings were the collecting spots of waste generation at the Faculty of Engineering. Building TG represented a solid waste generation of the Manufacturing Engineering and Chemical Engineering Department. Building TC appeared as the Electrical and Informatics Engineering Department's waste generation. Building TF showed the solid waste generated by the Industrial Engineering Department and Administration Office Faculty of Engineering.

2.2. Solid waste sampling

In order to determine the generation of the solid waste has been carried out sampling for 12 days in the Faculty of Engineering. The four days were preliminary sampling to determine the primary waste categories. The aim was to simplify the sorting activity. The eight days were the main of solid waste sampling. Sampling methods and procedures for the characterization of the wastes were derived using the Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste (SNI 19-3964- 1994). All samples were taken during working days to assure that the sampling results describe the active university operations during the academic year. The sampling procedure involved unloading and analyzing a quantity of produced daily waste at a collecting spot in a controlled area isolated from winds and separate from other activities. Sampling was done after office operation hours when almost there was no activity inside the buildings, and all wastes were collected by workers and placed in storage rooms. Total generated waste in the collecting spot was collected and weighed. In the isolated site, all samples were hand grouped into 5 primary waste classifications and weighted. Waste

categories included food waste, plastic waste, food packaging, paper, and residue. The plastic waste was segregated into a plastic bottle, drinking cup, plastic spoon, packaging bag, and straw.

3. Results and discussions

3.1. Quantity of waste generation

Knowledge of the characteristics of solid waste in Ubaya is a prerequisite to assist the following sustainable waste management alternatives and to carry out farther research. Generation rate research is essential to ameliorate at all levels of scopes to forbid solid waste generation in the future. Table. 1 represents the quantity of the solid waste.

Table 1. Quantity of solid waste.

| Collecting spot | Average generation rate (kg/day) |
|-----------------|----------------------------------|
| TG Building | 11.31 |
| TF Building | 4.7 |
| TC Building | 3.25 |
| Sum | 19.26 |

The result of sampling shown that the average weight of solid waste generation in the Faculty of Engineering is 19.26 kg per day. The highest quantity of total solid waste was generated from TG Building that represents Manufacturing Engineering and Chemical Engineering Department. It is generated from student activities that gather in the TG building.

3.2. Waste composition

Segregation in this study is based on preliminary sampling at the collecting spot. The following result renders the apparent whereabouts of the cradle of waste, and the classification of wastes by category is simpler at the sources.

Table. 2 Composition of solid waste.

| Type of waste | Average generation rate (kg/day) | Percent generation |
|----------------|----------------------------------|--------------------|
| Food waste | 5.21 | 27 |
| Plastic | 4.93 | 25.8 |
| Food packaging | 3.39 | 17.6 |
| Paper | 1.9 | 9.8 |
| Residue | 3.83 | 19.8 |
| Sum | 19.26 | 100 |

From most to least, the amount of solid waste generated by the Faculty of Engineering is food waste (27 %), Plastic (25.8 %), Residue (19.8 %), food packaging (17.6 %), and Paper (9.8%). Table. 2 represents that food waste, plastic, and residue dominated solid waste generation at the Faculty of Engineering. It has to consider reducing or avoiding waste.

3.2.1. Food waste. Food waste is the central portion of solid waste generated by the Faculty of Engineering, representing 27% of solid waste. This consists of leftover food from breakfast and lunch packs. Food waste is highly varying depending on its sources. Food waste, when segregated from other waste, can be converted into compost or biogas. Zhang et al. [1] shows that the reprocessing possibility is definitely connected to the portion of food waste on campuses, which involves an interrelation between recycling potency and waste depiction. The higher the percentage of food waste, then the recycling potential is higher. It is perceivable that food waste has recognized as recyclable waste in all studies, and its part in a waste generation will undoubtedly have a positive impact on the recycling pace. Painter et al. [8] recommend that campaigns can be used within the higher education which express the information of food waste generation on campus, economic along with environmental gains of food

waste lessening, and education courses must be planned to meditate differences in gender, age, academic curriculum, and level of studies.

3.2.2. Plastic. Plastic waste is the second-largest component in the waste generated in the Faculty of Engineering (25.8%). The plastic waste consists of plastic bottles (8.8%), drinking cups (4.1 %), plastic spoons (2 %), plastic packaging bags (9.9 %), and straw (1%). This type of waste consists mainly of plastic bottles and plastic bags from consuming beverages and mineral water. This plastic waste can be reused and recycled. The percentage of PET bottles is 8.8% and are the primary recyclable plastic waste. Because of its higher economic value in the recycling industry, PET bottles are always picked out by the cleaners who can easily exchange it for money. Most disposed bags are contaminated from source, making sortation difficult with further cleaning procedure needed after segregation. The high percentage of plastic wastes in Ubaya includes mineral drinking water bottles and drinking cups. Considering the non-biodegradable plastics and their immense environment destruction, the best way to control the waste is to eliminate and reduce generating these wastes in the university. Plastic bottles and plastic packaging bags portray the most significant waste creating on campus. It represents 18.7% of the total waste. The study displays that 1% of plastic waste is straw. It shows that the canteen provides straw for beverages. The University demands to ratify policy which will stimulate the using of water dispenser in the canteen, commercial areas, and offices. This will help concentrating plastic stream point for alleviate collection and inhibit the consuming of water bottled drinks by providing water at less cost [9].

3.2.3. Food packaging. Plastic waste is the third largest component in the waste generated in the Faculty of Engineering (17.6%). Most food packaging is designed as single-use. It is not recyclable or reusable because of its plastic-coated surface. Source reduction is the way to decrease food packaging waste. Ubaya canteen still uses food packaging to serve a meal for the students. There is no other way to avoiding this waste except stop using food packaging.

3.2.4. Paper. The quantity of paper waste generation at the Faculty of Engineering is relatively minor (1.9 kg/day), and it creates mostly from teaching activities. The papers are often damp or contaminated with other waste. Cross-contamination of paper is significant issue related to recycling paper from mixture waste. Paper waste decreasing will need more commitment to the paperless policy and enhanced paper recycling by staffs and students [9]. Prevention is the most environmentally preferable means to reduce paper waste.

3.2.5. Residue. Other wastes include the portion of waste that cannot be recycled or reused, for instance tissues due to technological limitations, costs, natural resources, and human resources. There is no method to controlling the residue waste except to avoid and decrease its production. The survey represents that 10.2 % of total residue is tissue. Tissue waste generates from eating activities because most meal tenants at the canteen provide tissue, and there is tissue on fast food packaging.

3.3. Reducing potential. A sustainable and integrated solid waste management plan incorporating completely evolved recycling applications at the university level became a perceptible need. The first pace to applying source reduction and reuse programs is to examine different details of the campus's operation, recognizing potential sources of avoidable waste. This process needs exploring campus-wide sources, as well as tutoring department staff to determine waste. Other procedures can also assist in detecting and prioritize reduction chances. The data supplied by the classification of solid waste can be applied as discernment for potential recycling and waste reduction strategies [10]. Information on the daily quantity of the waste by category can further support dimension the future management facilities that achieve nutrient and energy recovery operations [2]. A satisfactory comprehension of waste generation and composition is crucial for resonating decision making that will guide efficient solid waste management. Hence, for integrated solid waste planning, it is requisite to designate solid waste from the communities and its composition. The solid waste management system needs to be upgraded to fit the

waste's quality, quantity, and composition [11]. The study shows that 77.8 % of total waste can be reduced, such as: food waste, Plastic, and Paper. Food waste composting can be applied because food waste constitutes the highest composition of waste. Food waste (organic) has the potential for recovery to produce fertilizers. It is demanded to adequately manage the number of plastic products used in universities and decrease plastic waste from the origin. It requires applicable policies to lessen or ban the use of plastic bags. To make less the amount of paper generation needs obligation to green initiatives, such as paperless policies and double-sided printing. Paper segregation from other waste and forbid Paper from becoming soiled will raise the recycling rate of the Paper. Source reduction is considered the first and most important of the components. As combated to recycling, which pursues to seize material already in the waste stream, the objective of source reduction is to reverse purchasing and consumption practices to prohibit avoidable waste from being generated in the first place. Waste separation at the beginning escalates the reuse and recycling potential of waste components [12]. An efficient solid waste management system will directly influence the standard of life [11].

4. Conclusion

There is an extensive possibility for implementing a solid waste management system in the Faculty of Engineering, hence improved solid waste management can be adopted. Segregation is crucial for developing a waste management system. Hence the waste should be segregated from the source. The study results showed that the average solid waste generation faculty of engineering was to be 19.26 kg/day, and the percentage of solid waste was found to be food waste 27%, plastic 25.8%, food packaging 17.6%, Paper 9.8%, and residue 19.8%. The material recovery potential of the Faculty of Engineering solid waste for recycling and reuse is very high.

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