

Solid Waste Management Practices at The Academic Institution: Current Situation and Strategic Plan

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Article

Solid Waste Management Practices at The Academic Institution: Current Situation and Strategic Plan

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Abstract. Waste management is one of the actions of environmental management for improving environmental quality. This study describes the waste management in the campus through improvement of operational techniques, starting from container, collection, and transportation. Case study was taken in the university, which the amount of waste generation is about 166.559 kg/day or 0.013 L/person/day. The waste collection system is designed to use individual disaggregated sorting patterns that are adjusted to the composition of the waste, colour differentiation, and label of the container. Amount of sorted containers are 478 pieces. The waste collection system is planned by an indirect individual collection pattern and a temporary shelter plan in the form of a partition wall is adjusted to the composition of the waste. Planning for waste transportation system is using a fixed container system with motor cart under capacity of 2.3 m³ with 1 fleet. Transportation is carried out on a scheduled basis. Transportation management is arranged twice per-day for organic waste, once per-day for valuable waste, once per-week for hazardous waste, once every 2 days for other water. Transportation schedule is carried out twice per-day, in the morning and evening.

Keywords: solid waste; waste generation; container; collection; transportation

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1. Introduction

Waste is one of the most complex and extensive problems in a city, one of which is in the education sector. In addition, waste is the residue from the results of human activities in daily life in the form of solid. The more the number of people with all their activities, generated waste will increase inline with increasing population. An effective and efficient waste management is needed in accordance with various kinds of trash production. Waste management is currently classified as conventional concept, which is only limited for collecting, transporting, and disposing which end up in the final disposal site [1, 2]. According to Indonesian Regulation [3] about Waste Management, it is explained that waste management is a systematic, comprehensive and sustainable activity that includes the reduction and handling of waste. Waste reduction consists of three main parts, namely limiting waste generation (reduce), recycling and recycling (reuse). Waste management consists of sorting, collecting, transporting, processing and final processing. Urban waste management operational techniques consist of sorting, storing, collecting, moving, transporting, processing, and final disposal.

This research took a case of waste management in the university, which classified the generated waste based on the type of activity, as previous studies have been done [4,5,6]. University waste sources are divided into two areas, namely waste from lecture buildings, offices, canteens and open area of parking lot. Generated waste from open area of parking lot, such as dried leaves, was composted and managed by the Faculty of Agriculture. The volume of leaf litter from the park-road is about 0.291 m³/day. The existing composting capacity is about 1.5 m³ or about 70% of average dried leaves for a week of composting. However, the generated waste on the following day cannot be composted directly because composting takes 2-3 weeks, therefore the waste is only limited to being piled up and then burned. For the generated waste from lecture buildings, offices and canteens have not been managed properly, since about 10% has been managed and carried out by third parties. The rest of the rubbish is limited to collecting and transporting, then being burned on empty land to reduce its volume. Waste management by burning can cause some nutrients such as carbon to be lost and if done continuously it will cause pollution in the surrounding environment [4,7].

Therefore this study aims to evaluate the existing waste management and to arrange the strategic planning to improve operational techniques in waste management, including compartment, sorting, collecting, and transporting at University of

Pembangunan Nasional "Veteran" Jawa Timur (UPNVJT).

2. Material and Method

Observation of waste management was conducted in University of Pembangunan Nasional "Veteran" Jawa Timur (UPNVJT) for 2 weeks. UPNVJT has ± 21 Ha of land area with various facilities such as office buildings, lecture rooms, canteens, sports fields, mosques, parks and parking lots, which contributed to generate waste. The total number of UPNVJT members is approximately 12943 people, consist of students, lecturers, and employees.

Implementation of waste management in this case study has four stages, including determination of sampling points, collecting primary data and secondary data, data analysis, and strategic planning. Determination sampling points was carried out to select the collection and composition of waste. The equipment used was adjusted according to method used in Indonesian National Standard [8]. Coordination with the cleaning service, especially in coordinating the installation of trash bags in the trash and the schedule for transporting garbage to the temporary collection place were conducted.



Fig.1. Research area study

Figure 1 shows a research area study at UPNVJT which presented the 3 service blocks, namely:

- Block I has 8 points, including Garden and Security Post, GPPS, GPPS, Tennis Court, Clinic, Faculty of Architecture (FAD), Faculty of Law (FH), Student Housing.
- Block II has 7 points, including Faculty of Economy and Business (FEB), parking lot FEB, Faculty of Engineering (FT), Faculty of Computer Science (FIK), Canteen, Techno Park (TTG), Faculty of Political Science (FISIP).
- Block III has 4 points, including parking lot of FISIP, Mosque, Faculty of Agriculture (FAPERTA), Rectorate.

Primary data is related to the existing campus waste management data and the generation and composition of waste data, were collected. Secondary data related to the number of students, lecturers, and UPNVJT employees. The collected data was analyzed using formulas or rules according to the planning approach, while evaluated data was conducted as a basis for planning the operational aspects of waste management techniques.

3. Results and Discussion

3.1. Existing Waste Management System

Waste management system is focusing on waste container, waste collection, waste transportation and waste processing. The container has different sizes, it is adjusted for capacity between 20-100 L. The containers has not been divided according the the type of waste, waste are not provided separately, or organic and inorganic waste is mixed. Therefore, additional work to separate waste is required, which means take more time and energy to sort it. In addition, the number of trash bins in several places is insufficient to accommodate the existing waste capacity, therefore, a lot of waste falls scattered due to the density of student activities. Waste collection is carried out by cleaning services in each building, starting from the container or trash bin from the source to the temporary shelter. The temporary shelter⁸ has two different types, a box building with a size of 1.8 x 1.6 x 1 m and a trash bin with various sizes, both is located on the side of the faculty building. The former is only found in the FAD, FEB, and Giri Loka, while the second one is found in the other location. Waste form the yard directly sends to the final disposal site by local officials using motorized vehicles. Waste has not been disaggregated or remains mixed in the temporary shelter. Waste transportation is carried out by using cart with capacity 600 L. Transportation is scheduled twice a day, in the early morning before lecture activities, around 5.30 - 07.00 WIB and in the afternoon around 15.00 - 17.00 WIB. The number of transportation rations is not counted at one time each day, depending on the amount of generated waste (12-13 times a day). In addition, the absence of a schedule has caused un regularly waste transportation, such as outside the prescribed hours, during lecture hours and planning for the waste transportation route has resulted that waste has not being transported at some point. Transportation is conducted by officers for transporting waste from main office buildings, faculties building, and canteens, while local janitor will transporting waste from the yard and parking lots. For processing part, only leaf litter from the yard will be treated into compost. The

authority for composting facilities is under Faculty of Agriculture. The size of composting area is 10 x 8 m, it is quite small, therefore not all daily leaf waste can be processed into compost. In addition, maturation of compost requires 2-4 weeks, therefore composting is not processed every day. Compost are only used for planting around UPNVJT and the remain will be used for practical purposes, such as student experiment, etc. Generated waste from main faculties buildings, offices, canteens, and other facilities is sorted to separate valuable waste, such as plastic bottles and paper, while the remain is disposed in the temporary disposal. The valuable waste is sold to collectors, however the proceeds from the sale of valuable waste is handled by third parties. Other residual waste is then burned in the morning before lecture activities begin and in the afternoon when lecture activities is finished.

3.2. Waste Generation

Waste generation measurement is carried out for two weeks. The measurement of waste generation was began in the morning by distributing trash bags to local sanitation workers and several places were immediately placed in temporary waste shelters. According to the⁵ results of data measurement, it is obtained that waste generation rate of UPNVJT is 0.013 kg/person/day, the amount of the generation is influenced by the number of people and the area of the building. Figure 2, Fig. 3 and Fig. 4 show the measurement of waste generation in 3 service areas of UPNVJT for two weeks observation.

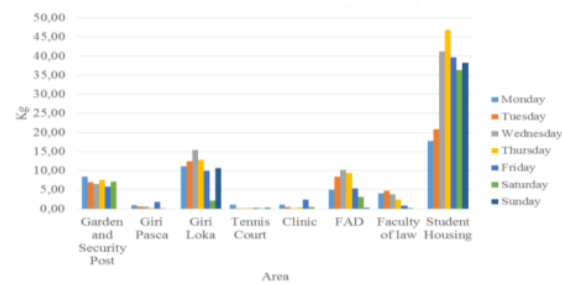


Fig. 2. The average mass weight of generated waste at Block I.

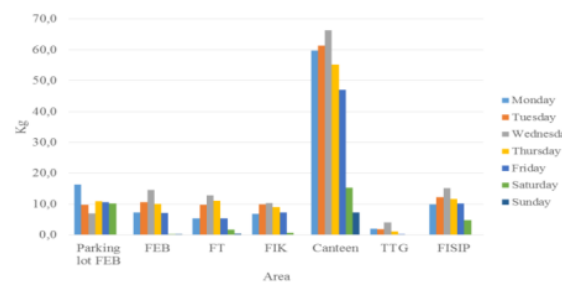


Fig. 3. The average mass weight of generated waste at Block II.

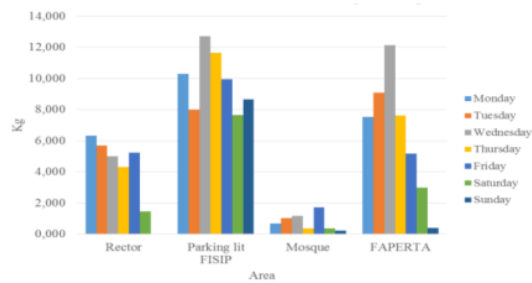


Fig. 4. The average mass weight of generated waste at Block III.

Figure 2 indicates that the rate of waste generation in Block I has gradually stabilized on the working day. The highest rate of solid waste generation in Block I is found in low-cost housing, it is probably due to the residence of low-cost housing or students dormitory, always produces waste every day. The consumptive behaviour of students can be seen from the composition of the resulting waste, which is found mainly waste food wrappers and leftovers. The highest rate of waste generation in Block II is the canteen, this is due to consumers or students tend to buy a lot of food when hungry without caring about the consequences of food being wasted and they were lack of planning in buying food. Prevention to the formation of leftovers is not yet a priority since the consumptive behaviour of students for buying food is the main issue. The peak rate of waste generation from the faculty building is on wednesday. There is a difference in the generation rate between working days and holidays, this is reasonable since few students have activities in the campus during holidays. In addition, there was an UKM Expo and new students orientation on the first week of research observation. The lowest rate of waste generation in Block III is found in the mosque, while the high rate of waste generation in FAPERTA occured on wednesday. This is due to the density of lecture activities were on that day, the number of activities after the course, which take up to night. In addition, the waste generation on working off such as saturday and sunday is probably due to there were still some students have activities in the campus.

3.3. Waste Composition

Based on the measurement of waste generation and composition, the classification of waste composition is distinguished according to Indonesian National Standard [8]. The classification of waste consists of organic waste destined for food waste,

economic value waste intended for plastic bottle bins, food and beverage cans, paper and cardboard, other waste (residue) is intended for waste such as tissue, plastic, wood, rubber, sanitary napkins, styrofoam, and cigarette lighter, and hazardous waste consisting of light bulbs (glass), tapes, bottles of medicine, medicine packaging, injections, patchwork, batteries and paint cans. The composition of the UPNVJT waste is obtained from sorting and weighing the results of

Table 1. Average waste composition during two weeks

Composition (Kg/day)	Average Waste Composition (%)							Total
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
Food waste	83.6	101.9	126.1	103.1	92.9	48.9	41.8	52
Leaf	35.9	24.7	26.91	31.5	25.8	24.9	0	15
Paper	20.7	22.1	28.0	21.9	18.6	7.1	10.9	11
Recycled	17.1	17.8	19.3	21.9	11.9	5.5	5.1	8
Plastic								
Fabric	6.8	9.6	16.0	14.8	9.1	3.0	1.5	5
Tissue	6.3	5.2	7.8	5.8	6.9	3.4	5.1	3
Wood	4.1	3.8	3.6	3.8	2.9	1.0	0.9	2
Glass	1.2	3.7	4.6	5.0	3.2	0.2	0.8	2
Rubber	1.7	0.6	0.7	0.4	0.6	0.1	0	0
Hazardous and toxic	0.1	0.2	0.1	.6	0.1	0	0	0
Metal (non-ferrous)	2.9	1.2	2.1	2.3	2.1	0.6	0.1	1
	1.2	0.4	0.9	0.9	1.1	0.1	0.1	0
	Total							100

chilling according to the type of waste, the unit is Kg. Table 1 shows the waste composition based on observation in the field study during two weeks.

The waste composition is mainly dominated by food scraps, leaves, paper and plastic bottles, as shown in Table 1. Food waste with an average percentage of 52% comes from the canteen and low-cost housing. A number factors influences the high food scraps, such as the large number of people, building area, lack of planning in buying food, and consumers or students do not care about the consequences of wasted food. In addition, this canteen is the centre or the only canteen in UPN and the duration of the canteen operates from morning at 06.00 WIB until late at night around 17:30 WIB, therefore, this situation causes high food waste in the canteen.

3.4. Planning for Improving Waste Management System

3.4.1. Planning for Container System

According to the observation, this study found that container system has various shapes and sizes in most of building, such as in the faculties offices which is university facilities. The difference in size is intended in accordance with the place and function. The implantation has not been implemented in a disaggregated manner, therefore the planning for container system is a disaggregated sorting system into 4 categories, namely containers for organic waste such as food scraps, containers for economic value waste such as plastic bottles, paper, etc., hazardous

waste such as light bulbs (glass), cassettes, used medicine bottles, drug packaging, injections, patchwork, batteries and paint cans and other waste that cannot be composted or that have no economic value, which will be disposed of in landfills (Stephen, 2002; Jerie, 2006). The planning pattern for waste is sorting from source to transportation. In this case, it is also necessary to take part between the campus, especially the janitor coordinator regarding the waste handling operational system which must be differentiated according to the type. The technical requirements regarding storage are regulated in Indonesian National Standard [9]. Table 2 presents the requirements of container for supporting planning for container system.

Table 2. Amount of containers

Area	Amount of waste containers existing conditions										Total	Planned Container Without Sorted Sorting
	20L	30L	40L	50L	60L	70L	80L	90L	100L	120L		
Garden											2	6
PPS	3	2			1						6	1
Giri Loka			2		6						8	4
Tennis Court	1				1						2	1
Clinic					1						1	1
FAD							1				15	2
							5					4
FH	1				1	4					6	1
Student House					1	45					46	9
Parking											0	1
FEB												3
Rectorate					1			13	8		22	2
FT						4					4	2
FT					2	4		26			32	2
FIK	1				5					1	7	2
Canteen											10	3
TTG							10				3	1
FISIP	4				3			2			26	2
Parking					6						6	1
FISIP											6	1
Mosque						8					8	1
FAPERTA	1				11						12	2

3.4.2. Planning for Collection System

Waste collection is planned in term of indirect individual collection pattern, as suggested in the previous studies [10,11]. Waste collection is carried out in a disaggregated pattern according to the type of temporary shelter. Planning for temporary shelters in each faculty building and other facilities are in the form of insulated wall platforms adjusted to the type, making it easier for further management. The location of the temporary collection point is adjusted in the location, therefore it can be reached by the vehicle cart, as shown in Fig. 5. Manually waste collection is scheduled for three times a day, in the morning, afternoon during break time, and evening, to reduce the burden or the accumulation of waste in the source of waste or container. Design of temporary collection place was determined based on the largest volume of waste generation divided by number of service blocks [1, 12]. The volume of waste is chosen from the largest waste generation in units per week, this is due to anticipate the potential for higher waste generation

which is influenced by the number of activities in several locations.

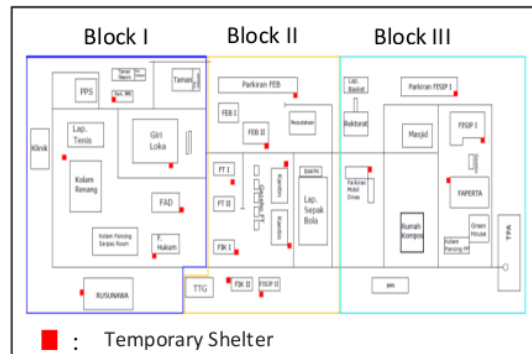


Fig.5. Placement of Temporary Shelter

3.4.3. Planning for Transportation System

Planning for transportation is carried out by using a fixed container system, the sequence of route of transportation is from the pool to the first source of waste, to the second source point, to the third, until the vehicle is full and then to the final disposal site. Waste transportation is conducted with different scheduling, which depend on to the type of waste disaggregated [10]. This is because the sorted waste is no longer mixed. Transportation for organic waste, which is easy to rot and smell, will be transported twice per-day, that is in the morning and evening. The valuable waste will be transported once per-day, in the afternoon. Residue or other waste will be transported every two days. Hazardous waste will be transported according to the regulations for hazardous waste management. The transportation is arranged for once a week on Sunday, this is because the amount of hazardous waste generation is quite small and less impact to the campus activities. In this case, the transportation destination is located behind the FISIP 1 building. Schedule for waste transportation is started in the morning and afternoon, at 05.30 - 07.00 and 16.00 - 17.00, respectively. According to waste generation data, this study determines to apply only one motorized wagon carts with one transportation fleet. The capacity of the motorized wagon is planned based on the average volume of waste generation per day, which is 2320 L/day. Therefore, waste transport vehicle is planned to use a mini dump truck with a capacity of 2.3 m³. The motorized wagon is distinguished with a lid in order to anticipate the scattered waste spills, as shown in Figure 6. Number of vehicles needed is calculated based on the amount of waste generation divided by

container capacity, which has been converted with compaction factor, as shown in the following text [1,4].

$$\begin{aligned} & \text{Number of mini dump trucks (1)} \\ &= \frac{\text{The amount of generated waste}}{\text{container capacity} \times \text{compaction factor} \times \text{rarely}} \\ &= \frac{2320 \text{ L}}{2300 \text{ L} \times 1.2 \times 3} \\ &= 1 \text{ piece} \end{aligned}$$



Fig.6. Motorized Carts

Figure 7 shows a transportation route, which is planned according to site location, the location of the temporary waste collection site. Transportation route for Block I starts from FAD-Giri loka-PPS-Tennis Court-(Clinic)-Rusunawa-FH-final disposal site. Block II has transportation route from FEB parking lot-north canteen-FEB-FT-FIK-TTG-FISIP- southern canteen-final disposal site, while Block III has route from FISIP-FISIP parking lot-Rectorate-FAPERTA-final disposal site.

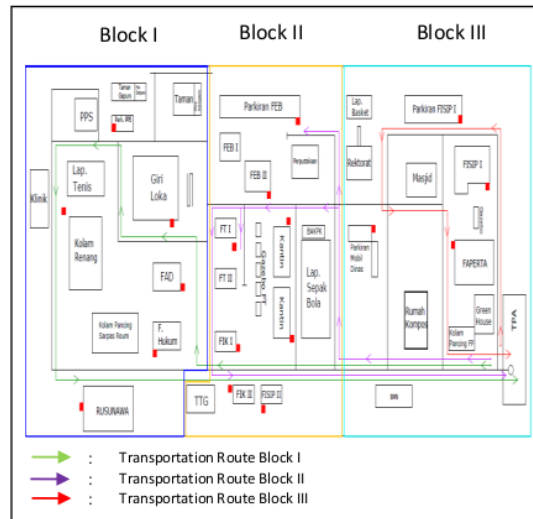


Fig. 7. Transportation Route

4. Conclusions

- Solid waste management system at UPNVJT, as case study, has not been in accordance with government regulation of Waste Management in term of waste reduction and waste handling.
- The amount of waste generated is 166.559 kg/day. The highest composition of waste produced is 52% food scraps, 15% leaves, 11% paper, and 8% plastic bottles.
- Containers are disaggregated between organic waste, valuable waste, hazardous waste, and others. The total number of waste containers needed is as many as 478 pieces of sorted waste containers.
- Planning for collection system uses an indirect individual collection pattern, the temporary shelters are planned in the form of insulated wall plates, it will be adjusted according to the type of disaggregated waste.
- Planning for transportation system is designed by using a fixed container system pattern with capacity 2.3 m³, such as mini dump truck. Transportation routes are arranged based on service blocks and placement of the temporary shelters.

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