Assessing solid waste management strategy in higher education institutions of Indonesia: A case study of IPB University

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Abstract. Globally, the solid waste management sector is facing numerous challenges. To encourage solid waste management IPB University launched the Green Campus program 2020. The critical success of this program was fulfilled by awareness with the participation of the family of IPB University. The objective of this study was to assess the relationship between the awareness and respective practices’ in solid waste management, among IPB University students. The study employed a descriptive research design with (n=108) randomly selected students. Data were analyzed and interpreted by using descriptive and inferential statistics. The study revealed that the students are highly aware of solid waste management, and also the students have good practices in terms of proper reducing and reusing, but moderately proper segregation, recycling, and disposal practices. The level of awareness of the students is influenced by their practices in waste segregation, reduction, reuse, and recycling but not influenced by their practices in terms of disposal. The study also revealed that the most waste generated in University dormitories was plastic bags, leftovers food, tissue papers, and cans waste. Meaningful recommendations were suggested to raise awareness among students in proper segregation and disposal practices.

1. Introduction

Globally solid waste management is a tragedy in developing countries. Currently, the World Bank reported that the Urban cities generated 1.3 billion tons of solid waste per year [1], amounting to a footprint of 1.2 kilograms per person per day [2,3,4,5]. Population growth and urbanization result in a higher amount of solid waste produced with rapid economic prosperity, [6,7], Solid waste generation is expected to rise to 2.2 billion tons by 2025 [1,5,8,9,10,11,12,13]. As the volume and difficulty of solid waste increase, the environmental risk caused by waste materials including human health risks and environmental degradation [14,15].

According to [16] it was suggested that studying the best methods to minimize and manage the waste produced has become important in today’s polluted world. Meanwhile, the main strategy adopted by different countries and institutions regarding its solid waste management (SWM) is to reduce, reuse, and recycle (3R’s) program [6]. Solid waste management is the collecting, transporting, treating, and disposing of unwanted material resulting from the combination of residential, institutions, industrial and commercial activities in certain areas, that is throwing away material that has served its purpose or no longer needed [17,18,19]. Solid wastes can be categorized according to their origins such as domestic waste, industrial and agricultural also based on their contents like organic, glass, metal, and plastic.
In Indonesia, the solid waste management sector faces various challenges, since the population has grown over 265 million in 2019 and is expected to continue growing to over 285 million by 2025. In this sense, the rising population, urbanization, and human activities would increase waste production [20,21,22,23]. The common method used in solid waste management in Indonesia is a collect, transport, and disposal in a landfill. [21] 3R’s model (reuse, reduce, and recycle) is applied to solve the waste problem. Despite the methods used and several regulations and management systems, SWM issues in Indonesia have not been resolved [24].

IPB University is one of the biggest academic institutions in Indonesia, that has launched the “Green Campus” program with the target of achieving a sustainable environment [25]. IPB has been managing solid waste through the collection, transportation, and disposal without separation[26]. Solid waste produced by every unit in IPB Campus Dramaga such as classrooms, laboratories, canteens, offices, and dormitories were transported by three labeled trucks, which are plastic, paper, and organic. However, solid waste collected from the university premises’ dustbins is not sorted thus making the SWM difficult. According to [27,28,29] the higher education institutions play an important role to shape positive behavior in society and activities related to environmental management. In Indonesia, environmental education is integrated nearly in all subjects’ curriculums. The University of Indonesia, which is like IPB, also has a green campus program that emphasizes solid waste management, awareness and knowledge, and information teachings that enhance the University’s integration of environmental concerns with all faculties. Although students have been trained about environmental education, for a sustainable environment, they are not conscious of waste management practices and concepts such as sorting, reduction, recycling, re-use, and proper disposal.

Many researchers have suggested that education is the best tool to keep the environment clean [1,30,31]. People think that all forms of waste are the same and should just be thrown in one container and should not be managed. Community participation is a very important way to mitigate waste at source[23]. Awareness and practices are the key components for students to participate in the proper waste management program around the universities where an effective and sustainable goal could be achieved [32]. Therefore, this study was carried out to assess solid waste management strategy in higher education institutions of Indonesia.

2. Methods
This study used the descriptive research design focusing on assessing solid waste management strategy in higher education institutions of Indonesia. To relate variables, the study was conducted at both female and male students’ dormitories of IPB University Dramaga campus, as shown in (figure 1). The sample size selected was 108 students using a simple random technique without replacement. The data were collected through questionnaires and observation as a sample from Students IPB campus Dramaga at the study area. A structured questionnaire with closed-ended questions was used for data collection. Likert scale was used to assess the level of awareness between female and male IPB students’ practices on solid waste management and to assess the relationship between the awareness of students and their practices on solid waste management.

The data were analyzed by descriptive statistics, percentage, standard deviation, mean, and rank were conducted using SPSS version 26 and Microsoft Excel 2016. Inferential statistics such as Pearson’s $r$ was used to determine the relationship between variables. Perception of the respondents was measured using a five-point Likert scale with its numerical scale, statistical limits, and verbal description, For the level of awareness on solid waste management, the following was adopted: 4.20-5.00 (very highly aware); 3.40-4.19 (highly aware); 2.60-3.39 (aware); 1.8-2.59 (not aware); 1.0-1.79 (very unaware). in like manner, to interpret the data on the practices of the students along with solid waste management, the following was also adopted: 4.20-5.00 (always); 3.40-4.19 (often); 2.60-3.39 (sometimes); 1.8-2.59 (rarely); 1.0-1.79 (never) and GIS technology were used as another tool for the identification of study location area map.
3. Results and discussion

3.1. Sex characteristics of the respondents

To determine the gender of the respondents in the study area, a descriptive analysis of the respondents’ characteristics based on gender was conducted.

Table 1. Characteristics of sex of the respondents.

| Gender | Frequency | Percentage (%) |
|--------|-----------|----------------|
| Male   | 46        | 42.6           |
| Female | 62        | 57.4           |
| Total  | 108       | 100.0          |

Table 1 shows that the sex ratio (female: male) among the overall respondents of this study was 108, with the ratio of 74.19% of all dormitory students’, where 62 (57.4%) were female respondents and 46 (42.6%) were male respondents. Male dormitories students tend to be fewer than female and this is the reason why there were fewer male respondents. Thus, the sex of the respondent has implications also in this study. As it is believed that most, in many society females are engaging in various economic activities related to solid waste generations.

3.2. Level of awareness for students in solid waste management

As shown in Table 3, the highest mean of 4.41 (SD= 0.71) corresponds with the importance of the green campus program in solid waste management in dormitories. This is interpreted as “Very highly aware” indicating that the respondents are mindful and aware of IPB green campus programs. Thus, solid waste management is very important in dormitories and requires education about the environment. The study also shows with the least mean of 3.74 (SD= 0.99) the importance of the economic value of waste interpreted as “Highly aware”. This means the students are aware of the importance of economic value and non-economic value of solid waste management, hence there is a need for the university to involve the students to emphasize function related to solid waste separation.

It also showed that a mean of 4.34 (SD= 0.73) for waste management may increase the aesthetic value of the General Competency Education Program (PPKU) in dormitories. The mean of 4.29 (SD=0.82) corresponds to the importance of waste disposal at a specific area. Furthermore, it shows the importance
of education in SWM with a mean of 4.24 (SD=0.74) which means the provision of education is very important for awareness of managing waste at dormitories. In addition, the possibility of diseases caused by unmanaged waste was shown by the mean of 4.22 (SD= 0.80). Therefore, results can be interpreted that the students were “Very highly aware”. Moreover, the students are assessed as “highly aware” with a mean of 4.18 (SD= 0.72) objectives of solid waste management at PPKU dormitories. For the importance of knowledge and role in solid waste management with a mean of 4.17 (SD= 0.70). The mean of 4.04 (SD= 0.80) relates to the importance of an active role in solid waste management. The significance of solid waste separation with a mean of 3.97 (SD=0.95). However, the Purpose of solid waste management in the dormitories, with the mean of 3.96 (SD= 0.77). Moreover, roles and responsibilities in solid waste management with a mean of 3.94 (SD=0.80), Finally the waste management discipline with a mean of 3.89 (SD=0.81). Therefore, it can be interpreted that the students are “highly aware”.

Generally, the students are "Highly aware" of solid waste management as evidenced by the grand mean of 4.12. This indicates that the students have the knowledge/ awareness about the concept of solid waste management as a program for green campus protection and conservation of the environment. This finding is congruent with confirming that the Philippines students have favorable knowledge of SWM [16]. Likewise, the earlier study revealed that the students were aware of solid waste management activities [33]. The students’ were aware of solid waste management practices in their schools and the local environment [34]. The study shows that the respondents had a high level of awareness and attitudes and high extent practices in solid waste management [35].

### Table 2. Level of awareness of students on solid waste management.

| No. | Responses                                                                 | Mean  | SD   | Interpretation            |
|-----|---------------------------------------------------------------------------|-------|------|---------------------------|
| 1.  | Importance of knowledge for SWM in PPKU dormitories                      | 4.17  | 0.70 | Highly Aware              |
| 2.  | Importance of playing an active role in SWM at PPKU dormitories          | 4.04  | 0.80 | Highly Aware              |
| 3.  | Objectives of waste management in PPKU dormitories                      | 4.18  | 0.72 | Highly Aware              |
| 4.  | Purpose of the SWM in PPKU                                            | 3.96  | 0.77 | Highly Aware              |
| 5.  | IPB Green campus program in SWM                                          | 4.41  | 0.71 | Very Highly Aware         |
| 6.  | Importance of disposing of trash in a designated area                   | 4.29  | 0.82 | Very highly aware         |
| 7.  | Roles and responsibilities for students in SWM PPKU dormitories          | 3.94  | 0.80 | Highly Aware              |
| 8.  | Education is an important factor in SWM PPKU dormitories                | 4.24  | 0.74 | Very highly aware         |
| 9.  | Implementation will be successful and effective if concerned Students will participate | 4.22  | 0.80 | Very Highly Aware         |
| 10. | Discipline in waste management at the PPKU dormitories                  | 3.89  | 0.81 | Highly Aware              |
| 11. | Possibility of diseases that can be caused by littering waste            | 4.24  | 0.82 | Very Highly Aware         |
| 12. | Waste management can increase the aesthetic value of the PPKU dormitory  | 4.34  | 0.73 | Very highly aware         |
| 13. | The importance of separating waste                                      | 3.97  | 0.95 | Highly Aware              |
| 14. | The importance of economic value and SWM                                | 3.74  | 0.99 | Highly Aware              |
|     | Grand Mean                                                              | 4.12  |      | Highly Aware              |

Note: SD=standard deviation.

#### 3.3. Level of practices in solid waste management

Table 4 displays the practices of the students in Solid Waste Management. The highest mean of 2.82 (SD= 0.48), interpreted as "Sometimes" indicates that students fell on the practice of properly disposing of waste. The students frequently practice proper disposal by not throwing and leaving garbage anywhere, and by disposing of waste in a proper dustbin by separating. The convenient access to solid waste bins may encourage the practice of reducing, reusing, and recycling [36].
Table 3. Practices of students on solid waste management.

| Responses                              | Mean  | SD    | Interpretation  |
|----------------------------------------|-------|-------|-----------------|
| The practices of proper segregation    | 3.37  | 0.43  | Sometimes       |
| The practices of proper reducing       | 3.90  | 0.47  | Often           |
| The practices of proper reusing        | 4.27  | 0.51  | Always          |
| The practices of proper recycling      | 3.01  | 0.68  | Sometimes       |
| The practices of proper disposal       | 2.82  | 0.48  | Often           |
| Grand mean                             | 3.47  |       | Often           |

Note: SD= standard deviation.

Similar to this, the students have also assessed themselves to "rarely" practice proper segregation, as evidenced by the computed mean of 3.37 (SD=0.43). This means that they can consider the importance of segregating biodegradable and non-biodegradable waste. Students have high knowledge about waste separation and positive practices [37]. This was also revealed by the computed mean of 3.90 (SD=0.47). This means that the respondents occasionally practice solid waste reduction.

Table 4, also displayed the mean of 4.27 (SD=0.51) for the practice of proper reusing interpreted as "Always". This shows that the respondents have a good practice in solid waste management in terms of reuse. A common practice of the students is to reuse washable food containers and reuse old materials than purchasing a new one. It also shows that with the mean of 3.01 (SD=0.68), the participants “sometimes” practice proper recycling. This means that students are aware of the importance of recycling solid waste materials. Part of the recycling activity they do is to make decorative materials from waste materials.

With the grand mean of 3.47 interpreted “often” along with the practices of solid waste management, it generally disclosed that the respondents observe good practices in terms of proper segregation, proper reducing, proper reusing, recycling, and disposing of. According to research findings of people’s perception of using bins in segregating, reduce, and reuse for solid waste management, the results show that respondents were aware of segregating waste at the source area, also they were positive towards reducing and reusing waste in their respective areas [38]. The respondents have a good level of knowledge, as well as have positive attitudes towards reuse, reduce and recycling, but their general practices towards solid waste management were poor [3]. Suggested that involving the community in practices will improve their knowledge, also encourage them to be effective for promoting environmental activities [7]. Solid waste management practices were implemented effectively [39]. Students had positive attitudes towards the reduce, reuse, and recycle programs, also the students have a high level of practice and responsibility in solid waste management [40].

Table 4. The relationship between the level of awareness and practices on solid waste management.

| Variables | Number of students | r     | P-value (two tailed) |
|-----------|--------------------|-------|---------------------|
| Awareness | 108                | 0.372  | 0.000               |
| Practices | 108                |        |                     |

* Correlation is significant at the 0.01 level (2-tailed).

A Pearson product-moment correlation was conducted to examine the relationship between awareness and practices in the IPB University dormitories. There was a correlation between awareness and practices, which was statistically significant (r value=0.372, n=108, P value=0.000). Hence, the null hypothesis is rejected. This implied that awareness and practices influence each other. Hence as awareness increase or decreases there is a possibility to affect the practices towards solid waste management. There is a significant relationship between awareness and practices among students towards solid waste management [1].
Table 5. The relationship between Green campus and practices on solid waste management.

| Variables     | Number of students | $r$     | P-value (two tailed) |
|---------------|--------------------|---------|----------------------|
| Green Campus  | 108                | 0.283 $^a$ | 0.003                |
| Practices     | 108                |         |                      |

$^a$ Correlation is significant at the 0.01 level (2-tailed).

A Pearson product-moment correlation was conducted to examine the relationship between the importance of the Green Campus 2020 program and practices in the IPB University dormitories. There was a weak positive correlation between the Green campus program and practices, which was statistically significant ($r$ value=0.283, $n=108$, $P$ value=0.003). Hence, the null hypothesis is rejected. This implied that practices and the Green Campus program influenced each other. Hence as practices increase or decrease there is a possibility to affect the program of green campus towards solid waste management.

Table 6. The relationship between the level of awareness and practices in terms of segregation, reduction, reuse, recycle, and disposal.

| Variables                        | $r$         | $P$-value | Interpretation |
|----------------------------------|-------------|-----------|----------------|
| The practice of Proper Segregation | 0.210 $^b$ | 0.029     | Significant    |
| The practice of Proper Reduce     | 0.265 $^a$ | 0.006     | Significant    |
| The practice of Proper Reuse      | 0.310 $^a$ | 0.001     | Significant    |
| The practice of Proper Recycle    | 0.270 $^a$ | 0.005     | Significant    |
| The practice of Proper Disposal   | 0.112       | 0.250     | Not significant |

$^a$ Notes are correlation is significant at the 0.01 level (2-tailed).
$^b$ Correlation is significant at the 0.05 level (2-tailed).

Table 5. shows the significant relationship between the level of awareness and practices on Solid Waste Management. According to the observation made in this analysis, I conclude that the calculated $p$-value of 0.029 and $r$-value of 0.210 shows that a significant relationship was found between the level of awareness and practices among students in solid waste management and proper segregation. Hence, the null hypothesis is rejected. It means that students are well oriented about solid waste management, hence, they can practice proper segregation according to recyclable and non-recyclable waste.

As also seen in the table 6, a significant relationship is found on the level of awareness of the students between their practice of proper reduction with the computed $p$-value of 0.006 and $r$-value of 0.265. Hence, the null hypothesis of the study is rejected. This means that if the students have a good knowledge of solid waste management, there is a possibility that they can reduce garbage properly. Meanwhile, the computed $p$-value of 0.001 and $r$-value of 0.310 shows there is a significant relationship between awareness and reuse. Hence, the null hypothesis of the study is rejected. This means that the level of awareness among the students on solid waste management affected their practice along with reuse. This also would mean that the students were able to internalize the practice of proper reusing.

In contrast, the computed $p$-value of 0.005 and the $r$-value of 0.270 reveals a significant relationship between awareness in terms of recycling. Hence, the null hypothesis of the study is rejected. This clearly shows that there is a correlation between the level of awareness of the students and their practices in terms of proper recycling. The finding also shows that if the students are more aware of solid waste management, the better they recycle things out of waste materials. Consequently, there is also no correlation between the level of awareness on solid waste management, and the practice of disposal with the computed $p$-value of 0.250 and $r$-value of 0.112. This indicates that the students have moderate knowledge of solid waste management and were not able to do proper disposal practices.

This study is in line with a previous study [30] which showed that there was a correlation between awareness and practices in solid waste management for students. This influenced their practices on proper segregation, reduction, and recycle but no influence on their practices on solid waste management towards reuse and disposal. Hence, the integration of knowledge, awareness, and attitudes was considered important elements in reshaping the behavior of students towards environmental practices. In like manner, some previous studies also contradict the relationship between environmental attitude
and knowledge. The awareness for students in solid waste management does not influence their proper practices in terms of disposal although their awareness was affected their proper practices definitely in segregation, reduce, reuse, and recycle [16]. There is a correlation between attitudes and knowledge in sustainable waste management [2]. a significant relationship between students’ attitude and their knowledge towards solid waste management [41].

Figure 2. Waste generated at IPB University dormitories.

Figure 2, shows the percentages of various types of waste which are generated at the IPB University dormitories, the results from the study revealed that the most generated plastic waste at the dormitory were plastic bags (15.16%), followed by wrapped plastic food containers (14.59%), plastic bottles (13.88%), plastic spoons or forks (12.61%), Styrofoam waste (12.18%), plastic straws (10.91%), shampoo bottle (10.91%) and plastic cups (9.77%). Thus a greater number of respondents (15.16%) indicated that the most generated waste in IPB dormitory were plastic bags and this supports by [3] who showed that plastic waste materials are the most highly generated. Plastic waste is increasing in Indonesia [42].

This study found that the most waste produced in IPB dormitories is tissue paper (24.76%), drink box wraps (23.33%), scrap papers (23.33%), card-boards (18.33%), and newspapers (10.24%). Therefore, the study indicated that tissue paper was the most common solid waste generated in IPB dormitories, supported by the findings of [43] which revealed that the composition of plastic waste, cans, papers, and glass bottles has increased. Moreover, the study found that food waste with the percentage of (61.24%) leftovers and (38.76%) of spoilage food are the highest food waste generated in dormitories since food is a basic need this is also argued for by [44] with a high percentage of food waste generated at the university campus, similarly, [4] show the increase of food waste at the campus.

Moreover, the study shows that there are other types of waste generated at dormitories which also need attention to be managed well, and the findings show that those types of waste were cans with the percentage of (27.60%), expired drugs (15.38%), used clothes (12.22%), glass bottles (13.12%), batteries (12.67%), mirrors (9.95%) and light bulbs (9.05%). Previous studies have shown that the most generated solid waste in IPB dormitories were plastic bags, leftovers food, tissue papers, and cans waste materials. The increase of plastic waste in Indonesia showed by research [45]. Developing and applying strategies for solid waste management to prevent food and plastic waste through enhancing recycle, reuse and reduction [46]. The major solid waste found in Nigeria includes polythene bags, plastics, papers, organic, and others, and the management of waste was implemented in terms of reusing, reducing, and recycling [47]. IPB university can also adopt their measures to reduce and recycle generated food waste. This is supported by [48] who suggested measures to be adopted to reduce and recyclable food waste in the University canteens. Plastic, paper, and food scrap waste were the most generated in IPB University [26]. Dormitories had a high number of plastics, paper, and food waste
because it related to the eating behavior of carrying food from outside of the dormitories [49]. Moreover, food waste was the highest amount generated at Nigerian university followed by plastics [19]. This also suggests that food waste should be properly disposed-off or used to generate power in the university community. Animal feed or fertilizer can also be derived from the waste.

4. Conclusion
The student’s awareness level in solid waste management is identified as high. Most of them were highly aware of the importance of the green campus program and they had suggested that the program can increase the aesthetic value of the PPKU dormitories. Moreover, the students have good practices in terms of reducing and reusing, but moderate segregation, recycle, and disposal practices. Also, the findings revealed that the level of awareness of the students influenced their practices in segregation, reduction, reuse, and recycle but not their practices in terms of disposal. The students were also able to reduce and reuse while they fall moderately in segregation, disposal, and recycling. Finally, there was a weak positive correlation between the awareness of the students and their practices in solid waste management. The study found that the most waste generated in IPB University dormitories is plastic bags, leftovers food, tissue papers, and cans waste.

Based on the present findings, the study recommends the following measures:
IPB University should conduct and encourage the students to participate in seminars, campaigns about solid waste management and allow them to be provided with full information. The IPB University should implement effective programs by conducting seminars and meetings with the students to raise awareness of proper segregation, and disposal practices in the contribution to solid waste management, this may lead to the students carrying out proper practices in segregation and disposal. Lastly, environmental education should be mandatory for all faculties to encourage students’ awareness about the environment.

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