Application of smart waste management in the Department of Civil Engineering, Bali State Polytechnic

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Abstract. The existence of the green campus program is expected to create awareness and concern for the campus community to participate and be responsible for reducing global warming. This research is expected to be a guideline in implementing smart waste management in the Civil Engineering Department of the Bali State Polytechnic in particular to improve quality in the environmental sector. The method of analysis in this research includes: Identification, planning of and quantity of waste generation. The analysis conducted in this study used an analysis referring to several standards regarding green campus, namely UI Greenmetric, Green Guide for University and Greening University Toolkits. Waste management in the Department of Civil Engineering has not carried out processing efforts such as recycling, composting or other integrated efforts. The waste generated from teaching and learning activities, practicum and canteen is carried out by making a reservoir and it is carried out by disposing of waste into the trash bins that have been provided, practicum waste is collected in carts, waste management is carried out in the area of the department such as in the room carried out by cleaning services, which is then the final handling in the campus area, namely garbage is disposed of to the Temporary Landfills (TPS) campus then brought to the Landfills (TPA) by the South Kuta District Sanitation Office. The main objective of the campus solid waste management plan is to maximize resource recovery, with the aim of minimizing the disposal of waste to the TPS. The main strategy is to implement a waste hierarchy by avoiding purchasing products that will eventually become waste, repair and reuse, then recycle, and finally if there is no other choice, disposal to the TPS.

1. Introduction

1.1. Background
Today's environmental problems have become public awareness. This can be seen by the number of public discussions about environmental issues, and efforts to manage them are becoming increasingly complex, covering a very wide variety of aspects, while human understanding of the environment is still very lacking.

The level of progress of a country can be seen from the quality of its higher education institutions. Therefore, a university should be at the forefront of solving national problems, including environmental problems, one of which is waste by inducing a green campus concept.

The Green Campus concept or the concept of a green campus which describes how the campus conditions are comfortable, peaceful, and beautiful based on environmentally friendly aspects. The
green campus program is one of the movements that have been carried out on various campuses both in developed and developing countries to help reduce the effect of global warming. The existence of the green campus program is expected to create awareness and concern for the campus community to participate and be responsible for reducing global warming. [1] If a university trains future decision-makers and often promotes green education, it would be advisable to build a green campus where students can practice green living. [2]

Sources of waste in the campus environment, especially the departments that are part of the campus, are the teaching and learning process in the classroom, administration of the department, the learning process in workshops and laboratories and the department's canteen. The waste produced is in the form of paper, markers, pieces of wood, pieces of iron, concrete mixture, the results of test objects, organic food waste, and others. This requires the handling of proper waste management so that the amount of waste generated can be minimized.

1.2. Research purposes
The objectives of this study are:
- Analyze the amount of waste generation of each type of waste that occurs in the Department of Civil Engineering, Bali State Polytechnic.
- Knowing the existing waste management in the Department of Civil Engineering, Bali State Polytechnic.
- Designing an appropriate waste management system to overcome the amount of waste generated in the environment of the Bali State Polytechnic Civil Engineering Department based on a green concept.

2. Literature Review

2.1. Green campus
Green Campus is a program that has an understanding of the extent to which campus residents can utilize existing resources in the campus environment effectively and efficiently, for example in the use of paper, waste management efficiency, use of electricity, water, land, and others. [3] Green campus has brought many benefits in terms of financial as well as environmental benefits. [4]

The assessment used to become a green campus-based campus is supported by several supporting indicators. The measure of success is determined by several indicators, including efficiency in the use of paper as a basic need for teaching and office administration activities, efficiency in waste management, efficiency in land use as green open space and aesthetics (landscape) efficiency of water use, efficient use of natural resources and efficient use of electricity.

2.2. Green campus concept
Green Campus is a program that has an understanding of the extent to which campus residents can utilize existing resources in the campus environment effectively and efficiently, for example in the use of paper, waste management efficiency, use of electricity, water, land, and others [3].
- Smart Energy
  The energy needed by the campus must be very large in supporting all activities carried out by the campus community. The energy used comes from non-renewable natural resources, renewable natural resources, and alternative energy. It is the use of energy derived from renewable natural resources and alternative energy that must be used more dominantly by the campus in supporting all its activities.
- Smart Mobility
  The campus community certainly has their own activities. This activity requires high or low mobility depending on what you are busy with. In supporting this mobility, the campus is obliged to provide supporting facilities such as campus buses, motorcycle taxis, bicycles, etc.
- Smart Water
Water is one of the important elements for human life. Likewise with the conditions on campus, water is very supportive in all activities on campus. When the water is not managed properly, there will be problems in the campus. The provision of clean water is one of the conditions in building a campus.

- **Smart Public Service**
  A good campus certainly has good public servants too. Some of the general services provided by campuses include installing CCTV cameras, road signs, emergency communication systems, madding, and others.

- **Smart Building**
  Buildings are another important element of a campus. A building where the entire academic community is studying and a place to store various college or practicum needs and various archives needed. Building construction must sacrifice the environment to become a building. However, the construction of an environmentally friendly building can certainly be a solution in preventing further damage.

- **Smart Rubbish**
  Garbage is something that will definitely not disappear from the campus environment. There are many activities on campus that inevitably produce waste, such as lectures, practicum, canteen activities, or activities on campus. The existence of this waste needs to be properly regulated so that there is no big waste problem.

Meanwhile, green campus has brought many benefits in terms of financial and environmental benefits. [5]. And Green Guide for Universities is a guide used by several universities in the world that are members of IARU. There are several parts in this guide that will be used as a reference in this research, namely the Sustainable Campus Organization, Campus-Wide Operation, Communication, Employee and Student Engagement, Laboratory and Universities as the catalyst for a sustainable society. [6]

Based on Greening University Toolkits, several indicators related to this study are as follows: (i) The sustainability committee; (ii) The sustainability team; (iii) Planning, Design and Development; (iv) Student and staff development; (v) The campus as living laboratory; (iv) Communications and documentation; (vii) Internal audit; (viii) Management review; and (ix) Preparing a sustainability report. [7]

2.3. **Smart waste management**
Processing in general is the process of transforming waste physically, chemically and biologically. Waste processing is an activity that aims to reduce the amount of waste, in addition to utilizing the value that is still contained in the waste itself (recycled materials, other products and energy). Waste processing can be carried out in the form of composting, recycling/recycling and reuse.

Sustainable solid waste management is the right approach to reduce the amount of solid waste generated in higher education institutions. However, the development and implementation of sustainable waste management programs by higher education institutions is a daunting task as it requires the diverse cooperation of stakeholders on campus. In fact, there are several problems that need to be addressed such as a lack of commitment from the campus community, inappropriate programs, and ineffective program monitoring. The integration of bottom-up and top-down approaches in developing programs related to solid waste management is very important to ensure the program is carried out in accordance with the campus environment [8].

3. **Research Methods**
The method of analysis in this study includes:

a. Identification of waste sources and quantity of waste generation in the Department of Civil Engineering, Bali State Polytechnic.

b. Planning a waste management model based on the identification of waste sources and the quantity of waste generation based on the Green Concept.

c. The application of waste management is based on the design model that has been made.
The analysis conducted in this study used an analysis referring to several standards regarding green campus, namely UI Greenmetric, Green Guide for University and Greening University Toolkits. In this study, an evaluation of the existing waste management was carried out and also an analysis of the generation and characteristics of the waste used in making the Green Concept-based waste management concept.

4. Research Result

4.1. Identification of waste generation in the Department of Civil Engineering

Based on the previous research, the rubbish that makes the biggest contribution in the campus environment is organic type waste and this waste mostly comes from tree branches and dry leaves, where this waste can be processed into compost and returned to the environment [9]. The Department of Civil Engineering, State Polytechnic of Bali consists of 3 (three) buildings as an operational teaching and learning process and 3 (three) supporting buildings, namely a lecture building equipped with an administration room and a lecturer room, a practicum building consisting of a soil mechanics laboratory, a hydraulics laboratory and a science practicum. measuring the land, the workshop building consists of a material laboratory, wood work practice workshop, steel work practice and scaffolding or masonry work practice, and a supporting building in the form of a canteen. From all existing buildings and activities that take place in them, it can be identified the waste generation that occurs from these various activities. There are 49 lecturer, 12 laboratory personnel, 3 administration staff and 625 students doing activity at Civil Engineering Department. Daily activities are carried out from 8.00 am to 4.00 pm (8 hours a day). Data collection was carried out by direct interviews with respondents who were involved in teaching and learning process activities and practicum, such as; laboratory personnel (PLP) in charge of laboratories and workshops, administrative staff of the Civil Engineering Department, cleaning service and canteen officers. Based on the results of interviews with respondents and initial identification, it was found that the sources of waste generation were paper, plastic waste, organic waste (food scraps), wood shavings, metal scraps, concrete test objects (cylindrical and cube shapes), asphalt and waste-remaining aggregate (sand and gravel).

4.2. Measurement of waste generation

The method of collecting and measuring waste generation and composition samples is based on SNI 19-3964-1994. And the purpose of this method is to obtain the amount of waste generation used in planning and waste management. Sampling can be done with the frequency of sampling carried out in 8 consecutive days at the same location, and is carried out in 2 mid-season sampling years. However, waste measurement activities cannot be carried out because at the time of this research there was a situation that made it impossible to measure waste due to the Covid19 pandemic which was caused by the corona virus which occurred not only in Indonesia but around the world experiencing this situation, thus requiring us to do so. act at home only (do not carry out activities outside the home) as recommended by the government to break the chain of spreading the virus. In the absence of these activities, the Department of Civil Engineering at the State Polytechnic of Bali will not have any activities for teaching and learning processes and others, so the measurement of waste generation that occurs during this pandemic period cannot represent normal conditions. The collection and measurement of waste is carried out by interviewing the respondents mentioned above to find out the volume of waste that occurs during the operational activities of the department.

From the results of interviews conducted for 1 (one) week, data on the sources and volume of waste that occurred in the Civil Engineering department were obtained as shown in Table 1:

| No | Name of Waste | Volume/year | Unit   |
|----|---------------|-------------|--------|
| 1  | Leaf          | 198,720     | litter |
| 2  | Paper         | 30          | rim    |
4.3. Waste management program indicators

Waste treatment and recycling activities are major factors in creating a sustainable environment. The activities of staff and students on campus produce a lot of waste according to the results of identification of waste generation from interviews and initial identification, therefore several programs and waste treatment must be the attention of the institution, namely recycling programs, waste recycling toxins, organic waste treatment, inorganic waste treatment, waste disposal, policies to reduce the use of paper and plastics on campus. The indicators for the waste handling program are: recycling program for campus waste, programs to reduce paper and plastic use on campus, organic waste treatment, inorganic waste treatment, toxic waste is handled, and waste disposal.

Waste management in the Department of Civil Engineering has not carried out processing efforts such as recycling, composting or other integrated efforts. The waste generated from teaching and learning activities, practicum and canteen is carried out by making a reservoir and it is carried out by disposing of waste into the trash bins that have been provided, practicum waste is collected in carts, waste management is carried out in the area of the department such as in the room carried out by cleaning services (CS), which is then the final handling in the campus area, namely garbage is disposed of to the TPS campus which is behind the canteen by a cleaning officer who is then brought to the TPA by the South Kuta District Sanitation Office.

4.4. Smart waste management design

The waste management design in the Civil Engineering department is based on the identification of waste generation arising from the management of the department as mentioned above and the concept of recycling and waste management such as reduce, reuse, recycle, replace and repair (5R) [10][11]. Recycling is an alternative that can be used to overcome environmental pollution, because recycling can reduce the amount of plastic waste in the world [12]. The innovation of plastic waste processing is by processing plastic waste into environmentally friendly bricks called Eco bricks [13]. Meanwhile in India it is called plastiqube, an alternative brick made from recycled plastic [14]. This design includes how to manage the waste generated by the department and what policies must be carried out by the department manager to minimize the waste generation, which can be seen in Table 2:

| No | Name of Waste | Management Plan |
|----|---------------|-----------------|
| 1  | Leaf and food scraps | This activity can be carried out by collaborating between the Department Manager and the Department Student Association, which collects most of the leftovers from the department and canteen waste, as well as the leaf litter that is produced quite a lot every year. This material is then put through a composting unit in a large box which uses an aerobic process to turn it into compost within two to three weeks. This is a sustainable method for disposing of organic waste. The simplest compost maker is called a composter with a capacity of 120 liters |
2 Plastic and Paper

Collaboration with waste banks. The waste bank plays a role in minimizing littering in the surrounding environment. Recycling is an alternative that can be used to overcome environmental pollution, because recycling can reduce the amount of plastic waste.

An innovation to reduce plastic waste is to reprocess it, one of which is by making environmentally friendly bricks that can be used for other purposes. Environmentally friendly bricks are made by inserting and compacting clean and dry plastic waste into plastic bottles. The development of processing plastic waste into environmentally friendly bricks is called Eco bricks.

In today's technological era, wood sawdust is also used as a combination material in making concrete blocks. The results of the research show that the combination of sawdust in concrete blocks can reduce production costs and the quality is not inferior to the types of bricks that do not use a combination of wood dust.

3 Sawdust

Processing of cylindrical and cube concrete specimen waste can be used as a substitute for coarse concrete forming aggregates, based on studies that have been carried out by concrete mixtures using concrete specimens waste, the compressive strength and the modulus of elasticity tend to decrease. This concrete specimen waste should be used as a wall substitute material that is created with other materials so that it can increase the artistic element in its use as a combination of wall, garden or other function materials.

4 Concrete specimen

5. Conclusion

Based on the research results above, it can be concluded that the following are:

1. Based on the results of interviews with respondents and initial identification, it is found that the sources of waste generation are paper, plastic waste, organic waste (food scraps), wood shavings, iron scraps, concrete specimens (cylindrical and cube shapes), asphalt, and aggregate remains (sand and gravel).

2. Waste management in the Department of Civil Engineering has not carried out any treatment efforts such as recycling, composting or other integrated efforts. The waste generated from teaching and learning activities, practicum and canteen is carried out by making a reservoir and it is carried out by disposing of waste into the trash bins that have been provided, practicum waste is collected in carts, waste management is carried out in the area of the department such as in the room carried out by cleaning services (CS), which is then the final handling in the campus area, namely garbage is disposed of to the Temporary Landfills (TPS) campus which is behind the canteen by a cleaning officer who is then brought to the Landfills (TPA) by the South Kuta District Sanitation Office.

3. The waste management design in the Department of Civil Engineering is based on the identification of waste generation arising from the management of the department as mentioned above. This design includes how to manage the waste generated by the department and what policies must be done by the department manager to minimize the waste generation.

Acknowledgment

This research was supported by Bali State of Polytechnic, Institutional Grant 2020. We thank our colleagues from Civil Engineering Department who provided insight and expertise that greatly assisted the research. We thank to the research team [Kristinayanti, Wiwin Andayani] who help analyse the research, and to our students [Kembang Pratiwi cs] who help conduct surveys and collect data. And thanks to the research support team [Prami, Mirah] as well who helped in reporting process. We would also like to show our gratitude to respondents for giving data collection.
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