Study of recycling potential of solid waste of tourist area in Pariaman City

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Abstract. This study aims to measure and analyze the data of solid waste generation, composition and recycling potential of the tourist area of Pariaman City. Sampling and determination of samples based on SNI 19-3964-1994. Sampling location was on three beaches in Pariaman City were Gandoriah Beach, Cermin Beach, and Kata Beach, and one island namely Angso Duo island. The results showed that the average unit of solid waste generation was 0.033 kg/cap./day or 0.344 liters/cap./day. The largest component of the waste was organic waste by 90.79%, while inorganic waste by 9.21%. Recycling potential consists of non-ferrous metal 95.072%, plastic 93.359%, glass 64.505%, food waste 36.787% and paper waste 19.231%. It was recommended that solid waste could be treated by composting technology to treat the garbage, cleaning and packing the rubbish, and utilizing the waste that has value to produce the creative product for supporting the tourism activity such as souvenirs.

1. Introduction

Studies of solid waste management on the tourism area lately, globally, have become an interesting field to be studied. In last fifteen years, these studies took place on several countries such as Kashmir [1], Cyprus [2], Spain [3], Vietnam [4], Romania and Italy [5]. In Indonesia, still limited studies on solid waste management of tourist area, their study located at Kelam hill in West Kalimantan [6] and Buleleng port in Bali [7]. These studies focus on various topics such as technical aspects, economical, and social of the solid waste management system.

Indonesia is famous for nature tourism. One of the provinces in Indonesia that well-known as favourite tourism spot is West Sumatra province. Pariaman City is one of the cities in the West Sumatra province which has tourism potential. The tourism objects in Pariaman City consist of nature tourism, historical tourism, and culinary tourism. The existing and developing tourism objects in Pariaman City are beach and island tourism. Beach tourism objects that are frequently visited in Pariaman City today are Gandoriah Beach, Cermin Beach and Kata Beach, whereas the island’s most visited tourist attraction in Kota Pariaman is Angso Duo Island.

Coastal and island attractions in Pariaman City become tourist destinations for people and tourists who come to Pariaman City because of its strategic location and located in the center of the city. In its development, Pariaman City tourism provides many tourism supporting facilities such as cafes, restaurants, bicycle rental to go around the beach, tents on the beach, parks, and the transportation provided into the island. The island that can be visited is Angso Duo Island, which is believed by the
public and visitors as one of the islands that hold historical value in the spread of Islam in West Sumatra.

The influence of tourism has the consequences of both positive and negative influence. Positive influences are the benefits of developing tourism, and negative influences can be traced as losses arising from tourism development. Tourism has a significant impact on the environment. Negative influence on environmental aspects, namely the presence of air pollution, water pollution, as well as a decrease in environmental quality due to waste around tourist areas [8].

Solid waste is the rest of daily human activities and/or solid natural processes. Solid waste classified into household waste, household-like waste, and specific waste. Tourism waste is included in household waste. Solid waste such as household waste must be managed through reducing and handling waste that is environmentally sound [9]. Management of tourism waste in Pariaman City is managed by the Pariaman City Environmental Agency. Solid waste management practice in tourist areas includes storage, transportation, and disposal to the final disposal site which has been regulated by the environmental agency of Pariaman City.

Research on solid waste generation, composition, recycling potential, and characteristics of tourist areas in Pariaman City have never been done before. Data of solid waste generation, composition, recycling potential and characteristics of a city and area are useful for planning waste management systems, such as determination of storage, collection, transportation, the design of processing facilities and landfill [10]. Therefore the results of the study are expected to be able to update the waste generation data, especially for the Pariaman City tourism area, which is carried out following the regulations and procedures of the applicable research in Indonesia. Besides, the results of this study can also be utilized by the local government to evaluate the planning of solid waste management in the Pariaman City tourism area.

The purpose of this study was to analyze the generation, composition, and potential for recycling waste in Pariaman City tourist area and recommend a suitable waste management system.

Solid waste generation is the amount of waste arising from the community in units of volume and weight per capita per day, or expanding the building, or extending the road [10]. Solid waste generation unit stated in liter/cap./day (l/cap./d) or liter/square meter of building/day (l/m²/d) and units of weight of kilogram/cap./day (kg/cap./d) or kilogram/square meter of building/day (kg/m²/d). The amount of garbage that must be managed by a city is influenced by the amount of garbage produced by an activity [11].

The solid waste composition is a depiction of each component contained in waste and its distribution. This data is important to evaluate the equipment needed. The grouping of waste that is most often carried out is based on its composition, for example expressed as a percentage (in weight or volume) of paper, wood, leather, rubber, plastic, metal, glass, cloth, food, and other waste [12].

Recycling is an activity to reuse an item/product but still requires additional activities/proceses. In Indonesia, especially in agricultural areas, people are familiar with waste recycling, especially biological waste, such as food waste, leaves, and so on. In solid waste management in Indonesia, recycling efforts are indeed quite prominent, although generally only involve the informal sector, such as solid waste traders (handymen), service providers of electronics, solid waste workers, scavengers, and dealers [11].

Recycling activities can open new jobs for the community by applying the principle of handling waste as an economic good. The perpetrators of the waste recycling business in urban areas are carried out by the informal sector, namely scavengers, collectors, stalls and waste recycling suppliers/dealers.

Tourism waste is solid waste generated from tourist areas that come from visitors’ waste and waste that comes from community activities around tourist areas. Tourism waste can disrupt the beauty and cleanliness of the tourist attractions themselves. The beauty and cleanliness of the tourist area reflect the culture of a nation. Therefore it is necessary to conduct environmental-based waste management.

Gandoriah Beach Area is one of the beaches in Kota Pariaman which is a favorite tourist destination in Pariaman City. Gandoriah Beach is located in Pasir Village, Central Pariaman Subdistrict, Pariaman City, which has an area of 0.85 km² out of the total number of Central Pariaman
Cermin Beach is one of the beaches located along the coastline of Pariaman City. Cermin Beach is located in Karan Aur Village, Central Pariaman Subdistrict, which is 1.5 km from the south of the center of Pariaman City. Cermin Beach has an area of 0.98 km$^2$ from the total area of Central Pariaman Subdistrict which is 15.68 km$^2$. Kata Beach is located on the southernmost beach of Pariaman City. The distance from Kata Beach to the center of Pariaman City is 3 km. Kata Beach stretches in two villages namely Taluk and Kelurahan Karan Aur. The Kata beach has an area of 2.05 km$^2$ and is the most extensive beach area in Kota Pariaman compared to Gandoriah Beach and Cermin Beach [13].

2. Material and Method

The research stages include literature studies in the form of collecting literature, journals, and previous related research. Furthermore, secondary data collection was carried out such as a general description of the location, number of commercial facilities, area and number of people at each facility and map of related research.

Sampling planning consists of determining the number of samples, time, and place of research. The number of samples was calculated based on SNI 19-3964-1994 [14] so that a sample of 18 locations was obtained in the facilities of the Pariaman City tourist area. The sampling location was limited to only three beaches and one island in the tourist area of Pariaman City. The selection of tourist areas was determined based on the development of tourism aspects and the number of visitors who come to the tourist area.

The locations of the tourist area chosen as the sampling locations were Gandoriah Beach, Cermin Beach, Kata Beach, and Angso Duo Island. Table 1 shows the number and location of sampling.

| Location | Facility type    | Facility number | Sampling number |
|----------|-----------------|-----------------|-----------------|
| Beach    | Street vendors  | 49              | 5               |
|          | Shop/stall      | 42              | 4               |
|          | Restaurant      | 8               | 1               |
|          | Park            | 5               | 2               |
|          | Train station   | 1               | 1               |
|          | Mosque          | 1               | 1               |
|          | Hotel           | 1               | 1               |
| Island   | Stall           | 4               | 1               |
|          | Area for pilgrimage | 1          | 1               |
|          | Gazebo          | 2               | 1               |
| Total    |                 | 114             | 18              |

Determination of the sample has represented the total number of facilities, and then it was proven by evaluating the results of the survey. The reliability of the survey was 99.28% for the coastal area and 98.394% for the island area which meant that the number of samples taken had represented the total number of these facilities.

Sampling was conducted for eight consecutive days according to SNI 19-3964-1994. The preliminary survey began with the distribution of questionnaires to locations that are the source of waste for tourist areas. The distribution of questionnaires aims to obtain additional information that can support primary data in the field such as the area and number of residents at a facility. Questionnaires contain questions about solid waste handling activities by sources, whether composting, selling waste to the Waste Bank, transporting into containers, burning or dumping into rivers, etc. In addition, the questionnaire also contains questions about the frequency of waste disposal and separation, as well as the types of available waste services.

The primary data needed is in the form of data solid waste generation, composition, and recycling potential of Pariaman City. Data were obtained from the tourist area. The steps taken in obtaining this
primary data were the analysis in the field consist of preparation of research equipment and supplies, sampling, measurement of the waste weight and volume, measurement of waste composition, calculation of the specific weight of waste, and analysis of recycling potential of waste.

Measurement of the weight and volume conducted by weigh the weight of each waste in a plastic bag, record the weight of the waste, pour in turns the sample into the volume measuring container and record the volume, beat the measuring container to the ground 3 times by lifting it 20 cm high, and measure and record the height of the waste in the compactor, then calculate the volume of waste.

Measurement of the waste composition was carried out based on SNI 19-3964-1994. The waste component is directly measured in the field by separating based on its components, namely food waste, paper, wood, fabric-textile, rubber-leather, plastic, non-ferrous metal, glass, and others (e.g., soil, sand, stone, ceramic). Percent composition of waste was obtained from the weight of each component of waste that has been weighed and divided by the total weight of the overall waste. Calculation of specific weight was obtained by comparing the weight of waste by its volume (kg/L).

The measurement of generation based on SNI 19-3964-1994 includes measurement of the weight and volume of waste from each sample based on the sources. Unit of volume generation is in L/cap./day and L/m²/d, while weight generation unit is kg/cap./day and kg/m²/d.

\[
\text{Generation formula per day: } = \frac{\text{weight or volume of waste (kg)}}{\text{area or number of waste producer (m² or person)}}
\]

Solid waste composition determined by measurement of the weight of each waste component compared with the total weight of the waste.

\[
\text{Composition formula (% weight): } = \frac{\text{weight of waste component (kg)}}{\text{total weight of waste (kg)}} \times 100\%
\]

The calculation of the characteristics of the waste in the form of specific weight is obtained from the measurement of the generation which uses volume data after compaction and weight of waste.

\[
\text{Specific weight formula (kg/L): } = \frac{\text{weight of waste (kg)}}{\text{volume of waste (L)}}
\]

Determination of waste recycling potential by sorting waste that can be recycled based on the type of waste that is sold and is not sold in the Waste Bank or waste shoppers in Pariaman City.

\[
\text{Waste recycling potential formula (%): } = \frac{\text{weight of the recyclable waste}}{\text{total weight of waste}} \times 100\% 
\]

3. Result and Discussion

3.1. Solid Waste generation

Determination of solid waste generation in the Pariaman City tourism area has considered correction factors and compaction factors. Determination of waste generation is expressed in units of weight (kg) and volume (liters). Waste generation units for each source are made into kg/cap./day or L/cap./day which aims to facilitate data analysis.

Based on the data processing, it was found that the waste generation in the Pariaman City tourism area was 0.033 kg/cap./day in units of weight or 0.344 L/cap./day in units of volume. Table 2 shows the generation of waste in the tourism area of Pariaman City in weight and volume units per capacity per day. In general, the value of solid waste generation in Pariaman City’s tourist area occurs on weekends, namely Saturday and Sunday. This was influenced because on the day of the weekend is a weekend and is a national holiday that is widely used by visitors come tourist attractions for refreshing and holidays.
Each waste source experiences a different amount of waste according to its sources. This is influenced by the development of tourism and cultural aspects of the community around the tourist area. The results of the calculation of solid waste generation were compared with the generation of solid waste in other tourist areas in the city in Indonesia, namely the Kelam hill tourist area of Sintang Regency and Ex Buleleng Port, Bali. Solid waste generation of the tourist area of Pariaman City was the highest as 2.408 L/day while 2.070 L/day and 1.033 L/day for Kelam hill tourist area, Sintang and Ex Buleleng Port, Bali. This higher quantity could be caused by the differences in activities in each tourist area. Moreover, research at Kelam hill, Sintang and Ex Buleleng Port, Bali, was carried out in 2014, at which time tourism in Indonesia had not developed much compared to 2017. Interest in visitors for holidays and visiting tourist areas was still less than in 2017. Furthermore, the square area also affecting the amount of solid waste generation obtained in all tourist area, the Kelam hill tourism area of Sintang and Exs Pelabuhan Buleleng, Bali districts are smaller than the area of Pariaman City tourist area studied.

### Table 2. Average Solid Waste Generation of Tourist Area of Pariaman City

| Sources         | kg/cap./day | L/cap./day |
|-----------------|-------------|------------|
| Street vendors  | 0.007       | 0.303      |
| Shop/stall      | 0.202       | 0.913      |
| Restaurant      | 0.018       | 0.222      |
| Park            | 0.005       | 0.109      |
| Train station   | 0.001       | 0.063      |
| Mosque          | 0.001       | 0.033      |
| Hotel           | 0.030       | 0.720      |
| Island          | 0.002       | 0.151      |
| **Average**     | **0.033**   | **0.344**  |

3.2. Solid Waste Composition

The results of the study on the composition of solid waste in the Pariaman City tourist area indicate that the composition of organic waste is greater than inorganic waste. Figure 1 showed the composition of waste in the tourist area of Pariaman City.

![solid waste composition](image)

**Figure 1.** The composition of solid waste in the tourist area of Pariaman City.
The waste component which has the largest composition is food waste by 30.86%. Other waste compositions were plastic waste 26.31%; paper 18.29%; page waste 11.01%; other waste 6.92%; wood waste 2.57%; non-ferrous metal waste 1.27%; glass waste 1.02%; textile waste 0.90%; and 0.85% rubber waste.

The composition of waste is also classified based on organic and inorganic waste. The composition of organic waste is 90.79% consisting of food waste, paper, plastic, textile, rubber, yard, and wood while the composition of the inorganic waste of 9.21% consists of glass waste, ferrous metals, non-ferrous metals, and other waste.

In comparison with other related studies, the composition of solid waste in an area is influenced by the habits and culture of the region. Comparison of the composition of tourism solid waste in Pariaman City, Kelam hill tourist area Sintang, and Ex Buleleng Port, Bali is shown in Table 3. From the table it can be seen that there are differences in the waste studied in each location, wherein Kelam hill there were no components of paper, wood, textile, rubber, and metal waste, while the Ex Pelabuhan Buleleng study found no glass components. When compared between the three study sites, it was found that the total organic component of this study was larger than the Kelam hill study while smaller than the study in Ex Buleleng port. The biggest organic component of Ex Pelabuhan Buleleng study is plastic waste similar to the results of studies at Kelam hill, while this study shows that food waste is the highest while plastic waste is second.

3.3. Recycling Potential of Tourist Area Waste of Pariaman City
The types of solid waste that can be recycled from the Pariaman City tourist area were analyzed using field survey data on waste components that sellable.

1. Paper Waste

Paper waste that potentially recycled includes cardboard drinks, milk, cigarettes, Print paper, egg containers, and magazines. Paper waste can be reprocessed into recycled paper. The paper that has been recycled has economic value, and the price depends on the type of paper. Types of paper waste that cannot be recycled such as food wrapping paper, tissue paper, and carbon paper, it cannot be recycled because it is difficult in processing and it has no market. The average potential for recycling paper waste in the Pariaman City tourist area was 19.231%, and paper waste that has no potential to be recycled was 80.769%.

| Component of waste | Eks Buleleng Port, Bali (%) | Kelam Hill Tourist Area, Sintang (%) | Tourist Area of Pariaman City (%) |
|--------------------|-----------------------------|-------------------------------------|----------------------------------|
| Organic            |                             |                                     |                                  |
| Food waste         | 14.3            | 25.44                              | 30.86                           |
| Yard waste         | 19.68           | 22.52                              | 11.01                           |
| Paper              | 8.04            | -                                  | 18.29                           |
| Wood               | 4.61            | -                                  | 2.57                            |
| Textile            | 2.21            | -                                  | 0.90                            |
| Rubber             | 19.21           | -                                  | 0.85                            |
| Plastic            | 29.83           | 29.59                              | 26.31                           |
| Total Organic      | 97.910          | 77.55                              | 90.790                          |
| Inorganic          |               |                                     |                                  |
| Metal              | 0.36            | -                                  | 1.270                           |
| Glass              | -               | 22.45                              | 1.020                           |

Table 3. Comparison of the Composition of Tourism Solid Waste
2. Plastic waste
Plastic waste is produced by shops/stalls and hotels. The shop generates plastic waste from the product packaging. Plastic waste in the tourist area of Pariaman City has a recycling potential of 93.359%. Plastic waste that cannot be recycled, such as mixed plastic consisting of plastic bags, etc., has no market since it has no economic value and some of the waste also contains chemicals that require further processing. Moreover, the cost factor that must be spent on recycling is almost the same as the cost of making new plastic. Therefore, plastic waste does not have a recycling market.

3. Glass waste
The type of glass waste generated was generally in the form of beverage bottles, glasses, and plates. The bottles can be recycled into glass ores which can later be reused or reprocessed into a glass that can be used. In addition, the bottles can be sold directly to the place of sale used goods such as stalls and Waste Bank. Glass that cannot be recycled such as plastic coated glass, color plates, and light bulbs, car glass, and color plate glass because it is difficult to process, and the results from processing cannot be used. The results showed that the potential for glass waste recycling in the Pariaman City tourist area was 64.505%.

4. Non-ferrous metal waste
Non-ferrous metals that have the recycled potential in tourist areas such as beverage cans and milk cans. Non-ferrous metal can be reprocessed into aluminum seeds or reprocessed into an item composed of aluminum. Also, it can be reused as a versatile container, and metal waste can also be converted into crafts such as displays, shelves, etc. Research results indicate potential recycling of non-ferrous metal waste in the tourist area of Pariaman City was 95.072%.

5. Food Waste
Types of food waste that has the potential to be recycled in the form of food waste, yard waste, vegetables, fruit waste, and other biodegradable organic materials. For waste that is not feasible, compost is found such as eggshells, shells, and bones. The non-recyclable food waste remains as young coconut waste. The restaurant is the most contributing means to generate food waste. The average recycling potential of food waste in the Pariaman City tourist area was 36.778%.

### Table: Waste Recycling Potential

|                | Other |       | Total Inorganic |       | Total       |
|----------------|-------|-------|-----------------|-------|-------------|
|                | 1.73  |       | 2.09            | 22.45 | 9.210       |
| **Total**      | **100.00** | **100.00** | **100.00**      |       |             |

3.4. Preliminary Study of Tourist Area Waste Management in Pariaman City
The results of the research on the recycling potential of the Pariaman City tourism area showed that the potential for waste recycling was 50.095%. The amount of recycling potential and waste composition obtained can be concluded that the application of recycling in new tourism areas can be prioritized for organic waste in the form of food, paper, plastic, textile, rubber, wood, and yard waste. Waste processing that can be recycled can be done by composting and recycling or reusing waste with different shapes and functions.

Initial recycling activities can be done by separating from the source of waste generation based on the type of waste. Besides, it can also be done by providing color for different colors of each type of waste. Green containers are for food and yard waste, blue containers for plastic, yellow containers for plastic, white for glass, and gray for cans and metals. The transport system should also be considered more. Transportation can be done every day for tourist areas so as not to interfere with aesthetics and reduce the quality of the environment in the tourist area.
Based on the results of the research that has been done, it can be seen from the composition of waste in coastal and island tourism areas dominated by plastic waste and food waste. The average amount of compostable food waste left is 4.132% of the total food waste. Based on these results, waste processing for the Pariaman City tourism area for food waste can be done by composting. When viewed from the biodegradability test results, organic waste in the Pariaman City tourism area is also suitable for composting. Management can be carried out by building processing with the principle of TPS 3R specifically serving tourist area waste. It is intended that waste from coastal and island tourism areas can be utilized and can reduce the possibility of environmental degradation that occurs due to waste.

The average plastic waste that can be recycled from this research also has a large amount of reaching 93.359%. Most of the plastic waste generated from tourist areas is bottled garbage and plastic bag waste used for packaging drinks and food bottles. The bottle waste can be recycled by making crafts from plastic bottles or ornaments that have artistic value. Besides that, plastic bottles can be sold to the nearest garbage bank in the coastal area.

Initial recycling activities can be done by separating from the source of waste generation based on the type of waste. Also, it can also be done by providing a color for different colors of each type of waste. Green containers for food and yard waste, blue containers for plastic, yellow containers for plastic, white for glass, and gray for cans and metals. The transport system should also be considered more. Transportation can be done every day for tourist areas so as not to interfere with aesthetics and reduce the quality of the environment in the tourist area.

Conclusion
Conclusions of the results of the study were solid waste generation unit in units of weight was 0.011 kg/cap./day or 0.017 kg/m²/day and in units of the volume was 0.253 L/cap./day or 0.448 L/m²/day. The composition of tourism waste in Pariaman City was dominated by food waste by 30.86%, plastic waste by 26.31%, paper waste by 18.29%, and yard waste by 11.01%. Meanwhile, the potential for recycling of tourism waste were 95.072% for non-ferrous metal waste, 93.359% for plastic waste, 64.505% for glass waste, 32.602% for wet waste, 19.231% for paper waste, and 16.408% for wood waste.

References
[1] Bhat RA, Nazir R, Ashraf S, Ali M., Bandh SA, and Kamili AN 2014 Waste Manage Res. 32 165–169
[2] Zorpas AA, Irene Voukkali I, and Loizia P 2015 Desalin Water Treat. 56 1141-1149
[3] Arbulú I, Lozano J, Rey-Maquieira J 2016 Waste Manage. 51 252-258
[4] Hoang MG, Fujiwara T, and Pham Phu ST 2017 Journal of JSCE. 5 123-132.
[5] Giurea R, Precazzini I, Ragazzi M, Achim MI, Cioca LJ, Conti F, Torretta V, and Rada EC 2018 Resources. 7 1-12
[6] Naltaru M, Purmaini R, dan Irsan R 2014 Perencanaan Sistem Pengelolaan Sampah di Kawasan Wisata Bukit Kelam Kabupaten Sintang. Undergraduate Thesis. Universitas Tanjungpura: Pontianak
[7] Wijaya IW, dan Trihadiningrum Y 2014 Strategi Penanganan Sampah di Objek Wisata Eks Pelabuhan Buleleng, Bali. Undergraduate Thesis. Institut Teknologi Sepuluh Nopember: Surabaya
[8] Suzanna RS 2003 Peran Pariwisata Dalam Pembangunan. Semarang: Badan Penerbit Universitas Diponegoro Semarang
[9] Undang-Undang Republik Indonesia No. 18 Tahun 2008 tentang Pengelolaan Sampah.
[10] Badan Standardisasi Nasional 2002 *Tata Cara Teknis Operasional Pengelolaan Sampah Perkotaan*. Indonesia. Nomor Publikasi: SNI-19-2454-2002

[11] Damanhuri E dan Padmi T 2016 *Pengelolaan Sampah Terpadu*. Bandung: Teknik Lingkungan Institut Teknologi Bandung (ITB)

[12] Technobanogloes G Theisen H and Vigil S 1993 *Integrated Solid Waste Management*. New York: Mc Graw Hill Inc

[13] Badan Pusat Statistik Kota Pariaman 2016 *Kota Pariaman dalam Angka*

[14] Badan Standardisasi Nasional 1994 *Metode Pengambilan dan Pengukuran Contoh Timbulan dan Komposisi Sampah Perkotaan*. Indonesia. Nomor Publikasi: SNI-19-3964-1994