Study on solid waste generation in Lake Toba area

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Abstract. Girsang Sipangan Bolon and Merek do not have basic data for solid waste management design. This research aimed to analyze the generation, composition of domestic and non-domestic waste. Sampling methods are determined based on SNI 19-3962-1994. The average amount of waste generation in units of volume for the area divider factor and the number of inhabitants for Girsang Sipangan Bolon and Merek are 92,771 and 87,227 m³/day, respectively. This study found the composition of domestic waste in Girsang Sipangan Bolon consists of 65% organic waste; 7% paper; 17% plastic; textiles 6%; rubber 0%; wood 0%; glass 2%; 0% metal and 3% other waste. The composition of non-domestic waste consists of 61% organic waste; 12% paper; 15% plastic; textile 1%; rubber / leather 0%; wood 1%; glass 0%; metal 1% and other waste 9%. In Merek, the composition of domestic waste consists of 69% organic waste; paper 14%; 8% plastic; textile 1%; rubber / leather 0%; wood 0%; glass 2%; 0% metal and 6% other waste. The composition of non-domestic waste consists of 55% organic waste; paper 14%; plastics 21%; textile 0%; rubber / leather 0%; wood 1%; glass 3%; 0% metal and 6% other waste.

1. Introduction
Lake Toba is the largest lake in Indonesia and the largest volcanic-tectonic caldera (giant volcano crater) worldwide. It was formed about 75,000 years ago due to volcanic eruptions and tectonic soil. Lake Toba has a length of 87 km northwest-southeast with a width of 27 km, an altitude of 904 meters above sea level, and the lake's most profound depth of 505 meters. This area covers part of 8 (eight) districts, namely Samosir Regency, Toba Samosir Regency, Dairi Regency, Karo Regency, Humbang Hasundutan Regency, North Tapanuli Regency, Simalungun Regency, and Pakpak Bharat Regency [1].

Lake Toba area is a strategic national tourism area. A national strategic has a significant national influence on state sovereignty, defense and national security, economic, social, cultural, and environmental, including areas that have been designated as a world heritage [2]. In order to realize Lake Toba as a tourism spot that attracts local, national, and international level tourists, it needs to be designed a sustainable layout. Lake Toba Spatial Plan, set up by Presidential Regulation No. 81 of 2014, mentions the purpose of the Lake toba national strategic areas spatial arrangement is to realize a safe, comfortable, productive, and sustainable lake area community. One of the policies formulated to achieve that goal is to construct waste management systems (articles 24, paragraphs 1, and 2) [3]. The existence of tourism areas has a positive and negative impact. The positive impact is in the form of the addition of local native income or economic improvement. Meanwhile, the negative impact on tourist areas is the decrease in environmental quality, such as water pollution, air pollution, and increasing amounts of waste.
A study about waste management has been done in a country like Tunisia [4], Ukraine [5], China [6], Pahalgam[7], and Vietnam [8]. In contrast, a study about waste management has been done only a few in Indonesia, especially in North Sumatera province. The research about waste management in Indonesia has been performed by some researchers like Chrisdianti [9]. It showed that the most dominated waste in Bromo-Tengger National Park is plastic, and travelers and vendor owners throw organic waste. This study parallels, according to Megi [10]. In Singkarak Lake, the most extensive waste composition is dominated by food waste (25.488 %) and plastic waste (24,834 %). The waste composition in Pariaman city is dominated by food waste amount 30,86% and plastic, 26,31%[11].

The environmental problem in the Lake toba tourism area is unwell managed waste. It could be seen through existing conditions around Lake toba, such as in sub-districts of Girsang Sipangan Bolon and Merek. Both districts still used the old waste management system, collecting, transporting, and dumping the waste. Besides temporary waste disposal, the limited and final waste process cannot be used in the long term. Related study of waste density, composition, a waste management plan in the Merek sub-district in Karo regency, and the Girsang Sipangan Bolon sub-district in Simalungun regency has not been done comprehensively. It is because there has not been any waste management following standard in the location. Data on generation and composition waste will affect and change the strategy and waste management system planned in the Lake Toba area. It can be found from the waste collection, transport system setting, waste management system design, landfill design, recycling program, and equipment that needed. This study is intended to figure out the generation and composition of waste in the Toba area.

2. Materials and methods

2.1. Study area
The determination of the location of the study under the directive in Presidential Regulation of the Republic of Indonesia No. 81 of 2014 on the Spatial Plan of Lake Toba area and its surroundings states that the body of Lake Toba is surrounded by 7 (seven) districts and 28 (twenty-eight) sub-districts. The Merek sub-district selection is representative of the Karo Regency, and the Girsang Sipangan Bolon sub-district representing the Simalungun Regency.

2.2. Data collection
The primary data are embossing data, composition, garbage characteristics, and questionnaires about household and non-household waste in the Girsang Sipangan Bolon sub-district and Merek Sub-district. Primary data is obtained by taking and measuring directly in the field and conducting surveys and interviews with the people who enter the sample criteria. This secondary data is population data in 2018 in the Girsang Sipangan Bolon sub-district and Merek Sub-district, map of Girsang Sipangan Bolon sub-district and Merek Sub-district, regional development direction and policies, institutional data, and others of general nature (literature study).

2.3. Calculation methods
The measurement and calculation of waste arising samples are conducted following SNI 19-3964-1994[12]. Based on the SNI, there was a sampling number for these areas as many as 35 locations representing housing, shops, schools, markets, offices, roads, hotels, restaurants, and other public facilities. Sampling was carried out for three consecutive days.

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.

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\text{Generation formula per day} = \frac{\text{weight or volume of waste (kg)}}{\text{area or number of waste producer (m}^2\text{or person)}}
\]

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

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

3. Result and discussions

3.1. Waste generation

In this study, the calculation of the arising and composition of garbage was guided in SNI 19-3964-1994 [12]. Waste collection in the Girsang Sipangan Bolon sub-district and Merek Sub-district can be found in table 1.

| No | Source               | Girsang Sipangan Bolon | Merek         | SNI 19-3983-1995 | Unit       |
|----|----------------------|------------------------|---------------|------------------|------------|
|    |                      | Weight (kg)            | Volume (l)    | Weight (kg)      | Volume (l) |
| 1  | Household            | 0.414                  | 3.02          | 0.166            | 2.93       | 2.5 – 2.75 person/day |
| 2  | Shops                | 1.727                  | 24.19         | 0.150            | 20.81      | 0.15 – 0.35 officer/day |
| 3  | Restaurant           | 1.404                  | 11.39         | 1.176            | 16.50      | -                      |
| 4  | Hotel                | 0.190                  | 3.37          | 0.460            | 6.19       | -                      |
| 5  | School               | 0.006                  | 0.05          | 0.009            | 1.17       | 0.010 – 0.020 student/day |
| 6  | Market               | 0.106                  | 0.13          | 0.370            | 0.20       | 0.10 – 0.30 m²/day    |
| 7  | Port                 | 0.011                  | 0.47          | -                | -          | -                      |
| 8  | Tourism area         | -                      | -             | 0.004            | 0.09       | -                      |
| 9  | Bank                 | 0.026                  | 4.44          | 0.268            | 2.24       | 0.025 - 0.10 employee/day |
| 10 | Road                 | 0.010                  | 0.29          | 0.016            | 0.33       | 0.010 - 0.050 m²/day  |
| 11 | Office               | 0.175                  | 7.20          | 0.032            | 2.80       | 0.025 - 0.10 employee/day |

Based on table 1, the amount of waste for household scale in Girsang Sipangan Bolon amounted to 0.414 kg/person/day, and Merek Sub-district amounted to 0.166 kg/person a day. Compared to SNI 19-3983-1995 [12], the generation of household waste for the Girsang Sipangan Bolon sub-district and Merek Sub-district is still below the standard. Population and community activity levels could affect the result. The number of household waste in the area around the Toba area is higher than the Singkarak Lake tourism area, whose waste is only 0.021 kg/person/day [10].

Meanwhile, for non-household waste generation, the highest amount of waste generated is in Girsang Sipangan Bolon, namely shops and restaurants. The largest non-household waste generation in Merek comes from hotel activities. Merek area is close to tourist spots, so tourist numbers dramatically influence it. This result is in line with research conducted by Kasam [13] in Gunungpring tourist park that is an immense waste pile on Sunday, about 155.1 kg, and the smallest on Wednesday is about 90 kg because the number of visitors on holidays is more than a typical day.

Another study conducted by Subzar in Pahalgam, India, found that non-household waste in the tourist area is more significant than household waste [7]. The results showed that 74% of non-household waste came from hotels and restaurants.
3.2. Waste composition

The result of the waste composition from this study can be seen in figure 1 and figure 2.

**Figure 1.** Composition of household and non-household waste in Girsang Sipangan Bolon Subdistrict

**Figure 2.** Composition of household and non-household waste in Merek Subdistrict

Based on the composition of waste from both, the dominant waste is organic waste from household and non-household sectors ranging from 55 - 70%. This figure follows data from KLHK [14], where the most extensive waste composition in Indonesia is the organic waste of 60%. A study on waste generation and composition conducted in the provincial capital, Medan City, also shows a similar composition [15]. In line with research conducted by Minh [8], the largest composition in Hoi An area, Vietnam’s tourist area, is an organic waste by 42%. Meanwhile, Kasam's research in the Gunungpring park area is plastic waste, a recyclable paper by 49.84%, organic waste that can be composted by 29.53%, and the rest discarded [13].

When considering the composition of the dominant waste is organic waste, composting is to reduce waste generation. The composting process can be done in an integrated manner by making compost
houses in each district. The composting process can be done aerobically with either a windrows or a mechanical system. Windrows composting has the principle of flowing air using an air tunnel at the beginning of composting. Windrows systems need to pay attention to temperature and humidity by manually reversing[16].

Meanwhile, for the mechanical system, the composting process is carried out in a reactor equipped with a mechanical reversal. Usually the amount of compost produced is 30% of the raw material for compostable organic waste. The quality of the compost produced must of course comply with SNI 19-7030-2004 standards regarding the specifications of compost from domestic organic waste with good compost requirements, namely a water content of <50%, Nitrogen content <0.4, C-organic content > 9.8, Calcium content <25.50 and pH ranges from 6.8 to 7.49[17].

4. Conclusions
The results of the study of waste generation and composition around the Lake Toba Tourism Area, namely Girsang Sipangan Bolon District and Merek District, obtained waste generation for household waste ranging from 0.166 to 0.414 kg/person/day. In contrast, the dominant waste generation from non-household waste originated from hotels, restaurants, and shops. The dominant composition of waste in the study area is organic waste ranging from 55 to 69%, plastic waste 8-21%, and paper waste 7-14%. Waste handling based on the composition of waste in the study area that can be done is composting, recycling, and the rest is disposed of in the landfill.

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