Analysis of infrastructure needs and operational systems for traditional market solid waste management (A case study on Makassar – Niaga Daya traditional market)

N A P Mangarengi¹, A Zubair¹, M A Abdurrahman²

¹Department of Environmental Engineering, Faculty of Engineering, Universitas Hasanuddin, Jl. Poros Malino KM. 6, Bontomarannu, Gowa, 92172, Indonesia
²Department of Civil Engineering, Faculty of Engineering, Universitas Hasanuddin, Jl. Poros Malino KM. 6, Bontomarannu, Gowa, 92172, Indonesia

E-mail: nurannisa.mangarengi@gmail.com

Abstract. Municipal authorities in developing countries face a challenge in managing solid waste. The challenging is mainly due to the increasing generation of waste that is not followed by the improvement of infrastructure and operational systems. The city of Makassar has also experienced the problem. Solid waste, especially in the traditional market, has not adequately managed, resulting in a complex waste management issue. The study is purposely to calculate the volume of solid waste generation and to assess the infrastructure and management systems, including trash cans, collection, temporary solid waste disposal in the form of container and transportation. The results show as follows: The total volume of Niaga Daya's market solid waste is 9000 l/day. The infrastructure required is 600 pieces of trash cans in which every stall needs 1, four carts, and two containers, transporting solid waste once a day to landfill. Optimization solid waste operational activities will be maximized by adding the number of service rations, additional work time, adding labor, and increasing the number of temporary solid waste disposal and transportation.

1. Introduction

Solid waste has become an issue, especially in developing countries. Solid waste from year to year continues to increase, along with the rate of population growth [1]. Rapid population growth has an impact on the increase in the amount of waste produced [2]. According to UU, No. 18/2008 about waste management, it is explained that waste is human daily activities disposal or natural processes that are in the solid form [3]. According to [4], waste is unusable human disposal from their activities removed to the environment. The characteristic of waste is solid and semi-solid, organic and inorganic substance, and biodegradable and non-biodegradable.

Municipal authorities in urban areas, especially in developing countries, face a challenge to manage solid waste. Municipal or household garbage is often derived from several sources, where different human activities are encountered. Some studies showed that most of the municipal solid waste in developing countries is derived from the household (55-80%) and commercial such as market areas (10-30%) [5,6,7]. One of the contributors to municipal waste is activities done in the market areas.
market is one of the various systems, institutions, procedures, social relations, and infrastructure where businesses sell goods, services, and labor to people in exchange for money. A market is a meeting place where there are transactions between the direct seller and buyer. Most markets sell daily needs, such as food ingredients in the form of fish, fruit, vegetables, meat, clothing, service, and others. Wastes from these sources are generally heterogeneous in the environment [8] and have different physical characteristics depending on their composition and where they can be found. The form of waste from these sources are food waste, wood, plastics, papers, metals, rubber, fabric, textile, etc.

The city of Makassar, for instance, has experienced the problem of managing solid waste. Solid waste, especially in commercial and public space, has not adequately controlled, resulting in a complex waste management issue. An increase in the waste generation that is not followed by the improvement of infrastructure and operational systems has a severe impact on the environment and public health. There are more than two-thirds of solid waste generation is not directly collected [9]. As a result, the uncollected waste and illegal waste disposal in the street contribute to flooding, breeding of insect and rodent vectors as well as the spread of disease. Disposal of garbage carried out in the open such as markets can also result in increased pollution intensity, pollution to air, soil, water, and low aesthetics.

Solid waste management is one of the alternative ways to tackle the problem of an increase of uncollected waste volume in the city. However, it requires proper handling because the presence of garbage volume is significantly growing with a rise in the human population. Therefore, this study aims to analyze the total amount of waste produced and the composition of the waste generated as a basis for integrated waste management planning. This study also aims to investigate the management and operational systems of solid waste, including storage, collection, and transportation systems, to optimize reliable management services, especially operational techniques for the waste market in Makassar city. In explaining the problem to facilitate the analysis, there are limitations to the issues given in this paper. The first one is that this research was conducted on the scale of direct observation.

2. Methodology
The type of research used is descriptive quantitative, namely systemic scientific research on parts, phenomena, and their relationships. The purpose of quantitative analysis is to develop and to use systematic models, theories, and hypotheses related to natural phenomena [10]. The simple random sampling method is used to determine samples from the population. The methods of taking and measuring waste generation samples based on the Indonesian National Standard (SNI)19-3964-1994 [11]. Twelve samples to be taken using the following formula:

\[ S = P_S \sqrt{C_D} \]  

Where,
- \( S \) = Number of samples
- \( P_S \) = Population
- \( C_D \) = Coefficient of non-residential

Data that has been gathered will be analyzed and used in waste management planning. Waste density is calculated using the following formula:

\[ \text{Waste density} = \frac{\text{Waste weight (kg)}}{\text{Waste volume (m}^3\text{)}} \]  

Where the weight of the waste is obtained by weighting the sample, while the volume of waste is measured by a wooden box measuring 20 x 20 x 40 cm. While the percentage of waste composition is determined using the equation below:
\[
\% \text{Composition of waste} = \frac{\text{Weight of component}}{\text{Total weight of waste}} \times 100\% \tag{3}
\]

The number of shops served by hand cart for every trip (HCs) is obtained by calculating the distance (Di) divided by the average of solid waste generation (Wg) per day:

\[
HCs = \frac{Di}{Wg} \tag{4}
\]

The number of hand cart needed is calculated using the equation below:

\[
HC = \frac{Vw + Vw \text{streets}}{Cc \times Cf \times Rit} \tag{5}
\]

Where,

- \(HC\) = Total Hand cart needed for transporting the waste
- \(Vw\) = Volume of waste
- \(Vw \text{streets}\) = Volume of street waste (10\% of the volume of waste generation)
- \(Cc\) = Capacity of the waste collector
- \(Cf\) = Compaction factor = 1.2

The container needs for commercial needs or public facility is calculated using the equation below:

\[
CN = \frac{Vw + Wg \text{for streets}}{Cc \times Cf \times Rit} \tag{6}
\]

Where,

- \(CN\) = Container needs
- \(Cc\) = Capacity of container
- \(Rit\) = 1 (trip made by a dump truck)

Determination of total composter used for recycling organic as compost with the area of 150 m² based on the following equation:

\[
\text{Composter} = \frac{Vw \text{organic} + Vw \text{streets}}{Vbk} \tag{7}
\]

Where,

- \(Vw \text{organic}\) = Volume of organic waste
- \(Vw \text{streets}\) = Volume of street waste (10\% of the volume of waste generation)
- \(Vbk\) = Volume of 1 mold of compost piles = 5000 l = 5 m³ = ± 600 kg

3. Results

3.1. Analysis of volume and composition of solid waste generation

Generation solid waste produced by the Niaga Daya market comes from trading activities from buyers and trader garbage every day. The average generation of waste per day is affected by the number of buyers due to the consumer consumptive pattern. The solid waste generation data will be presented using liters/day.

Measurements of waste generation are conducted for eight days, starting from 9 October – 16 October 2013. By taking samples at each source of waste, it can be used to represent the entire generation of garbage, deriving from activities that occur in the market. The measurement used based
on SNI 19-3964-1994 regarding "Methods for taking and measuring samples of waste generation and composition of residential and non-residential waste" [12].

Based on the results in Table 1, it is known that the average of waste generated from trading activities in the Niaga daya market per day is 15.01 l/day. The total volume of waste produced is obtained from calculating 600 active shops in the market with the average of waste generation after eight days of sampling are taken. So, the total volume of waste is 9000 l/day or nine m³/day. The highest amount of waste produced per day is sample 1, with the production of garbage is 26.55 l/day, followed by the lowest volume of sample 8.

As shown in Figure 2, the most significant percentage of waste composition of Niaga Daya traditional market per day is organic waste, which is 77.55%, and the rest of it is inorganic. Based on the results, the highest percentage of inorganic waste is plastic, which is 8.29%, followed by paper and wood by 6.41% and 4.07%, respectively. While glass, metal, fabric, and rubber take the smallest portion of the waste composition produced per day.

**Table 1. Recapitulation solid waste generation in Niaga daya traditional market.**

| Type of Sample | Waste Volume | Average |
|---------------|--------------|---------|
|               | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
| Sample 1      | 24    | 38    | 26    | 24    | 25    | 26    | 24    | 26    | 26.55 |
| Sample 2      | 25    | 27    | 22    | 24    | 23    | 20    | 22    | 20    | 22.85 |
| Sample 3      | 8     | 10    | 8     | 4     | 5     | 11    | 13    | 13    | 9     |
| Sample 4      | 8     | 10    | 8     | 4.8   | 10    | 9     | 8     | 8     | 8.2   |
| Sample 5      | 10    | 12    | 24    | 15    | 18    | 25    | 26    | 27    | 19.6  |
| Sample 6      | 8.8   | 16    | 6.4   | 4     | 6     | 7     | 8     | 10    | 8.3   |
| Sample 7      | 17    | 15    | 15    | 14    | 19    | 17    | 18    | 18    | 16.5  |
| Sample 8      | 6.8   | 6     | 6.8   | 3.2   | 6     | 8     | 9     | 9     | 6.8   |
| Sample 9      | 7.2   | 10    | 23    | 14    | 17    | 22    | 21    | 20    | 16.65 |
| Sample 10     | 4     | 14    | 14    | 8     | 10    | 15    | 14    | 14    | 11.65 |
| Sample 11     | 30    | 16    | 30    | 10    | 11    | 30    | 30    | 26    | 22.85 |
| Sample 12     | 9.2   | 6     | 9.2   | 14    | 14    | 13    | 10    | 14    | 11.15 |
| Sum           |        |       |       |       |       |       |       |       | 180.1 |
| Grand Average |        |       |       |       |       |       |       |       | 15.01 |

3.2. *Analysis of waste infrastructure and operational systems*

In this study, the Indonesia national standard (SNI 3242:2008) [12] regarding waste management in a residential area is used to calculate the waste infrastructure and operational system. Even though this standard explains about waste management in the residential area, it also describes the way to calculate waste management for a commercial and public facility such as market areas.

3.3. *Analysis of the waste collection system*

Operational systems used to collect the waste is direct communal patterns. The debris from each source in the market will be raised first in hand carts or similar, transported to temporary disposal sites in the form of containers. The hand cart is a simple garbage transportation tool than from each point of storage; it is directly transported to the container without the transfer process. Niaga daya traditional market uses a temporary container in the form of arm roll. The container is a storage device in this collection system. It cannot be ascertained when the container in the market is full (uncertain), since
the low participation of the community in the service area. The recommended container/arm roll truck for use has a volume of 5-10 m$^3$. There are eleven janitors at the markets who collect the garbage. The cleaning officers collect the waste using a hand cart only once, transferring all collected waste to temporary disposal sites (containers) at 10.00 p.m.

![Figure 1. Percentage of waste composition in the Niaga Daya market.](image)

**Table 2.** Composition of Niaga Daya Market’s waste.

| Waste Components | Waste composition (%) | Average |
|------------------|-----------------------|---------|
|                  | Day                   |         |
|                  | 1         | 2     | 3     | 4     | 5     | 6     | 7     | 8     |
| Organic          | 72.82     | 80.75 | 79.17 | 74.64 | 80.74 | 78.47 | 76.71 | 77.14 | 77.55 |
| Plastic          | 8.75      | 6.57  | 11.69 | 12.13 | 5.95  | 6.65  | 7.45  | 7.14  | 8.29  |
| Paper            | 7.17      | 4.56  | 3.59  | 4.44  | 5.16  | 8.06  | 9.27  | 9.04  | 6.41  |
| Fabric           | 0.42      | 0.55  | 0.26  | 1.16  | 0.60  | 0.00  | 0.00  | 0.00  | 0.37  |
| Wood             | 10.57     | 1.59  | 2.18  | 3.06  | 3.84  | 4.51  | 3.17  | 3.68  | 4.07  |
| Glass            | 0.00      | 0.00  | 0.00  | 2.96  | 2.47  | 1.39  | 1.17  | 1.06  | 1.13  |
| Metal            | 0.00      | 4.94  | 2.42  | 1.48  | 1.23  | 0.93  | 1.17  | 1.06  | 1.65  |
| Rubber           | 0.26      | 1.05  | 0.69  | 0.14  | 0.00  | 0.00  | 1.06  | 0.89  | 0.51  |
| **Sum**          | **100.00** |       |       |       |       |       |       |       |       |

**Table 3.** Recapitulation of Infrastructure and operational needs.

| Total of Active Shops | Total of Hand Cart | Transportation by Hand cart | Total Container | Transportation to landfill | Composter |
|-----------------------|--------------------|-----------------------------|-----------------|---------------------------|-----------|
| 600                   | 4                  | 2                           | 2               | 1                         | 2         |

3.4. **Analysis of waste transportation system**

The transportation system carrying out the waste from the market to landfill is only once, and back to the station for subsequent transportation in a day. However, it cannot be determined when the container is full. The transportation system using the arms roll container taken from the temporary
disposal site is ineffective. Truck arm roll must go twice and return to the container to pick up the waste generation and replace it after emptying from landfill to point the same transfer location. On the other hand, the transportation pattern carrying out waste directly from each source of waste is quite effective and efficient. Transportation of Niaga Daya market waste is carried out by the Department of sanitation of Makassar city using dump trucks. Waste transportation is done every day with one traffic, starting from 9.00-10.00 p.m.

4. Discussions
After obtaining results from Niaga daya traditional market, the percentage of organic waste is 77.55%, which means that around 837.54 kg/day of organic waste is produced. Therefore, the power trading market requires at least two units of composers, which can produce about one compost, 9 tons of organic fertilizer per month. With the addition of composter devices, the compost harvesting period only takes 5-9 days. That includes two days of compost cooling. Piles of organic waste which have been cut into pieces by the enumerator immediately put into the composter. With the enumerator, practically, organic waste from the market can be as small as powder. The activity adds to the income of the PD Pasar Makassar City and can add waste facilities and operational infrastructure by utilizing organic waste into fertilizer. As a result, private parties and industries can buy processed organic waste.

On the other hand, there is a potential for inorganic waste to recycling. The recycling process is an attempt to utilize material that is still useful for reuse, and indirectly, this process can extend the life of the landfill. Based on the results, the highest percentage of inorganic waste is plastic, followed by paper, so that it can be recycled. PD Pasar Makassar should collaborate with private collectors and recyclers of inorganic waste in the form of plastic or paper (recycling industry). Retribution fees obtained by PD Pasar can be invested every day into the Small Recycling Industry by utilizing traders and communities in the market area as human resources. By holding an MOU of cooperation between the PD Pasar and the Recycling Industry, it can add awareness and business opportunities for people around the Market and market traders themselves to participate. Inorganic waste is processed, either into finished products (recycled paper), semi-finished products (for plastic), or only packaged for later sale (metal, glass, cardboard) in the area. The recycling industry manager collects plastic and paper from traders and cleaning workers around the market to make a profit. Later, what percentage of the profits from the recycling industry will be given to PD Pasar as financing for waste facilities and operational infrastructure.

5. Conclusion
From the calculation results based on [12], infrastructure and operating system required is 600 trash cans, four hand carts with two times transportation to temporary disposal sites (TPS). Meanwhile, whole containers needed are two containers for at least 1-time transit per day.

Whereas from the direct observation in the field, solid waste collection systems in Niaga daya traditional market is a garbage collection system with direct communal systems. Waste from each source is collected using a hand cart to a temporary shelter container, which is usually containers/arm roll trucks with a volume capacity of 5 m³. Total hand cart in the market is one with only 1-time transferring the waste to the container at 10.00 p.m. The total container in Niaga daya traditional market is one. Transportation waste to landfill is uncertain and cannot be determined when the container is full.

References
[1] Guerrero L A, Maas G, Hogland W 2013 Solid waste management challenges for cities in developing countries Waste Management 33(1) 220-232
[2] Henry R K, Yongsheng Z, Jun, D 2006 Municipal solid waste management challenges in developing countries–Kenyan case study Waste Management 26(1) 92-100
[3] Hidup K L 2008 Undang-Undang RI Nomor 18 Tahun 2008 tentang Pengelolaan Sampah
[4] Tchobanoglous G 1993 Integrated solid waste management engineering principles and management issues (New York: McGraw-Hill)
[5] Nabegu A B 2010 An analysis of municipal solid waste in Kano metropolis Nigeria Journal of Human Ecology 31(2) 111-119
[6] Okot-Okumu J 2012 Solid waste management in African cities–East Africa Waste Management–An Integrated Vision (Croatia: InTech)
[7] Nagabooshnam J K 2011 Solid waste generation and composition in Gaborone Botswana Potential for resource recovery Linköping University
[8] Valkenburg C, Walton C W, Thompson B L, Gerber M A, Jones S B, Stevens D J 2008 Municipal solid waste (MSW) to liquid fuels synthesis, volume 1: availability of feedstock and technology (United States: Pacific Northwest National Lab. (PNNL) Richland WA)
[9] Madani M 2011 Agenda setting pengelolaan sampah pasar di kota Makassar Otoritas: Jurnal Ilmu Pemerintahan 1(1)
[10] Muhson A 2006 Teknik Analisis Kuantitatif (Yogyakarta: Universitas Negeri Yogyakarta)
[11] Nasional B S 1994 Standar Nasional Indonesia (SNI) 19-3964-1994 tentang Metode Pengambilan dan Pengukuran Contoh Timbulan dan Komposisi Sampah Perkotaan (Jakarta: Departemen Pekerjaan Umum)
[12] Nasional B S 2008 SK SNI 3242-2008 Tentang Pengelolaan Sampah di Pemukiman (Jakarta: Balitbang DPU)