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Investigation on Municipal Solid Waste Characteristics from Commercial Sources and Their Recycling Potential in Padang City, Indonesia

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Abstract. The aim of current study is to analyze the Municipal Solid Waste (MSW) characteristics for the last 10 years including generation rates, composition, proximate analysis, and recycling potential in commercial area of Padang City. Such characteristics are very important for MSW management planning. National Standardization Agency of Indonesia (SNI) 19-3964-1994 was used as guidance for 8 consecutive days sampling to commercial facilities including traditional market, shop, hotel, restaurant and automobile service point. Types of marketable waste observed from recycling agents, scavengers and solid waste banks (SWB) were used as reference for estimating the recycling potential of dry waste (non biodegradable waste). Current investigation on MSW generation rate, composition, and chemical characteristics was compared to those in 2005 and 2009. As a result, MSW generation rates tend to increase from 2005 to 2009 (0.430 kg/cap/day and 0.523 kg/cap/day), while decrease from 2009 to 2016 (0.523 kg/cap/day and 0.346 kg/cap/day). People awareness on waste reduction and reuse might be contributing to this decrease. Composition of plastic waste has been increasing in the last 10 years due to the increasing level of plastic-packaged food production (13.00% and 34.59%). Recycling potential for biodegradable waste, paper waste, plastic waste, glass waste, non ferrous metal waste, and ferrous metal waste are 69.901%, 74.994%, 79.863%, 85.604%, 95%, and 71.591%, respectively. The high recycling potential of MSW creates an opportunity for the local government to promote waste recycling program and to reduce the waste entering the municipal landfill. 3R waste treatment facility (TPS 3R), Integrated waste treatment facility (TPST), and SWB must be established at source and municipality scale.

1. Introduction

Poor municipal solid waste management (MSWM) practices can result in land, water and air pollution. To avoid any disruption to the environment and human health, the local government must assure the implementation of MSWM following the national standard. A good design of MSWM requires accurate MSWM characteristics. They include waste generation rate, composition, proximate analysis, and recycling potential.

Previous research of generation rate, composition, and recycling potential of commercial solid waste in Padang city had been done by other researchers [1, 2, 3]. Municipal solid waste (MSW) is produced from different activities such as traditional markets, restaurants, hotels and automobile services point.

In order to provide basic data for developing and implementing an appropriate MSWM in a comprehensive and integrated system, analysis on the last 10 years of MSWM characteristics in Padang City was carried out in this paper. Current 8 consecutive days sampling of MSWM characteristics (2016) was compared to the ones in 2005 and 2010, done by other researchers. In addition, the recycling potential of dry marketable waste was analyzed based on the real market of practitioner (such as scavengers, solid waste bank, recycle agent). Some programs on waste recycling based on MSW compositions and their recycling potential were also discussed in this paper. Therefore, the results of this research are expected to update the basic data of the local MSW and to evaluate the opportunity in utilizing the recycling potential that may give benefits to the local authority and citizens.

2. Methods

This research consists of field observations, MSW sampling and laboratory works, and literature reviews. Field observations include a preliminary survey. It begins with questionnaire distribution to locations that became the source of commercial wastes. Questionnaire aimed to obtain additional information such as the size and number of facilities that support the MSW sampling. The field observations also consist of questions about the MSWM activities including composting, solid waste bank, waste collection and transportation, illegal waste handling, etc.

72 MSW sampling locations which are located in 3 districts of the total 11 districts in Padang City commercial area were chosen based on the National Standardization Agency of Indonesia (SNI 19-3964-1994) [4]. Selected districts are determined by population level, which represent the highest, medium and lowest number of commercial facilities. *Koto Tangah* District represents an area with the highest population number, *Lubuk Kilangan* District represents an area with the medium population number, and *Padang Barat* District represents an area with the lowest population number. Reliability survey of 99.166% which means the number of samples has been represented. Table 1 displays the number of sample.

Table 1. The number of MSW sampling of current research

No.	Facilities	Kota Tangah (unit)		Lubuk Kilangan (unit)		Padang Barat (unit)		Total sample
		Number of facilities	Number of sample	Number of facilities	Number of sample	Number of facilities	Number of sample	
1.	**Restaurant**	20	4	12	3	84	9	16
2.	**Shop**	37	10	23	10	38	10	30
3.	**Traditional market**	3	3	1	1	2	2	6
4.	**Hotel**	4	2	-	-	53	7	9
5.	**Automobie service**	18	4	7	3	18	4	11
	Total	82	23	43	17	195	32	72

MSW Sampling was performed for 8 consecutive days from 11 to 23 October, 2016. It was followed with laboratory analysis. 8-day sampling was done for collecting MSW generation rate and composition, while laboratory analysis was carried out for proximate analysis. Measurement MSW generation rate is based on SNI 19-3964-1994 determine its number in volume basis (L/cap/day, L/bed/day, and L/m^2/day) and in weight basis (kg/cap/day, kg/bed/day, and kg/m^2/day). Measurement of MSW composition (Percent by weight) was calculated by Equation 1.

$$\text{Percent of MSW composition} = \frac{B}{BBS} \times 100\% \qquad (1)$$

Note: B = weight of MSW component (kg)
     BBS   = total weight of MSW (kg)

Analysis of MSW in the laboratory was performed to obtain the proximate data and C/N ratio. Proximate analysis consists of moisture content (%), volatile content (%), ash content (%) and fixed carbon (%), while the analysis of C/N ratio consist of the levels of C-organic, levels of total-N and C/N ratio. Moisture content, volatile content, ash content and fixed carbon were measured with the heating method using furnace. Weight reduction of the sample after heating was measured using analytical balance. Moisture content is expressed as loss of moisture when heated to 105°C for 1 hour. Volatile content is expressed as additional loss of weight on ignition at 600°C. Ash content is expressed as weight of residue after drying at 900°C. Fixed carbon is expressed as remaining combustible residue after volatile matter is removed. Measurement of C/N ratio obtained from a comparison of the value of C-organic with N-Total. C-Organic and N-total were measured by spectrophotometer and Kjeldhal method, respectively.

Recycling potential of dry waste (non biodegradable waste) was determined based on the ratio of the marketable dry waste and total dry waste. Types of marketable dry waste were collected from the field observation of solid waste bank, scavenger, recycle agent, and other informal sectors in Padang City. Meanwhile, the recycling potential of biodegradable waste was determined from literature reviews [5].

3. Results and discussion

3.1. Generation rate of MSW

8 consecutive days of MSW sampling in commercial areas of Padang City gave an average generation rates of 0.346 kg/cap/day or 3.435 liter/cap/day. The largest contribution comes from traditional market as displayed in Table 2. In general, higher generation rates are occurred on the weekend due to the higher number of visitor. Figure 1 suggests that the MSW generation rates tend to increase from 2005 to 2009 (0.430 kg/cap/day and 0.523 kg/cap/day), while decrease from 2009 to 2016 (0.523 kg/cap/day and 0.346 kg/cap/day). People awareness on waste reduction and reuse might be contributing to this decrease.

Table 2. MSW Generation rates of commercial
facilities in Padang City in 2016

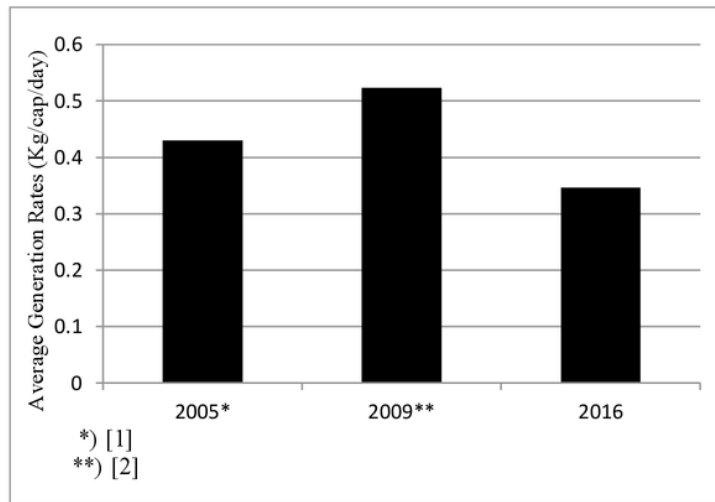| Facilities	kg/cap/day	l/cap/day
Shop	0.375	6.918
Restaurant	0.252	2.416
Traditional market	0.595	0.737
Hotel	0.378	4.795
Automobile service	0.132	2.310
Average	0.346	3.435

Figure 1. Comparison of MSW generation rates in the last 10 years

3.2. MSW composition

In general, composition of organic waste is higher than in inorganic waste in Padang city as displayed in Figure 2. Organic waste consists of food waste, yard waste, papers, plastics, textiles, rubbers, and wood, which is 86.768%. While inorganic waste is only 13.232%, which consists of glass, ferrous metals, non ferrous metal, and others. The three largest components of MSW is plastic waste (34.590%), followed by food waste (31.021%) and paper (13.624%).
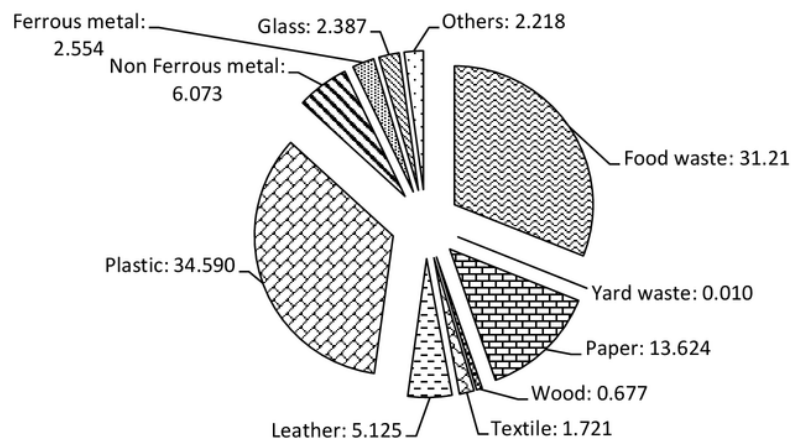

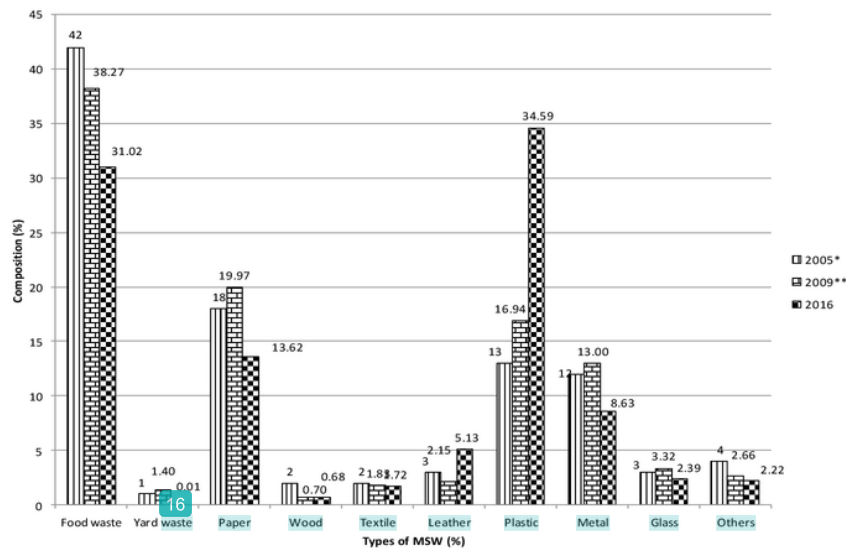**Figure 2.** MSW Composition of MSW in 2016

Figure 3. Comparison of MSW composition in the last 10 years

Figure 3 shows that the organic waste component has increased from 80% in 2005 to 86.768% in 2016. The inorganic waste component has decreased from 19% in 2005 to 13.232% in 2016. The plastic waste component shows the highest increase in the last 10 years from 13% to 34.59%. The increasing level of plastic-packaged food production might be contributing to this increase. Inversely proportional to the increase of the plastic waste component, food waste and other components have decreased over the last 10 years.

3.3. Proximate analysis

Analysis of moisture content, volatile content, and ash content of biodegradable MSW in the last 10 years are displayed in Table 3. The average moisture and volatile content in biodegradable waste generated from commercial facilities is 41.86% and 47.72%, respectively. The effective moisture content for composting process is 40-60% [5]. According to Luo and Chen, too high or too low moisture content would reduce the efficiency of the composting process [6]. The condition of waste with high water content (> 60%) leads to reduce aeration, create anaerobic condition, produce odors and slow down the process. If the moisture content is too low (<40%) or too dry then it needs the addition of water and stirring. According to Haug, the decomposition of organic material by microorganisms is affected by moisture and oxygen content in the material. The waste with high moisture content needs more frequent MSW collection to minimize the bad odor. Meanwhile, the presence of volatile content may support the biodegradation process [7].

Table 3. Comparison of moisture, volatile and ash content of MSW

Year	Moisture content (%)	Volatile content (%)	Ash content (%)
2006[a]	32	58	10
2010[b]	41.16	44.98	12,27
2016	41.86	47.72	10,59

5

Optimum C/N ratio for composting is 20-25 [5]. Figure 4 suggests that biodegradable waste from shops, restaurants, traditional markets and hotel waste is well used as a compost raw material.
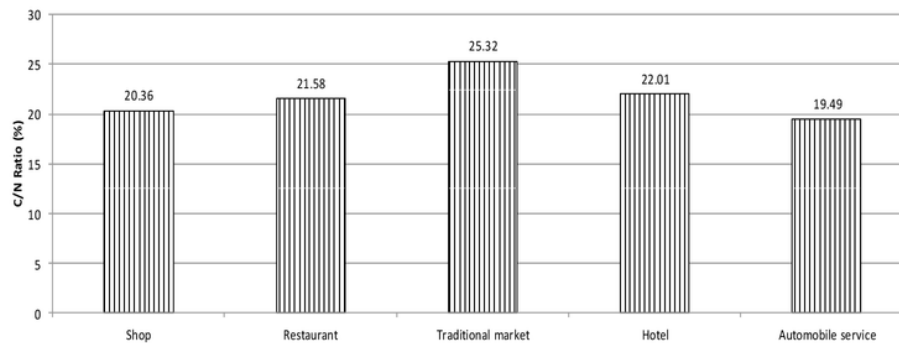
Figure 4. C/N ratio of biodegradable MSW in 2016

3.4. Recycling potential

Wet garbage including food scraps, yard waste, vegetable, fruit, wood and organic ingredients are more easily biodegradable. While, egg shells, shells and bones are non biodegradable. Traditional markets and restaurants contribute most to produce biodegradable waste.

Another category of recyclable waste is marketable dry waste. Table 4 displays the types of marketable dry waste in Padang City. The data were collected from the real market of practitioner (such as scavengers, solid waste bank, recycle agent).

Recyclable paper wastes are printing paper, newspaper, cardboard, and egg carton. Other paper wastes such as tissue paper, food packaging paper, carbon paper, are not recyclable. Clear plastic bottle is the largest component of recyclable waste generated by restaurants and hotels. The recyclable glass waste is generally in the form of bottled drinks, glasses, plates, ketchup bottles and condiment bottles. The bottles can be recycled into glass ore that can later be recycled into glass. Examples of recyclable non-ferrous metals are beverage can, milk can, aluminium, and copper. Non-ferrous metals can be recycled into aluminium ore or recycled into a product which is composed of aluminium. Ferrous metal could be found in markets and automobile service, such as automobile parts, iron electronic goods, metal pipes, etc. Ferrous metals generally are recycled into iron ore and reprocessed into new products. Table 5 displays recycling potential of MSW in 2016.

3.5. Waste utilization program

Table 5 displays that there is an opportunity to reduce the waste transferred to landfill by around 79.5% by conducting recycling program, depending on the types of waste. They can be divided in two categories based on available waste treatment facilities, namely biodegradable waste and marketable waste. Table 6 suggests the proposed system to utilized biodegradable waste and marketable waste.

Table 4. Types of marketable dry waste in Padang City

Recycling Agent	Enviro Waste Bank	SMAKPA Waste Bank	Scavenger
Printing paper (HVS)	Printing paper (HVS)	Printing paper (HVS)	Printing paper (HVS)
Newspaper	Newspaper	Newspaper	Newspaper
Cardboard	Cardboard	Cardboard	Cardboard
Clear plastic bottles (PET)	Clear plastic bottles (PET)	Clear plastic bottles (PET)	Clear plastic bottles (PET)
Colour plastic bottles (PET)	Colour plastic bottles (PET)	Colour plastic bottles (PET)	Colour plastic bottles (PET)
Plastic cups (PP)	Plastic cups (PP)	Plastic cups (PP)	Plastic cups (PP)
Cleaner agent bottle, cosmetics bottle, etc (HDPE)	Cleaner agent bottle, cosmetics bottle, etc (HDPE)	Cleaner agent bottle, cosmetics bottle, etc (HDPE)	Cleaner agent bottle, cosmetics bottle, etc (HDPE)
Various food packaging plastic bottle	Various food packaging plastic bottle	Various food packaging plastic bottle	Various food packaging plastic bottle
Beverage cans	Beverage cans	Beverage cans	Beverage cans
Canned milk / similar	Canned milk / similar	Canned milk / similar	Canned milk / similar
Iron		Iron	Iron
Aluminium		Aluminium	Aluminium
Clear glass		Clear glass	Clear glass
Copper		Copper	Copper
Egg carton		Egg carton	Egg carton
Battery			

Table 5. Recycling potential of MSW in 2016

No	Types of waste	Recyclable Waste (weight %)	
		Recyclable	Not recyclable
1.	Wet garbage	69.901	30.099
2.	Paper waste	74.994	25.006
3.	Plastic waste	79.863	20.137
4	Glass waste	85.604	14.396
5.	Non-Ferrous Metal waste	95.000	5.000
6.	Ferrous Metal waste	71.591	28.409
	Average	79.492	20.508

Table 6. Proposed system for utilizing biodegradable waste and marketable waste

No.	Type of waste	Recycling facility	Technology/activity
1.	Biodegradable Waste	3R waste treatment facility (TPS 3R) Integrated waste treatment facility (TPST)	Composting and/or anaerobic digester
2.	Marketable Waste	Solid waste bank (SWB)	Waste savings, sorting, processing, and selling
		3R waste treatment facility (TPS 3R) Integrated waste treatment facility (TPST)	Waste collection, sorting, processing, and selling

TPS 3R, *TPST* and SWB are regulated by the national program for conducting recycling activities [8, 9]. However, their implementation in Padang City is still limited, account for only 5% of the total waste generation in 2013 [10].

Raharjo, et al. suggests that recycling activities must be carried out at source scale by community and municipality scale by the local government [10,11]. Biodegradable waste can be recycled using composting or anaerobic digester. While, the marketable waste can be collected from customers (sources), sorted, processed, and sold to the recycle agents/factories by the SWB system and/or *TPS 3R* and *TPST*. The local government must establish SWB at municipality to protect the marketing system of community SWB. In addition, it is expected that the informal scavengers would join or establish their own SWB.

4. Conclusion

The MSW generation rates tend to increase from 2005 to 2009 (0.430 kg/cap/day and 0.523 kg/cap/day), while decrease from 2009 to 2016 (0.523 kg/cap/day and 0.346 kg/cap/day). The plastic waste component shows the highest increase in the last 10 years from 13% to 34.59%. Investigation on the recycling potential suggests that there is an opportunity to reduce the waste transferred to landfill by around 79.5% by conducting recycling program, depending on the types of waste. Proximate analysis suggests that biodegradable waste from shops, restaurants, traditional markets and hotel waste is well used as a compost raw material. Biodegradable waste can be recycled in *TPS 3R* at source scale and *TPST* at municipality scale using composting or anaerobic digester. Meanwhile, the marketable waste can be collected from costumers (sources), sorting, processing and selling to the recycle agents/factories by the solid waste bank, and/or *TPS 3R* and *TPST*.

Acknowledgements

References

[1]   Nizmah 2005 *Report on Waste Generation, Composition, and Recycling Potential from Commercial Area in Padang City during Rainy Season in 2005* (Department of Environmental Engineering – Universitas Andalas)

[2]   Desnifa L 2009 *Report on Waste Generation, Composition, and Recycling Potential from Commercial Area in Padang City in 2009* (Department of Environmental Engineering –

Universitas Andalas)

[3]   Pangerani M 2005 *Report on Waste Generation, Composition, and Recycling Potential from Commercial Area in Padang City during Dry Season in 2005* (Department of Environmental Engineering – Universitas Andalas)

[4]   SNI 19-3964-1994 1994 *Methods of Measurement of Generation Rate and Composition of Municipal Solid Waste* (National Standardization Agency of Indonesia)

[5]   Tchobanoglous G, Theisen H, Vigil S 1993 *Integrated Solid Waste Management: Engineering Principles and Management Issues* (Mc. Graw-Hill, Inc, New York)

[6]   Luo W, Chen T B, Zheng G D, Gao D, Zhang, Y A and Gao W 2008 *Resour. Conserv. Recycl.* **52** 635

[7]   Haug R T 1993 *The Practical Handbook of Composting Engineering* (Lewis Publisher - Boca Raton)

[8]   Ministry of Public Work – Indonesia 2013 *PerMen PU No. 03/PRT/M/2013 about enforcement of solid waste facilities for handling household solid waste*

[9]   Ministry of Environment – Indonesia 2012 *PerMen LH No. 13/2012 about the guidelines on reduce, reuse and recycle through Solid Waste Bank*

[10] Raharjo S, Matsumoto T, Ihsan T, Rachman I and Gustin L 2017 *J. Mater. Cycles. Waste.* **19** 201

[11] Raharjo S 2017 *J. Eng. Appl. Sci.* **12** 3789

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