Vol. 11, No. 1 (2022) : 70 - 78
DOI : http://dx.doi.org/10.23960/jtep-l.v11.i1.70-78

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Characterization of Traditional Market Solid Waste (TMSW) and Its Recycling Potential (Case Study:Traditional Markets in Bandar Lampung)

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Article History :

Received : 3 February 2022
Received in revised form : 21 March 2022
Accepted : 21 March 2022

Keywords :

Recycling
Solid Waste Management
Traditional Market Solid Waste
Waste Characterization

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ABSTRACT

Solid waste has always been a problem for developing countries. In Bandar Lampung, the traditional market is the second largest contributor of solid waste, after households. Data for Traditional Market Solid Waste (TMSW) composition and generation rate in Bandar Lampung is rarely found, even though, data is needed to write the policy for TMSW management and its recycling potential. This research aims to provide data on TMSW composition, generation rate and chararacteristic in Bandar Lampung, also its recycling potential. The sample from 10 of 31 traditional markets in Bandar Lampung is collected for 8 consecutive days in morning and afternoon. Then, the sample was processed to obtain its composition, generation and density. 48.06% of TMSW compositions is donated by vegetable. Meanwhile, metal is rarely found in traditional markets, with only 0.37%. The average density of TMSW is 180.11 kg/m^3, while Kangkung Market has the highest density with 237.84 kg/m^3 and Cimeng Market has the lowest TMSW density with 123.07 kg/m^3. The generation rate of TMSW is 53,602.35 kg/day. Biodegradable wastes from traditional markets in Bandar Lampung, with 53% water contents, can be potentially recycled by composting and/ or anaerobic digestion because of its economic value and characteristic.

1. INTRODUCTION

Solid waste is materials with little or no value for human being (Pitchel, 2014). Globally, in 2012, the generation rate of solid waste in a day was 1.2 kg per capita and it can be estimated up to 1.42 kg per capita in 2025 (Hoornweg & Bhada-Tata, 2012). The generation of solid waste grows rapidly and has become a major problem in many countries (Aye & Widjaya, 2006). Based on data from the Ministry of Environment Republic of Indonesia (2021), in 2021, the generation rate of solid waste in Indonesia reached more than 32.7 million tons, where in Bandar Lampung City, Lampung Province, reached 276.649,16 tons and 19% of it, comes from the traditional market or the second largest after households.

Solid waste from the traditional market in Indonesia is directly managed by the local government (Sukresno *et al*., 2019). Most local governments do not handle the solid waste by 3R activities (reduce, reuse and recycle) optimally and rarely use waste sorting as the first step before the next treatments (Raharjo *et al*., 2019). Handling solid waste by open burning or collecting and dumping to landfill is commonly used by local government in Indonesia (Raharjo *et al*., 2017, Hartono *et al*., 2015) Open dumping method will result in a bad impact on the environment and mankind for long term (Boonthavornsatien & Wiwattanadate, 2019).

In open burning method, any material is openly burnt without proper duct or stack (Kumari *et al*., 2019). The product from this method will directly emit into the ambient and can result global warming (Das *et al*., 2018; Haviz *et al*., 2021). It serves as of pollutants like Carbon Monoxide (CO), Nitrogen Oxide (NO_2), Sulphur Dioxide (SO_2) and many particulate matters (Reyna-Bensusan *et al*., 2018).

Open dumping method provides many impacts for environment and mankind. Water and soil contamination also are the products from open dumping method. It makes the area arround the landfill become toxic (Mohan & Joseph, 2021). Data from Traditional Market Solid Waste (TMSW) in Bandar Lampung, especially composition and generation rate, is barely available. It is needed by researcher, local government and others as a reference for various activities. This research aims to provide data for solid waste composition, density and generation rate from traditional markets in Bandar Lampung, Lampung, Indonesia. Thus, its recycling potential can be designed for more optimal local TMSW management.

2. MATERIALS AND METHODS

This research has been located in 10 of 31 traditional markets in Bandar Lampung, Lampung Province, Indonesia. The samples were a part of the solid waste population that can represented it with respective consideration (Nyampundu *et al*., 2020). Method for sampling process referred to Indonesian Government Standard, SNI 19-3964-1994 (1994) on "Method of Collection and Measurement of Waste Generation and Composition". The sampling process was done for 8 (eight) consecutive days, in the morning (6 A.M.) and afternoon (6 P.M), where tool for this sampling process was a container with dimension 0.58 m x 0.42 m x 0.36 m or 88 litters of volume.

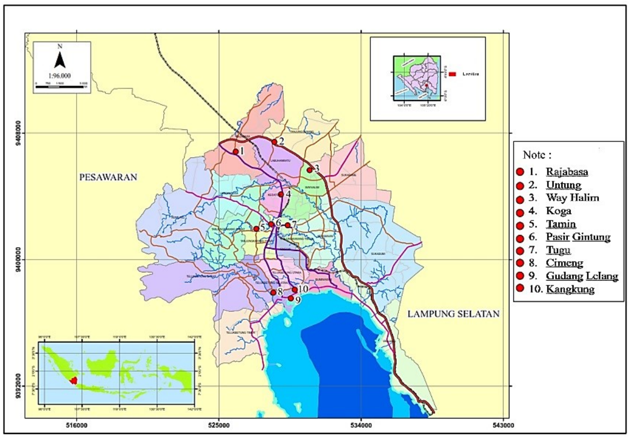

Figure 1. Research locations (red dots)

Variables in this research consist of Traditional Market Solid Waste (TMSW) composition, density and generation rate (Surya & Ariefahnoor, 2020). All of the variables have to consider the volume of the temporary solid waste collector in each market (Devi & Mugilvannan, 2018). The formula for determining TMSW composition, density and generation rate can be shown in equation 1-3 respectively. Furthermore, after all the research variables are obtained, it is continued with providing the potential recycling facilities for TMSW in Bandar Lampung before dumping it into the landfill.

$$WCS = \frac{\text{weight of waste component (kg)}}{\text{total measured weight (kg)}} \quad (1)$$

$$WD = \frac{\text{weight of sample (kg)}}{\text{container volume } (m^3)} \quad (2)$$

$$GR = \text{volume of collector}(m^3) \text{ x waste density } (kg/m^3) \quad (3)$$

Where WCS is waste composition from sample (% weight), WD is waste denstiy from sample (kg/m^3), and GR is Generation rate/day (kg/day).

3. RESULTS AND DISCUSSION

Temporary solid waste collectors should be considered for determining the generation rate of traditional market solid waste (Oloo & Awuor, 2019). Every market has a different volume of the temporary solid waste collector (Sarnobat *et al.*, 2019). Table 1 shows the dimension of the temporary solid waste collector in a different condition. The temporary solid waste collector is rarely found in empty or full condition. There is an excess about 0.05-0.5 m of height in every temporary solid waste collector. Figure 2 shows the waste-collecting and sortings from temporary solid waste collectors in the traditional market.

TMSW was collected from four different spots in a temporary solid waste collector (Al Anas *et al.*, 2021). Then, TMSW was sorted based on its characteristic.

Table 1. Volume of temporary solid waste collector

No.	Location	Empty Volume (m^3)	Average Excess (m^3)	Total Volume (m^3)
1	Tamin	9.24	4.62	13.86
2	Rajabasa	10.24	5.12	15.36
3	Gudang Lelang	14.84	7.42	22.26
4	Untung	12.00	3.00	15.00
5	Koga	22.78	0.00	22.78
6	Cimeng	12.24	6.12	18.36
7	Kangkung	11.52	3.60	15.12
8	Tugu	8.33	4.16	12.49
9	Way Halim	6.83	3.41	10.24
10	Gintung	2.21	1.11	3.32

(a) (b)

Figure 2. (a) Collecting the sample (b) Waste sorting

The average of TMSW composition for eight consecutive days sampling in the morning and afternoon can be shown in Table 2 and subsequently :

Table 2. Average weight and characteristic of solid waste from sampling process

No.	Location	Weight (kg)											Total
		Vegetable	Fruit	Paper	Wood	Textile	Metal	Nappies	Plastic	Glass	Rubber	Misc	(kg)
1	Tamin	8.98	2.78	1.41	1.87	0.46	0.04	0.64	2.65	0.05	0.03	0.00	18.89
2	Rajabasa	4.66	3.74	1.19	1.12	0.79	0.01	0.62	3.00	0.30	0.08	0.00	15.49
3	Gudang Lelang	4.01	0.49	0.97	0.95	1.06	0.16	0.99	3.93	0.40	0.27	1.41	14.61
4	Untung	9.51	3.31	1.13	0.53	0.03	0.11	0.54	2.26	0.02	0.02	0.09	17.53
5	Koga	7.85	2.53	0.59	2.01	0.65	0.18	0.31	3.22	0.06	0.23	0.13	17.73
6	Cimeng	4.07	1.22	1.01	2.28	0.32	0.01	0.12	1.77	0.04	0.02	0.00	10.83
7	Kangkung	10.56	3.11	0.89	0.94	0.15	0.02	1.08	3.70	0.04	0.12	0.35	20.93
8	Tugu	6.45	1.97	1.06	0.51	0.20	0.04	0.65	1.66	0.06	0.01	0.00	12.60
9	Way Halim	6.36	3.02	0.64	1.04	0.18	0.01	0.11	1.51	0.05	0.01	0.79	13.70
10	Gintung	13.74	0.40	0.66	0.03	0.02	0.03	0.01	1.27	0.03	0.01	0.00	16.19
	Mean (kg)	7.62	2.26	0.95	1.13	0.38	0.06	0.51	2.49	0.10	0.08	0.28	15.85
	Percentage (%)	48.06	14.24	6.02	7.10	2.41	0.37	3.19	15.74	0.65	0.49	2.25	100.00

From Table 2, TMSW is dominated by vegetables with more than 48% during the sampling process in eight consecutive days; and, more than 75% of traditional market solid waste is organic waste, which means solid waste from the traditional market has the potential to be reuse and recycled in the future. Figure 3 shows the percentage of TMSW composition in the pie diagram.

3.1. TMSW density

Table 3 shows the average density of solid waste from 10 traditional markets in Bandar Lampung, Indonesia, with sampling apparatus' dimension is 0.088 m^3 or 88 liters of volume. From Table 3, the highest density of TMSW is in Kangkung Market with 237.84 kg/m^3, while Cimeng Market is the lowest with 123.07 kg/m^3. The average density of TMSW from 10 traditional markets is 180.11 kg/m^3.

3.2. Generation Rate of TMSW

The generation rate of TMSW can be determined by multiplying total weight of the temporary solid waste collector with TMSW density and from the sampling process.

Table 4 shows the generation rate of TMSW from 10 traditional markets in Bandar Lampung.

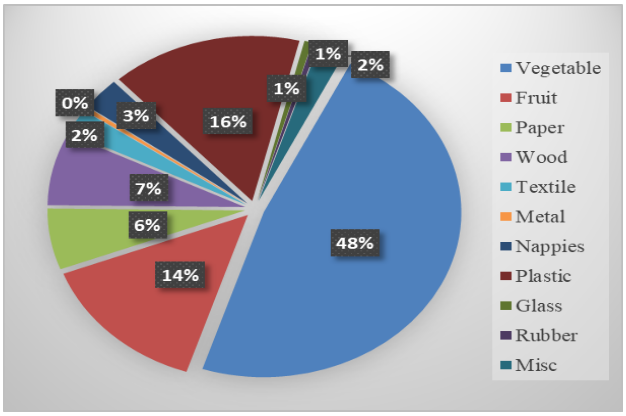

Figure 3. Percentage of TMSW composition in Bandar Lampung, Indonesia

Table 3 . Average density of TMSW from the sampling process

No.	Location	Weight (kg)	Density (kg/m^3)
1	Tamin	18.89	214.66
2	Rajabasa	15.49	176.02
3	Gudang Lelang	14.61	166.02
4	Untung	17.53	199.20
5	Koga	17.73	201.48
6	Cimeng	10.83	123.07
7	Kangkung	20.93	237.84
8	Tugu	12.60	143.18
9	Way Halim	13.70	155.68
10	Gintung	16.19	183.98
	Average	**15.89**	**180.11**

Table 4. Generation rate of TMSW from sampling process

No.	Location	Generation Rate (kg/a half day)	Generation Rate (kg/day)
1	Tamin	2975.19	5950.38
2	Rajabasa	2703.67	5407.33
3	Gudang Lelang	3695.61	7391.21
4	Untung	2988.00	5976.00
5	Koga	4589.71	9179.43
6	Cimeng	2259.57	4519.13
7	Kangkung	3596.14	7192.28
8	Tugu	1788.32	3576.64
9	Way Halim	1594.16	3188.33
10	Gintung	610.81	1221.63
	Total	26801.18	53602.35
	Average	2680.12	5360.24

From Table 4, average generation rate of TMSW is 5,360.24 kg/day. Every traditional market in Bandar Lampung, has the potential to produce solid waste from morning to evening or vice versa up to 2,680.12 kg/day. Afterall, the total TMSW produced from 10 traditional markets in Bandar Lampung can be estimated as 53,602.35 kg/day.

3.3. Characteristic of TMSW in Bandar Lampung

Characterization of TMSW can be divided into two types, organic and inorganic. Inorganic wastes, such as metal, glass and miscellaneous types, can't be decomposized (Iryani et al, 2019). Table 5 shows the characteristic of TMSW.

Vegetables, fruit, and nappies have high water content. Besides water content within the waste itself, vegetables, fruit, and nappies have a good ability to absorb the water from their surrounding (Yuliandari et al, 2019).

Table 5. Characteristic of TMSW in Bandar Lampung

Waste Type	Wet Weight (%)	Water Content (%)	Ash Content (%)	Dry Weight (%)	DOC_i (% in dry weight)	DOC_i (% in wet weight)
Vegetable	61.96	53.50	11.77	34.73	32.26	0.11
Fruit	58.77	53.03	11.80	34.00	32.12	0.12
Paper	4.65	35.36	3.06	61.58	44.00	0.27
Wood	0.94	11.66	5.2	83.14	50.00	0.41
Textile	6.77	13.33	0.34	86.36	29.30	0.25
Rubber	0.07	40.00	-	60	39.00	0.23
Nappies	4.19	54.16	2.03	43.81	60.00	0.26
Metal	0.78	-	-	-	-	-
Plastic	14.47	-	-	-	-	-
Glass	3.36	-	-	-	-	-
Misc	-	-	-	-	-	-

3.4. Recycling Potential

Burning and incinerating are often found as solid waste treatment in Indonesia. Those processes need fire to ignites gas methane from solid waste (de Vega *et al.*, 2008). Organic matters are decomposed during it. Furthermore, landfilling or open dumping is the most common solid waste treatment in Indonesia (Santosa & Sujito, 2021). Wet solid wastes, except nappies, vegetable, fruit, paper and wood, are more easily biodegradable, while others are non-biodegradable (Chaerul & Dewi, 2020). Dry waste including paper, glass, plastic bottle, and metal can be categorized as dry waste, that can be recycled into other products (Raharjo *et al.*, 2018).

The reasonable recycling facility for TMSW in Bandar Lampung, Indonesia, before dumping it to landfill are Solid Waste Bank (SWB), Integrated waste treatment facility (TPST), and 3R waste treatment facility (TPS 3R) (Elemile *et al.*, 2019; Wilson *et al.*, 2006; Raharjo *et al.*, 2019). The technology to process TMSW is shown in Table 6.

Composting and/or anaerobic digester are used to recycle the biodegradable waste and sellable waste can be sold to the customer, through the waste collector (people and/or factory) (Ma'arif *et al.*, 2018; Patel *et al.*, 2019). The regulation about recycling activities, TPS 3R, TPST and SWB, are regulated by the government of the Republic of

Indonesia (2012). Recylcing activities should be started from the community, in this case merchant in every traditional market and arranged by the local government (Arifin, 2018; Patel *et al.*, 2019).

Table 6. Proposed TMSW recycling facilities and technologies

No.	Type of Waste	Facility	Technology
1	Biodegradable waste (vegetable, fruit, paper, and wood)	- TPST - TPS 3R	- Composting - Anaerobic digester
2	Sellable waste (Paper, glass, plastic, and metal)	- TPST - TPS 3R - SWB	- Collecting, sorting, selling - Collecting, sorting, processing, selling

4. CONCLUSIONS

Waste from traditional markets in Bandar Lampung Indonesia is dominated by vegetable, with 48.06% of the waste composition. Meanwhile, metal is rarely found in traditional markets, because of its valuability. Metal can be directly resold to waste collector as sellable waste. The average density of TMSW is 180.11 kg/m^3, while Kangkung Market has the highest TMSW density with 237.84 kg/m^3 and Cimeng Market has the lowest TMSW density with 123.07 kg/m^3. The generation rate of TMSW is 53,602.35 kg/day, where the temporary solid waste collector is emptien twice a day, morning and evening. Biodegradable wastes, including vegetables and fruit has more than 53% water content, and it is the potential to be recycled by composting and/or anaerobic digester. Metal, plastic and paper can be categorized as sellable waste. They can be sold in various forms and at a reasonable price after going through a few processes.

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