



MUNICIPAL SOLID WASTE RECYCLING FACILITIES IN MALANG RAYA, INDONESIA

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ABSTRACT

The new paradigm of solid waste treatment that accentuate in reducing solid waste was applied in Malang Raya, Indonesia through 15 solid waste recycling facilities of different types. The objectives of this research were to identify types of the solid waste recycling facilities, and to determine solid waste recycling potential. Solid waste volume was measured according to load-count analysis method. Sampling for solid waste composition analysis was done randomly at solid waste recycling facilities with quarterly method. Total volume of solid waste input at solid waste recycling facilities was measured according to the amount and volume of various kinds of collecting vehicle. The results of this research showed that there were 4 types of solid waste recycling facilities in Malang Raya, which comprised 66.67% composting units, 20% Recycling and Compost Production Units (UDPK), 6.67% Integrated Solid Waste Treatment Facility (TPST), and 6.67% 3R Solid Waste Treatment Facility (TPST 3R). According to mass balance analysis, the recycling potential of solid waste was 76.77-88.92%.

Keywords: Malang Raya, recycling facility, municipal solid waste.

INTRODUCTION

The idea of integrated solid waste treatment was applied to reduce solid waste in its source. Solid waste that was produced must be recovered by reused and recycled, so that only the residual would be discarded into the landfill. Output from the treatment was used as input in process or converted to be added value of input for the other processes, to maximize resource consumption and to increase eco-efficiency [1].

The Indonesian Government Regulation Number 18/2008 concerning solid waste treatment stipulates the importance of basic paradigm change in solid waste treatment that accentuate in reducing and handling of solid waste [2]. Activity of reducing solid waste implied so that all of the society, including government, businessman and community do limitation on solid waste generation, also do recycle and reuse activity. That activity was known as 3R, Reduce, Reuse and Recycle. According to global trend, the solid waste treatment system was oriented to sustainability issue, especially through the combination of 3R technology [3]. Based on 3R principle, a lot of programs were implemented with the collaboration of government and private sector from social, technology, economy, public health and political perspective aspect [4].

There were various kinds of technologies to reduce solid waste accumulation in landfill, such as incineration followed by energy production, compost production from compostable solid waste, and material recovery through recycle. Those technologies had a potential to be sustainable method. However, with 55% of solid waste composition consisted of composted solid waste, composting was considered in many places in the world as a method to reduce solid waste in landfill [5].

Malang Raya Region covered Malang City, Batu City and Malang Regency administration region. Population growth of Malang City at 2013 was 840,803 people or the average growth was 0.86% per year [6], with the average waste generation rate in Malang City was 3.2 L/person/day [7]. Population growth of Batu City at 2013 was 196,951 people or the average growth was 1.17% per year [8], with the average waste generation rate in Batu City was 3.1 L/person/day [9]. Population growth of Malang Regency at 2013 was 2,506,102 person or the average growth was 0.85% per year [10], with the average waste generation was 2.09 L/person/day [11].

The objectives of this research were to identify types of the municipal solid waste recycling facilities in Malang Raya and to determine the recycling rate of municipal solid waste in each solid waste recycling facility for operational strategy reference in the future.

MATERIALS AND METHODS

The types of municipal solid waste recycling facilities were determined according to field survey about type and operational pattern, type of municipal solid waste, treatment method, people who did the treatment process, treatment capacity, cost of capital, operation cost and maintenance. The calculation of solid waste volume that entered recycling facility was done according to load-count analysis method by calculating total volume of solid waste that was received [12]. Measurement of solid waste composition was done with sampling method using minimum sample as much as 100 kg [13] and the composition sampling was done with quarterly method. The measurement of solid waste's specific weight was done randomly in various types of collector vehicles. Recovery factor's value was determined by measuring the weight of solid waste component which could be recycled and



calculated against total weight of solid waste. The recycling rate of solid waste was measured according to mass balance analysis.

TYPES OF SOLID WASTE RECYCLING FACILITY AND FLOW PROCESS PATTERN

According to survey's result, it could identified some types of solid waste recycling facilities in Malang Raya, these were:

1. Recycling and Compost Production Unit (UDPK). There were two kinds of integrated activity in that unit, i.e. recycling secondhand goods and making of compost. Both of these activities were done with the same raw materials that were household waste in the city [14].

2. Composting Unit. Composting unit was a small scale commercial unit that was functioned to process garbage into compost and to sell recycling product [15].
3. Integrated Solid Waste Treatment Facility (TPST). Solid waste was separated, processed and restored in order to be used as raw material in TPST. The raw material would be reprocessed [16].
4. Reduce Reuse Recycle Solid Waste Treatment Facility (TPS 3R). Collecting, sorting, reuse and recycling activities for region scale were implemented in TPST 3R [17].

The types of solid waste recycling facilities in Malang Raya were showed in Table-1 and the location of these recycling facilities can be seen in Figure-1.

Table-1. The types of municipal solid waste recycling facilities in Malang Raya.

The types of municipal solid waste recycling facilities	Total of recycling facilities				
	Malang city (unit)	Batu city (unit)	Malang district (unit)	Total	
				unit	%
Recycling and Compost Production Unit (UDPK)	3			3	20
Integrated Solid Waste Treatment Facility (TPST)			1	1	6.67
Composting Unit	10			10	66.67
Reduce Reuse Recycle Solid Waste Treatment Facility (TPS 3R)		1		1	6.67
Total				15	100



Figure-1. The location of municipal solid waste recycling facilities in Malang Raya.

UDPK facility in Malang City was built and managed with top-down model by Dinas Kebersihan dan Pertamanan (Cleaning and Landscaping Agency) Malang City. Each UDPK also functioned as TPS. Cost of capital, operational and maintenance of UDPK was subsidized by city government. There were 3 location of UDPK which had been operated since 1999. UDPK processed

compostable solid waste to compost in compliance with the processing capacity.

Whereas, non-compostable waste that still had economic value would be sorted and packaged, furthermore would be sold to collectors. Solid waste that couldn't be processed would be transported to the available container, furthermore would be discarded into



landfill. Flow chart of solid waste handling in one of UDPK, i.e. Gadang UDPK, Malang City was showed in Figure-2.

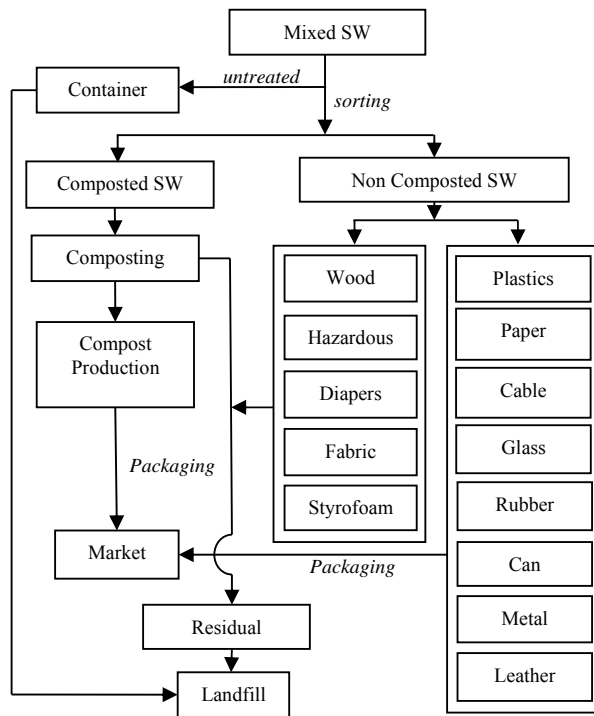


Figure-2. Process flow pattern at Gadang UDPK, Malang city.

There were 10 location of composting unit in Malang City. Similar with UDPK, composting unit was built and managed with top-down model by Dinas Kebersihan dan Pertamanan (Cleaning and Landscaping Agency), Malang City. Composting unit only processed compostable solid waste to compost in compliance with the processing capacity. Meanwhile, the sorting of non-compostable solid waste which still had economic value would be done by informal sector or scavengers. Flow chart of solid waste handling in one of composting unit, i.e. Jatimulyo composting unit, Malang City was showed in Figure-3.

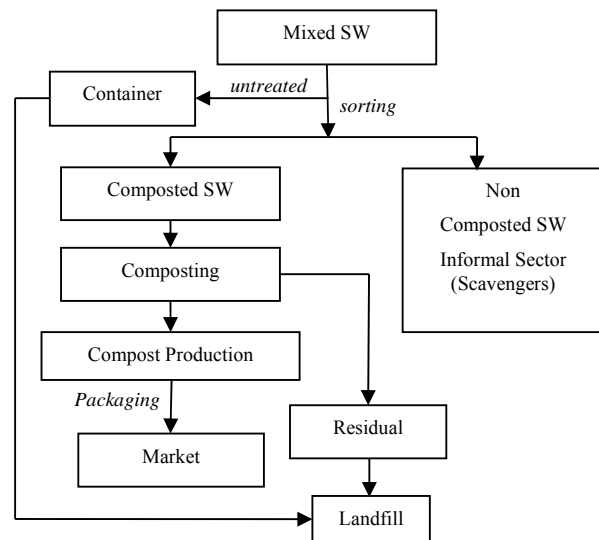


Figure-3. Process flow pattern at jatimulyo composting unit, Malang city.

Mulyoagung TPST had been built since 2011 and was managed by self-support group community (KSM). Mulyoagung TPST was located at Mulyoagung Village, Dau Subdistrict, Malang Regency. The initial capital of this TPST was a grant land as big as 0.34 hectare [18]. Mulyoagung TPST didn't get operational and maintenance cost from the government. TPST processed some kind of solid waste, i.e. yard waste which was processed to compost and food waste which was used as animal feed. Meanwhile, non-compostable solid waste which still had economic value would be sorted and packaged, furthermore would be sold to collectors. Mulyoagung TPST also processed PET plastic waste which would be processed to plastic ore before it would be sold. This TPST model was bottom-up because the idea and motivation was emerged by the community and it became the successful point of Mulyoagung TPST. Process flow pattern at Mulyoagung TPST, Malang Regency can be seen in Figure-4.

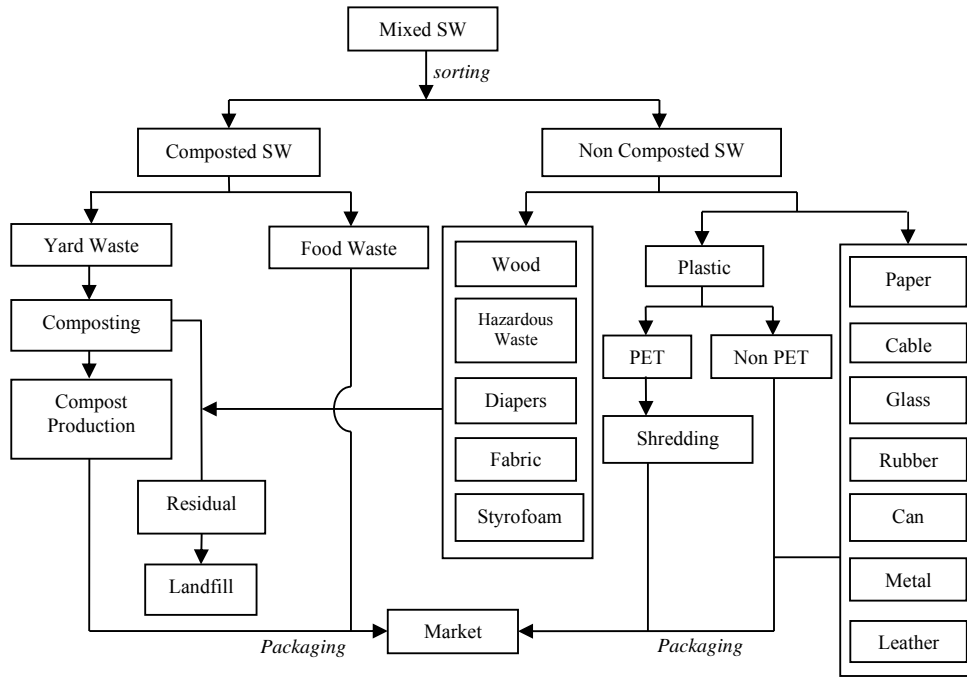


Figure-4. Process flow pattern at Mulyoagung TPST, Malang regency.

Pandanrejo TPS 3R was 0.129 hectare, located at Pandanrejo Village, Bumiaji Subdistrict, Batu City. It was recycling unit at village scale which was managed by self-supported community of Pandanrejo Village since 2009. Initial capital cost for this TPS 3R was a grant. Pandanrejo TPS 3R also didn't get operational and maintenance cost from the government. The compostable solid waste would be processed into compost in Pandanrejo TPS 3R. Meanwhile, non-compostable solid waste which still had economic value would be sorted and packaged, furthermore would be sold to collectors. Process flow pattern at Pandanrejo TPS 3R can be seen in Figure-5.

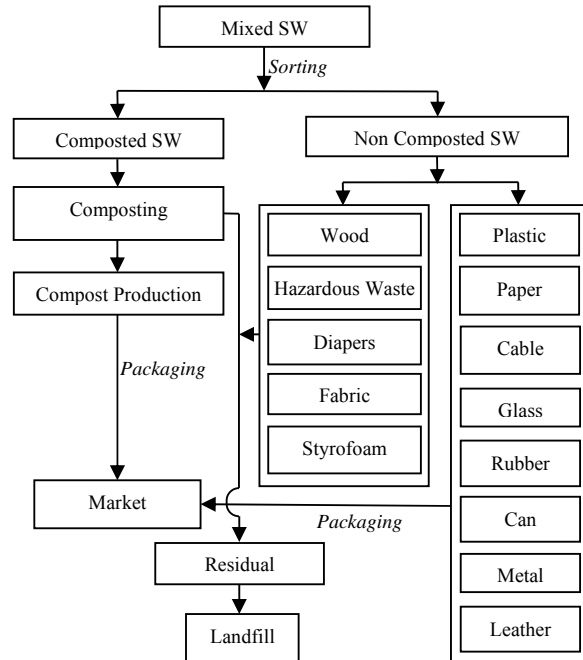


Figure-5. Process flow pattern at Pandanrejo TPS 3R, Batu city.

RESULT OF SOLID WASTE ANALYSIS IN RECYCLING FACILITY

The measurement result of solid waste volume was total input volume from various types of collector vehicles. The result of solid waste volume and specific weight could be used to calculate solid waste weight. The



analysis result of solid waste average weight that was entered the recycling facility could be seen in Table-2.

Table-2. Average solid waste input weight at each of recycling facility in Malang Raya.

Location	Average weight (kg/day)
Gadang UDPK	11209.07
Tlogomas UDPK	5042.26
Velodroom UDPK	7559.40
Jatimulyo Composting Unit	4544.94
Pandanwangi Composting Unit	3844.88
Polowijen Composting Unit	6414.25
Muria Composting Unit	9465.26
Manyar Composting Unit	4504.36
Narotama Composting Unit	3514.22
VEDC Composting Unit	4801.52
Asahan Composting Unit	9489.90
Sawojajar Composting Unit	2893.07
Supiturang Composting Unit	2135.00
Mulyoagung TPST	11864.40
Pandanrejo TPS 3R	3503.50

The analysis result of average composition in recycling facilities could be seen in Figure-6. The largest composition was compostable solid waste (food waste and yard waste) with the average 69.12%. Plastic waste (HDPE, LDPE, PET and plastic composite) with percentage reached 11.54%. Diapers waste 7.18%, paper waste (office paper, newspaper, magazine, book, cardboard and paper composite) with percentage 6.44% also the other kind of solid waste (cable, wood, hazardous waste, fabric/textile, glass, rubber, can, metal, leather, styrofoam, rock/sand, bone, hair) with percentage 5.72%. It could be known that input solid waste not only from household waste but also from the other kind of solid waste such as yard waste from agriculture product.

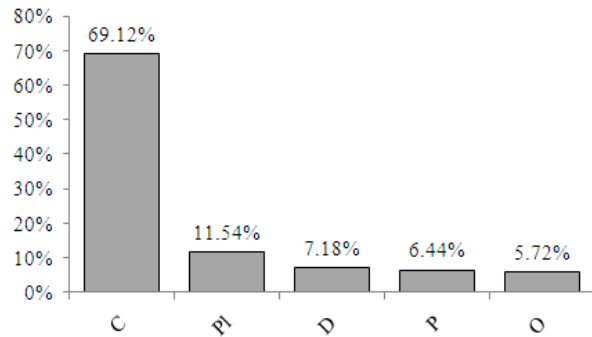


Figure-6. Average composition in solid waste recycling facility.

ESTIMATION OF RECYCLABLE SOLID WASTE

The recovery factor of each component of solid waste is shown in Table-3.

Table-3. Average recovery factor value for each solid waste composition.

Solid waste composition		Average recovery factor (%)
Compostable Solid Waste	Food Waste	99.47
	Yard Waste	99.25
Plastic	HDPE	90.20
	LDPE	58.93
	PET	88.96
	Plastic Composite	81.40
	Paper Composite	65.19
Paper	Office Paper	83.05
	Newspaper	84.93
	Magazine	35.62
	Books	36.39
	Paper Composite	65.19
	Cardboard	58.46
Cable		8.33
Glass		76.26
Rubber		84.70
Can	Aluminum Can	87.46
	Steel Can	46.67
Metal		72.96
Leather		69.05

Based on the recovery factors as shown in Table-3, the mass balance analysis was applied for measuring the recycling rate of the solid waste. Mass balance analysis at one of the Recycling and Compost Production Unit (UDPK), i.e. Tlogomas recycling and compost production unit (UDPK Tlogomas) could be seen in Table-4.

According to solid waste input weight in each of recycling facility, total residue that would be transported to landfill was 11.08-23.23% from total solid waste. So that, estimation of solid waste recycling rate was 76.77-88.92% with the calculation as could be seen in Table-5.

**Table-4.** Mass balance analysis at UDPK Tlogomas, Malang city.

Solid waste composition		Average weight		Recovery factor (%)	Estimation of solid waste recycling rate (kg/day)	Residual weight (kg/day)
		%	kg/day			
Compostable Solid Waste	Food Waste	14.50	731.13	99.00	723.82	7.31
	Yard Waste	59.67	3008.72	98.00	2948.54	60.17
Plastic	HDPE	5.14	259.17	54.30	140.73	118.44
	LDPE	3.01	151.77	57.83	87.77	64.00
	PET	1.49	75.13	57.47	43.18	31.95
	Plastic Composite	1.43	72.10	59.93	43.21	28.89
Paper	Office Paper	0.30	15.13	65.84	9.96	5.17
	Newspaper	0.69	34.79	62.15	21.62	13.17
	Magazine	0.02	1.01	33.33	0.34	0.67
	Paper Composite	3.67	185.05	68.18	126.17	58.88
	Cardboard	0.43	21.68	77.99	16.91	4.77
Diapers		4.65	234.47	0	0	234.47
Cable		0.01	0.50	0	0	0.50
Wood		0.93	46.89	0	0	46.89
Hazardous Waste		0.12	6.05	0	0	6.05
Fabric/ Textiles		1.33	67.06	0	0	67.06
Glass		0.87	43.87	100	43.87	0
Rubber		0.09	4.54	100	4.54	0
Can	Aluminum Can	0.07	3.53	100	3.53	0
	Steel Can	0.06	3.03	100	3.03	0
Metal		0.03	1.51	100	1.51	0
Leather		0.16	8.07	32.51	2.62	5.44
Styrofoam		0.12	6.05	0	0.00	6.05
Rock/Sand		1.21	61.01	0	0.00	61.01
		100	5042.26		4221.34	820.92

**Table-5.** Estimation of solid waste recycling rate at solid waste recycling facilities in Malang Raya.

Recycling location	Average weight (kg/day)	Estimation of solid waste recycling rate		Residual	
		kg/day	%	kg/day	%
Gadang UDPK	11209.07	8855.43	79.00	2353.64	21.00
Tlogomas UDPK	5042.26	4221.34	83.72	820.92	16.28
Velodroom UDPK	7559.40	6239.88	82.54	1319.52	17.46
Jatimulyo Composting Unit	4544.94	3734.04	82.16	810.90	17.84
Pandanwangi Composting Unit	3844.88	3325.78	86.50	519.10	13.50
Polowijen Composting Unit	6414.25	5474.22	85.34	940.03	14.66
Muria Composting Unit	9465.26	7596.40	80.26	1868.86	19.74
Manyar Composting Unit	4504.36	3570.04	79.26	934.32	20.74
Narotama Composting Unit	3514.22	2962.43	84.30	551.79	15.70
VEDC Composting Unit	4801.52	3961.32	82.50	840.20	17.50
Asahan Composting Unit	9489.90	7697.86	81.12	1792.04	18.88
Sawojajar Composting Unit	2839.07	2179.58	76.77	659.49	23.23
Supiturang Composting Unit	2135.00	1836.25	86.01	298.75	13.99
Mulyoagung TPST	11864.40	10525.69	88.72	1338.71	11.28
Pandanrejo TPST 3R	3503.50	3115.22	88.96	388.28	11.08

Mulyoagung TPST was the recycling facility with highest productivity and continuously increasing its service area. At 2011, Mulyoagung TPST only served one village and it increased to 5 villages in 2014. The amount of treated solid waste in that TPST also higher than the other recycling facilities, i.e. average was 11864.40 kg/day with estimation of recycled solid waste was 88.72% and only 11.28% residual.

CONCLUSIONS

There are four types of solid waste recycling facilities in Malang Raya, which comprised 66.67% composting unit, 20% recycling and compost production unit (UDPK), 6.67% integrated solid waste treatment facility (TPST) and 6.67% 3R solid waste treatment facility (TPS 3R). The analysis result of the largest solid waste weight average at Mulyoagung TPST was 11,864.40 kg/day. Meanwhile, the biggest composition in each of recycling facility was compostable solid waste with average percentage 69.19%. According to mass balance analysis, the estimation of solid waste recycling rate was very high about 76.77-88.92%.

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