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MATERIAL RECOVERY FACILITYPLANNING AT KLOTOKFINAL WASTE DISPOSAL SITE OF KEDIRI CITY, INDONESIA

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ABSTRACT

In 2017, there was around 1438.12 m^3 /day waste disposed at the final waste disposal site of Klotok, Kediri City. It gets increased every year according to the population growth of Kediri City and its activities. At present, the existing final waste disposal site is full, so the government is planning a new waste disposal site. Material recovery facility (MRF) planning is needed to reduce the amount of waste. In addition to that, MRF facilities are needed to carry out the recovery of waste. This study aims to plan land requirements for MRF as part of the planning of a new waste disposal site which is located close to the old waste disposal site. The research method was calculating the waste recovery factors based on the analysis of the waste composition at the Klotok waste disposal site. The results of the study concluded that the planned land area for material recovery facility and the number of workers needed are as follows: land of 2798 m^2 with 3 workers, sorting land of 1522.5 m^2 with 304 workers, composting land of 5042.04 m^2 with 8 workers, land for briquette making of 5634 m^2 with 5 workers, land for paper and cardboard recycle of 1250 m^2 with 5 workers, and land for cans, aluminum, glass storage of 529 m^2 with 2 workers.

KEYWORDS : TPA, MRF, Recovery factor, Kediri.

INTRODUCTION

In 2017, there was around 1438.12 m^3/day waste disposed at the final waste disposal site of Klotok, Kediri City. It gets increased every year according to the population growth of Kediri City and its activities. The collection of domestic waste by the city government tends to be more productive when compared with what is done by the private sector (Romano *et al.*, 2019). At present, the existing final waste disposal siteis full, so the government is planning a new waste disposal sitewhich is locatedclose to the old garbage disposal site. To make the new long-lasting waste disposal site, the planning is needed to reduce the amount of waste generation. Short-agedwaste disposal sites in most cities in Java Island lead toa problem, including in the city of Kediri. The problem can be overcome by recovering the waste disposed to the disposal site. Based on the analysis of the waste composition, recovery factors can be determined, and if the value of the recovery factor reaches an average of 50%, the disposal site can be long-lasting. Material Recoveru Facility (MRF) has been widely applied in most cities in the world to reduce waste generation. Muscat Oman (Baawain *et al.*, 2017) found that more than 43% of the disposed material consisted of biodegradable organic compounds. The results also showed that the main components of the total waste produced were plastic wrap (24%), cardboard (14%), and food waste (8%). Only 7% recycled from 822,200 tons of plastic waste was produced by Singapore in 2016 (Khoo, 2019). Aspects of adding value are important and relevant for plastic converters (Mwanza *et al.*, 2019). According to research conducted in Tehran, composting was the worst alternative in final disposal compared to anaerobic digestion and incineration and the percentage of recovery affected the rate of reuse and recycle (Heidaria *et al.*, 2019). On the other hand, in Southern Italy, the key role is in stability and maturity parameters in monitoring the composting process (Casero *et al.,* 2019). The odor during composting of organic substrates comes from hydrogen sulfide, metanethanol, dimethyl sulfide, and dimethyl disulfide (Rincon *et al.,* 2019). Waste into briquettes is one of the recovery methods, and for example, Madan wood waste can be considered as a potential renewable material to produce briquettes as an alternative energy source (Kongprasert *et al*., 2019). In the process of making briquettes from waste recovery, adding peanut straw significantly increases the mechanical properties of corn cob briquettes (Okot *et al*., 2019).

RESEARCH METHOD

This MRF planning method is part of the planning of the new waste disposal site. Therefore, the first step is to project the total population of Kediri City in the next ten years, according to the age plan of the new waste disposal site. Furthermore, the amount of waste in the new waste disposal site can be projected by assuming that everyone disposes of the waste as much as 3 liters/day. The next step is to analyze the composition of the existing waste in the Klotok waste disposal site. Assuming that the composition of the waste does not change over the next ten years, the amount of waste accommodated for each waste composition can be calculated. Next is the mass calculation of waste generation for MRF in tons/day. It was conducted by multiplying the mass of collected waste with a percentage of the MRF service. The percentage of MRF service was taken on average of 80%. This average was taken with the consideration that not all types of recoverable waste can be accommodated as much as 100% at the location of the waste disposal site since the municipal waste has been mixed. Also, there are only ten types of waste from 14 types of waste which are considered to be recoverable. The volume of waste for a Material Recovery Facility in m^3 / day can be calculated by multiplying the mass of waste generation with the density of waste from each type of waste.

RESULTS AND DISCUSSION

Based on the results of the population prediction of Kediri City for ten years using the Geometric method and the analysis of the waste composition at the Klotokwaste disposal site, the volume of waste can be calculated for the Recovery Facility Material as depicted in Table 1. Das *et al.* (2019) wrote that the geographical position and economic status of a country determine the characteristics of waste. Therefore, the composition of waste can be different for each city, so it is necessary to analyze the composition of waste based on the results of observations that will produce different primary data for each city. Empirical results show that separate collection of recyclable fractions can reduce the processing costs and processing facilities, but the overall cost of waste management does not change (Chifari *et al*., 2017). In Latin America, scavengers contribute 72% of the total collection of valuable

Table 1. Results of Analysis of Waste Composition and calculation of waste volume for MRF at Klotok waste disposal site until 2028

No	Waste type	Waste composition (%)	Collected waste mass (ton/day)	MRF service (%)	Waste mass for MRF (ton/day)	Waste Density (ton/m^3)	Waste volume for MRF (m^3/day)
1	Food waste	70.0	1085.698	80	868.599	0.35	2481.60
2	Park waste	8.0	123.409	80	98.727	0.20	493.64
3	Leather	0.5	7.965	80	6.372	0.18	35.4
4	Paper	5.0	80.065	80	64.052	0.09	711.69
5	Cardboard	3.0	48.794	80	39.035	0.08	520.46.
6	Plastic	5.0	80.484	80	64.387	0.10	643.87
7	Rubber	1.1	20.121	0			
8	Wood	0.8	13.012	0			
9	Glass	1.0	15.678	80	12.542	0.20	62.71
10	Cans	2.0	31.523	80	25.218	0.10	252.18
11	Textile	0.5	8.384	0	0.00		
12	Aluminum	1.0	15.510	80	12.408	0.10	124.08
13	Other metals	2.0	30.685	80	24.548	0.40	61.37
14	Dirt, dust etc.	0.1	1.677	0			
	Total	100	1563.005		1215.888		5387.00

solid waste (Botello-Álvarez *et al.,* 2018). From Table 1, the mass of waste generation that can be recovered is 1215,888 tons/day while the total mass of waste is 2095,9425 tons/day. It is equal to 58%, meaning that it can extend the period of the waste disposal site. The results of a case study in the Emirate of Abu Dhabi show that an environmentally friendly route is recycling components that can be resurfaced through recycling facility material and bioethanol production and the gasification of residual waste followed by catalytic transformation (Rizwan *et al*., 2019). There are still opportunities for energy recovery from waste, as studied in Turkey (Yilmaz and Abdulvahitoglu, 2019). The first plan for MRF are land acquisition. Especially for construction waste, it is necessary to select the location of land that does not affect the surrounding environment (Shi *et al.,* 2019; Bakchan *et al.,* 2019). Based on the calculations in Table 1, the land is planned to accommodate waste as much as 5387 m^3/day. With a 1 m of stack height plan, the results of the land acquisition plan are shown in Table 2. The next plan is to plan the sorting field. By the calculations in Table 1, the mass of waste is 1215,888 tons/day with the speed of sorting is 0.5 ton/person hour. The results are shown in Table 3. The next plan using the data in Table 1 is another MRF facility, namely land for making compost, land for making briquettes, land for recycling paper and cardboard, cans, aluminum, glass storage areas as shown in Tables 4, 5, 6 and 7.

Table 2. Plan for Land Acquisition Plan

No	Land Acquisition	Volume	Unit
1	Generation volume	5387	m^3/day
2	The height of the waste stack	1	m
3	Land area	5387	m^2
4	The ratio of length and width	1	
5	Width	51.9	m
6	Length	51.9	m
7	Access for worker mobility	1.0	m
8	Length	52.9	m
9	Width	52.9	m
10	Land area	2798.3	m^2
11	Number of workers	3	person

Table 3. Plan for Sorting Land Plan

NoSorting Land		Volume	Unit
1.	The mass of waste	1215.888	ton/day
2.	Sorting speed	0.5	ton/person.hour
3.	Sorting time	2431.7	hour/person.day
4.	Working hours	8	hour
5.	The number of workers	304	person
6.	Length of each conveyor	2	m/person
7.	Total conveyor length	608	m
8.	Conveyor width	1.5	m
9.	Conveyer area	912	m^2
10.	Access for worker mobility	1	m
11.	Length	2.5	m
12.	Width	609	m
13.	Land area	1522.5	m^2
14.	The number of workers	304	person

Table 4. Plan for Compost Production Land

No	Compost Production Land	Volume	Unit
1	Height	2.5	m
2	Length	8	m
3	Width	2.5	m
4	Capacity	78.5	m^3
5	Food waste	2481.6	m^3/day
6	Park waste	345.55	m^3/day
7	Time to become compost	2	week
8	Number of windrows	504	item
9	Number of windrow levels	2	level
10	Number of windrow per level	252	item
11	Actual length	50	m
12	Actual width	25	m
11	Land area	1250	m^2
12	The number of workers	8	person

CONCLUSION

Land area planned for the needs of Material Recovery Facility and the number of workers is as follows: acquisition land of 2798 m^2 with 3 workers, sorting land of 1522.5 m^2 with 304 workers, composting land of 5042.04 m^2 with 8 workers, land

Table 5. Plan for Briquettes Production Land

No	Briquettes Production Land	Volume	Unit
1	Park Waste	98.73	m^3/day
2	Plastic	515.10	m^3/day
3	Leather	35.40	m^3/day
4	Briquette diameter	0.15	m
5	Briquette height	0.25	m
6	Briquette volume	0.00442	m3
7	Number of Briquettes	147029	item/day
8	Length of land to produce	3	m
9	Width of land to produce	3	m
10	Land area to produce	9	m^2
11	Length of storage area	74.25	m
12	Width of storage area	74.25	m
10	Access for Worker Mobility	1	m
11	Actual Length	75	m
12	Actual Width	75	m
13	Land area	5625	m^2
14	Total area	5634	m^2
15	The number of workers	5	person

Table 6. Plan for Paper and Cardboard Recycle Production Land

No	Paper and Cardboard Recycle Production Land	Volume	Unit
1	Paper	711.69	m^3/day
2	Cardboard	520.46	m^3/day
3	Total	1232.15	m^3/day
4	High Stack Plan	1	m
5	Land area	1232.15	m^2
6	Width Length ratio	2	
7	Length	49.6	m
8	Width	24.8	m
9	Access for Worker Mobility	1	m
10	Actual Length	51	m
11	Actual Width	26	m
12	Land area	1326	m^2
13	The number of workers	5	person

for briquette makingof 5634 m^2 with 5 workers, land for recycled paper and cardboard of 1250 m^2 with 5 workers, land for storing can, aluminum, glass of 529 m^2 with 2 workers.

Table 7. Plan for Cans, Aluminum and Glass Storage Land

Sl. No	Cans, Aluminum, and Glass Storage Land	Volume	Unit
1	Glass	62.71	m^3/day
2	Cans	252.18	m^3/day
3	Aluminum	124.08	m^3/day
4	Other metals	61.37	m^3/day
5	Total	500.34	m^3/day
6	High Stack Plan	1	m
7	Land area	500.34	m^2
8	Width Length ratio	1	
9	Length	22.37	m
10	Width	22.37	m
11	Access for Worker Mobility	1	m
12	Actual Length	23	m
13	Actual Width	23	m
14	Land area	529	m^2
15	The number of workers	2	person

REFERENCES

Baawain, M., Al-Mamun, A., Omidvarborna, H. and Al-Amri, W. 2017. Ultimate composition analysis of municipal solid waste in Muscat. *Journal of Cleaner Production.* 148 : 355-362.

Bakchan, A., Faust, K.M. and Leite, F. 2019. Seven-dimensional automated construction waste quantification and management framework: Integration with project and site planning. Resources. *Conservation and Recycling.* 146 : 462-474.

Botello-Álvarez, J. E., Rivas-García, P., Fausto-Castro, L., Estrada-Baltazar, A. and Gomez-Gonzalez, R. 2018. Informal collection, recycling and export of valuable waste as transcendent factor in the municipal solid waste management: A Latin-American reality. *Journal of Cleaner Production.* 182 : 485-495.

Cesaro, A., Conte, A., Belgiorno, V., Siciliano, A. and Guida, M. 2019. The evolution of compost stability and maturity during the full-scale treatment of the organic fraction of municipal solid waste. *Journal of Environmental Management.* 232 : 264-270.

Chifari, R., Piano, S.L., Matsumoto, S. and Tasaki, T. 2017. Does recyclable separation reduce the cost of municipal waste management in Japan?. *Waste Management.* 60 : 32-41.

Das, S., Lee, S.H., Kumar, P., Kim, K.H., Lee, S.S. and Bhattacharya, S.S. 2019. Solid waste management: Scope and the challenge of sustainability. *Journal of Cleaner Production.* 228 : 658-678.

Heidari, R., Yazdanparast, R. and Jabbarzadeh, A. 2019. Sustainable design of a municipal solid waste management system considering waste separators: A real-world application. *Sustainable Cities and Society.* 47 : 101457.

Khoo, H.H. 2019. LCA of plastic waste recovery into recycled materials, energy and fuels in Singapore. *Resources, Conservation and Recycling.* 145 : 67-77.

Kongprasert, N., Wangphanich, P. and Jutilarptavorn, A. 2019. Charcoal Briquettes from Madan Wood Waste as an Alternative Energy in Thailand. *Procedia Manufacturing.* 30 : 128-135.

Mwanza, B. G., Mbohwa, C., Telukdarie, A. and Medoh,

C. 2019. Value Addition to Plastic Solid Wastes: Informal Waste Collectors' Perspective. *Procedia Manufacturing*. 33 : 391-397.

Okot, D. K., Bilsborrow, P. E. and Phan, A. N. 2019. Briquetting characteristics of bean straw-maize cob blend. *Biomass and Bioenergy*. 126 : 150-158.

Rincón, C. A., De Guardia, A., Couvert, A., Wolbert, D., Le Roux, S., Soutrel, I. and Nunes, G. 2019. Odor concentration (OC) prediction based on odor activity values (OAVs) during composting of solid wastes and digestates. *Atmospheric Environment*. 201 : 1-12.

Rizwan, M., Saif, Y., Almansoori, A. and Elkamel, A. 2019. Environmental Performance of Municipal Solid Waste Processing Pathways. *Energy Procedia*. 158: 3363-3368.

Romano, G., Rapposelli, A. and Marrucci, L. 2019. Improving waste production and recycling through zero-waste strategy and privatization: An empirical investigation. *Resources, Conservation and Recycling*. 146 : 256-263.

Shi,Q., Ren, H., Ma, X. and Xiao, Y. 2019. Site selection of construction waste recycling plant. *Journal of Cleaner Production*. 227 : 532-542

Yýlmaz, Ý. H. and Abdulvahitoðlu, A. 2019. Evaluation of municipal solid waste options in Turkey: Scenarios for energy recovery, carbon mitigation and consequent financial strategies. *Resources, Conservation and Recycling*. 147 : 95-110.