FEASIBILITY ANALYSIS AND DESIGN PROJECTION OF WASTE MANAGEMENT SYSTEM IN BALIKPAPAN

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Abstract

Waste generation in Balikpapan from 2016 to 2020 continues to increase by 443 to 482 tons per day. One of the efforts of DLH Balikpapan is to optimize the MRF and ITF facilities, as well as to analyze how much these facilities are needed to reduce waste generation at final disposal sites (Landfill) Manggar and enhance the durability of the landfill. The approach utilized in this study employs direct observation methods, such as data collection results on the amount of waste input and output, and secondary data, such as geometric methods and all data on waste generation in Balikpapan. The calculation of the feasibility and effectiveness analysis of the MRF inorganic waste processing facility using the recovery factor approach obtained 60.3%, while the ITF organic waste processing got a result of 45.7%.

With the current condition, Manggar Landfill can be used until the end of 2025, Manggar Landfill can be used until the end of 2025. By optimizing garbage processing in these two facilities, the MRF has expanded the service coverage to 3 urban villages and has a projected age of up to 2033. It will be optimized for ITF processing facilities by utilizing process biogas. The primary objective of this research is to determine how many additional processing sites are needed starting with household waste sources thus, the calculation findings show that an additional six units of MRF facilities and ten units of ITF facilities are required. As a result, with the addition of inorganic and organic waste processing sites, Manggar's Landfill estimated age is extended until 2028.

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1. Introduction

Garbage is a common issue in several cities in Indonesia. These issues come in the form of technical problems in waste processing and how to cope with waste generated in the city. Likewise, in Balikpapan, the waste problem is included in a highly concerned category to maintain a healthy environment in Balikpapan. Data of the interview result with a staff officer of environmental service (DLH) at February 2021 that in 2016 – 2020 the amount of waste generated in Balikpapan was recorded.

Table 1. Amount of waste generation

No	Years	Waste Generation (Ton/day)
1	2016	443
2	2017	451
3	2018	458
4	2019	459
5	2020	482

Given that the amount of waste generated in Balikpapan has increased over the previous five years, the Balikpapan municipal government must find a solution to overcome the waste problem.

The Balikpapan City Government is working to implement Regional Regulation (PERDA) number 13 of 2015 on the Processing of Household Waste and Similar Household Waste. As a form of Regional Regulation (PERDA) realization, mainly by applying the 3R principle (Reduce, Reuse, and Recycle) from the household scope before being discharged to the Landfill (Final Processing Site) at Manggar Village, Balikpapan. Based on the aforesaid Regional Regulation (PERDA), the government of Balikpapan has constructed supporting facilities in the form of MRF (Material Recovery Facilities) in Bahagia Mount Village for inorganic waste and ITF (Intermediate Treatment Facilities) in Sepinggan Village for organic waste, especially waste from the Sepinggan market.

The increase in waste generation in Balikpapan is exactly proportionate to the city's population growth. According to Central Bureau of Statistics (BPS) data for Balikpapan (BPS City of Balikpapan).

Table 2. Population in Balikpapan

No	Years	Population (people)
1	2016	625,968
2	2017	636,012
3	2018	645,727
4	2019	655,178
5	2020	688,318

The factor of increasing the average population is caused by migration factors or immigrant populations, particularly about relocating the new capital city. Consequently, the Environmental service (DLH) of Balikpapan proposed researching the need for waste processing facilities to extend the service life of the Manggar Landfill.

There are several classifications of waste based on the source (sumantri, 2010):

1. Residential waste is waste generated due to the actions of each household member who lives in a building or buildings. The majority of waste generated by household sources is organic waste such as vegetable waste, food waste, plastic bags, etc.
2. Public facilities waste and market places generated by public facilities such as markets, terminals, and stations. This garbage has enormous potential as a waste generator, producing waste such as tree branches, dried leaves, food

waste, vegetable waste, paper waste, cans, plastic, and other sorts of garbage.

3. Community service facilities waste includes dry waste such as leaf and tree twig waste and liquid waste such as plastic drink residue and food waste. This waste is sourced from community service facilities such as beaches, hospitals, health centers, government-owned offices, etc.

According to Monica Sitanggang (2017), waste management is a set of actions that processes and handles waste from generation to disposal. In general, waste handling activities include waste generation, on-site waste handling, waste collection, waste transportation, waste processing and processing, and final waste disposal. MRF Bahagia Mount was conducted for analysis. The research undertaken at the MRF facilities aims to analyze the feasibility of processing and sorting waste using the recovery factor method and the economic aspects using the net present value (NPV) way and exploring the estimated age of MRF Bahagia Mount.

2. Methodology

A. Data Collection Method

The observation and secondary data method were employed to obtain data in this study. The observation method is a direct action to the research site that aims to observe, analyze, and interact with officers and employees at supporting facilities and waste processing systems in Balikpapan, specifically MRF, ITF, and Landfill. While the secondary data in this study, all readily available and recorded data at the location of the waste processing system facility, as well as data that has been registered in the DLH Balikpapan city. Based on an interview with a staff officer at Environmental service (DLH), if the reducing waste of those facilities is more than 50%, it is decided feasible to applicate in this city.

B. Data Processing

a. Calculating waste generation and city projection of Balikpapan.

- Calculate the amount of waste generated per day.

$$WG = Population\ x \frac{WG/person}{1000}\ (Tonnes/day) \quad (1)$$

- Calculate the projected population growth of Balikpapan.

$$Pn = Po\ x\ (1 + r)^{dn} \quad (2)$$

Where:

Pn = Total population at the end of the period (persons)

Po = The initial population (persons)

r = average population growth rates each year (percent)

dn = projection of time period

b. Calculating MRF age eligibility analysis.

- Identify the amount of incoming inorganic waste.
- Calculate the volume of waste that has been processed.
- Identify the waste generation rate per person in Mt. Bahagia village
- Calculate the percentage of waste that is utilized (RF).

$$RF = \frac{volume\ of\ processed\ waste}{volume\ of\ incoming\ waste}\ x\ 100\%. \quad (3)$$

- Calculate the projected age and development of the MRF.

c. Calculating ITF age eligibility analysis

- Calculate the volume of incoming organic waste.
- Calculate the volume of output in the form of compost.
- Calculate the percentage of waste that is utilized (RF).

$$RF = \frac{volume\ of\ processed\ waste}{volume\ of\ incoming\ waste}\ x\ 100\% \quad (4)$$

- Product development in ITF support facilities

d. Calculating the feasibility analysis of existing landfill age

- Calculate the volume capacity of all new landfill zones at Manggar Landfill.
- Calculating the age feasibility of Manggar Landfill with existing conditions.

e. Projecting MRF requirements in Balikpapan.

- Identify the population of each village in Balikpapan
- Compare the population and waste generation in each sub-district with the pilot project in Gn. Bahagia.
- Determine the number of MRF facilities needed.

f. Projecting ITF requirements in Balikpapan.

- Identify the population of each Balikpapan sub-district.
- Determine the number of ITF facility requirements.

g. Projecting the extension of the age landfill in Balikpapan after determining the number of needs for MRF and ITF facilities.

3. Results and Discussions

a. Calculating waste generation and city projection in Balikpapan.

- Calculate the projected population growth in Balikpapan.

The following is a calculation of the projected population in Balikpapan over the next ten years:

Table 3. Population projection of Balikpapan city

No	Year	Population (N-1) (People)	Growth (%)	Total (People)
1	2021	688,318	0.2	702,084
2	2022	702,084	0.2	716,126
3	2023	716,126	0.2	730,449
4	2024	730,449	0.2	745,058
5	2025	745,058	0.2	759,959
6	2026	759,959	0.2	775,157
7	2027	775,157	0.2	790,661
8	2028	790,661	0.2	806,474
9	2029	806,474	0.2	822,604
10	2030	822,604	0.2	839,055

- Calculate the amount of waste generation per day.

The following is a calculation of the projected waste generation in Balikpapan over the next ten years:

Table 4. Waste generation projection of Balikpapan City

No	Year	Population (people)	Waste Rate (%)	Total (Ton)
1	2021	702,084	0.7	491
2	2022	716,126	0.7	501
3	2023	730,449	0.7	511
4	2024	745,058	0.7	522
5	2025	759,959	0.7	532
6	2026	775,157	0.7	543
7	2027	790,661	0.7	553
8	2028	806,474	0.7	565
9	2029	822,604	0.7	576
10	2030	839,055	0.7	587

b. Calculating MRF age eligibility analysis

- Knowing the volume of incoming inorganic waste.

According to the findings of 7 working days of recording, the average waste that entered the Bahagia Mount MRF is 28,540 / 7 days = 4,077 Kg/day or 4,077 Tons/day.

-Calculate the volume of waste that has been processed.

Waste from the sorting and processing waste at the MRF Bahagia Mount can be seen in Figure 1.

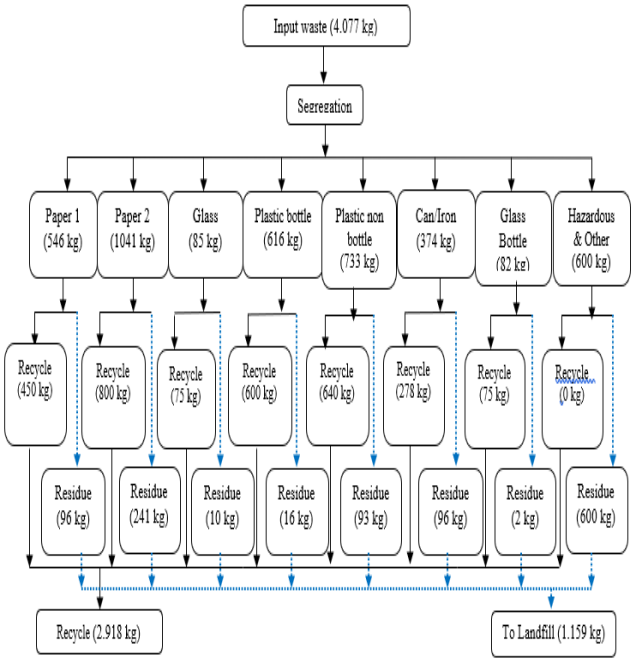

Figure 1. Record of inorganic waste segregation in MRF

- Calculate the percentage of waste that is utilized or recovery factor (RF).

After knowing the output of inorganic waste sorting then, the efficiency of the MRF sorting facility may be calculated using the following formula:

$$RF = \frac{2{,}918\ Kg}{4{,}077\ Kg}\ x\ 100\% = 60.3\% \quad (5)$$

- Knowing the waste generation rate per person in Gn. Bahagia Village.

According to DLH Balikpapan data, the organic and inorganic waste ratio is 52.4% and 47.6%.

Table 5. Amount of waste generation in Mt. Bahagia

No	Village	2020	Rate (%)	Waste Generation	Inorganic Waste
1	Bahagia Mount	20,987	0.7	14,691	6,993

-Calculating the projected age and development of the MRF facility.

It is known that the maximum capacity of MRF is 30 tons/day; two villages, Sungai Nangka and Sepinggan Baru have been added to optimize it.

Table 6. Waste generation in 3 villages

No	Village	2020 (people)	Waste Generation	Inorganic Waste
1	Bahagia Mount	20,987	14,691	6,993
2	Sepinggan Baru	30,608	21,426	10,199
3	Sungai Nangka	18,138	12,696	6,043
Total		69,733	48,813	23,235

Table 7. Age projection of MRF

No	Year	Population (people)	Rate (%)	Waste Generation (Ton)	Inorganic Waste (Ton)
1	2020	69,773	0.2	48,813	23,235
2	2021	71,128	0.2	49,789	23,699
3	2022	72,550	0.2	50,785	24,174
4	2023	74,001	0.2	50,801	24,657
5	2024	75,481	0.2	52,837	25,150
6	2025	76,991	0.2	53,894	25,653
7	2026	78,531	0.2	54,971	26,166
8	2027	80,101	0.2	56,071	26,690
9	2028	81,703	0.2	57,192	27,224
10	2029	83,337	0.2	58,336	27,768
11	2030	83,337	0.2	59,503	28,323
12	2031	86,704	0.2	60,693	28,890
13	2032	88,438	0.2	61,907	29,468
14	2033	90,207	0.2	63,145	30,057

To maximize processing and transporting, 15 additional pick-up units with a capacity of $2m^3$ and 54 employees are required.

c. Calculating ITF age eligibility analysis

- Calculate the volume of incoming organic waste.

The results of 7 working days of recording from February 8 to February 15 revealed that the average incoming organic waste was 64,330 tons/7 days = 9.19 tons/day.

- Calculate the volume of output in the form of compost.

Based on the findings of the above recording for seven working days, the average amount of compost products is 29.4 tons/7 days = 4.2 tons/day.

-Calculate the waste utilization or recovery factor (RF).

$$RF = \frac{4.2\ ton/day}{9.19\ ton/day}\ x\ 100\% = 45.7\% \quad (6)$$

-Product development in ITF support facilities

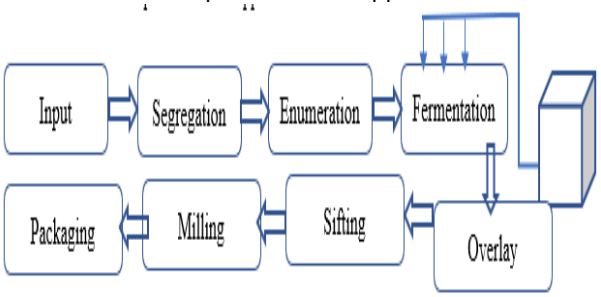

Figure 2. Process flow diagram of ITF

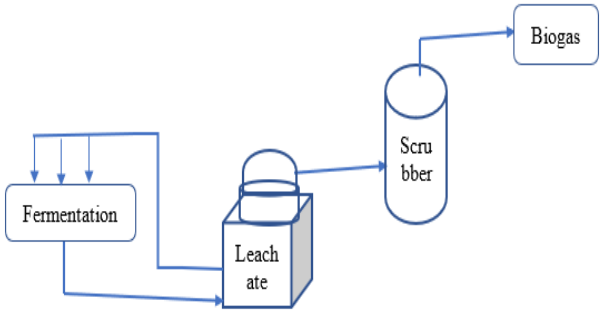

Figure 3. Process flow diagram of biogas

d. Calculating the feasibility analysis of existing landfill ages

-Calculating the volume capacity of all new landfill zones at Manggar Landfill.

Manggar Landfill has four additional landfill zones, namely zones 5, 6, 7, and 8, with a total area of 10.12 Ha and a total volume of 797,000 tons, and a stockpile height of 25 meters.

-Calculating the age feasibility of Manggar Landfill with existing conditions.

Manggar Landfill has a compost processing facility and cooperates with garbage collectors to reduce waste.

Table 8. Calculation of age projection of existing landfill

Year	Total Population (People)	Landfill Waste (Day)	Landfill Waste (Year)	Recycle Waste (3.3%)	Landfill Site (Ton)
2020	688,318	362	132,130	4,346	127,836
2021	702,084	374	136,510	4,505	132,005
2022	716,126	381	139,065	4,589	134,476
2023	730,449	389	141,985	4,686	137,299
2024	745,058	397	144,905	4,782	140,123
2025	759,959	405	147,825	4,878	142,947
Total			842,472	27,789	814,686

e. Projecting MRF needs in Balikpapan.

To project the need for additional MRFs by comparing the population and waste generation in each village in Balikpapan with the MRF Mt. Bahagia, also considering the composition of the amount of waste that goes to Manggar Landfill, which is approximately 47.6% inorganic waste.

- Determining the number of MRF facilities that are required.

The addition of 6 MRF units was obtained due to calculations and comparisons of the population and the generation of inorganic waste.

Table 9. Design projection of MRF Needed

MRF					
I	II	III	IV	V	VI
Baru Tengah	Prapatan	Sepingg-an	Gunung Sari Ilir	Manggar	Gunung Samarinda
Margas-ari	Telaga Sari	Damai Bahagia	Gunung Sari Ulu	Lamaru	Batu Ampar
Baru Ilir	Klandasa-n Ilir	Sepingg-an Raya	Sumber Rejo	Teritip	Gunung Samarinda Baru
Margo Mulyo	Damai	-	Karang Jati	-	-

f. Projecting ITF requirements in Balikpapan.

To project the need for additional ITF, compare the population and waste generation in each urban village in Balikpapan City to the maximum capacity and launched the age of the ITF, as well as the composition of the amount of waste that goes to Manggar Landfill, which is approximately 52.4 percent organic waste.

- Determine the required number of ITF.

It was found that there were ten more ITF units based on population and organic waste generation calculations and comparisons.

Table 10. Design projection of ITF needed

No	Village	Organic Waste (Ton)	ITF
1	Baru Tengah	7,855	I
2	Baru Ulu	7,819	II
3	Klandasan Ilir	8,170	II
4	Gunung Sari Ulu	7,698	IV
5	Gunung Sari Ilir	7,627	V
6	Karang Rejo	9,096	VI
7	Sumber Rejo	7,868	VII
8	Gunung Samarinda	8,438	VIII
9	Prapatan and Klandasan Ulu	9,063	IX
10	Damai Baru and Sepinggan Raya	8,651	X

g. Projecting the extension of the age of the landfill in Balikpapan after determining the number of needs for MRF and ITF facilities.

The projected age of the Manggar landfill is determined by calculating the addition of 6 MRF units and 10 ITF units, as well as analyzing the performance of each processing unit.

Table 11. Calculation of the projected extension of TPA age

Year	Total Population (People)	Landfill Waste		Recycle Waste (3,3%)	MRF and ITF Output (Ton)	Landfill Site (Ton)
		Day	Year			
2020	688,318	362	132,130	4,346	-	127,836
2021	702,084	374	136,510	4,505	44,147	87,858
2022	716,126	381	139,065	4,589	45,030	89,446
2023	730,449	389	141,985	4,686	45,931	91,368

2024	745,058	397	144,905	4,782	46,849	93,274

Table 11. Continued

2025	759,959	405	147,825	4,878	47,786	95,168
2026	775,158	413	150,745	5,039	48,742	96,964
2027	790,661	421	153,665	5,205	49,717	98,743
2028	806,474	430	156,950	5,377	50,712	100,862
Total			1,303,780	43,407	378,913	881,583

According to the calculation results in the table above, the age of Manggar landfill will be extended until the beginning of 2028 due to the volume of the landfill zone at the Manggar landfill of 797,000 tons.

4. Conclusion

Based on the research, feasibility anáyisis and proposed design projection needed of waste management system in Balikpapan can be concluded:

1. Process efficiency of MRF facilites is 60.3%, and scope level of population service at Gn. Bahagia around 58.3%.
2. To optimize the capacity of MRF up to 30 tonnes/day, Nangka river and Sepinggan Baru villages will be added.
3. The projection age of MRF with an optimization program can handle inorganic waste up to 2033. 15 units were picked up, and 54 employees were added to support the MRF process system.
4. Process efficiency of ITF facilities is 45.7% compost.
5. Based on this research: To develop ITF Facilities, it will be proposed to reuse biogas for supporting systems in ITF by adding a biogas processing unit.
6. Calculating of existing Manggar landfill up to 2025.
7. Offered six units MRF and ten units ITF facilities added to reduce waste goes to landfill.

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