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.

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. 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.

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                       |

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.

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             |

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.

\[ WG = \text{Population} \times \frac{WG/\text{person}}{1000} \text{ (Tonnes/day)} \]  

- Calculate the projected population growth of Balikpapan.

\[ P_n = P_0 \times (1 + r)^{dn} \]  

Where:

- \( P_n \) = Total population at the end of the period (persons)
- \( P_0 \) = 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).

\[ RF = \frac{\text{volume of processed waste}}{\text{volume of incoming waste}} \times 100\% \]  

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

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- Calculate the projected age and development of the MRF.

- 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).

- 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.

- 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:
According to DLH Balikpapan data, Bahagia Village.

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.

To maximize processing and transporting, 15 additional pick-up units with a capacity of 2 m³ 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 tons/day.

To calculate the volume of incoming organic waste, it can be calculated using the following formula:

\[
RF = \frac{2,918 \text{ Kg}}{4,077 \text{ Kg}} = 0.7 x 100\% = 60.3\% \quad (5)
\]

- 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%.

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- Product development in ITF support facilities

**Figure 2. Process flow diagram of ITF**

- Product development in ITF support facilities

**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 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 Jati                 | 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    | 8,651               | X   |

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 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) |
|------|----------------------------|----------------|----------------------|--------------------------|-------------------|
| 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           |
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 analysis and proposed design projection needed of waste management system in Balikpapan can be concluded:
1. Process efficiency of MRF facilities 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. W. K
7. Offered six units MRF and ten units ITF facilities added to reduce waste goes to landfill.

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