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# Optimization of Material Recovery Facility in Manyar Subdistrict, Gresik

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## ABSTRACT

The existing solid waste service in Manyar Subdistrict which currently as much as 40,4% was apparently far from the national target of 100% solid waste service for 2019. EstablishingMaterial Recovery Facility(MRF) temporary dump is an effort to achieve that target. MRF development plan at Manyar district was built upon the evaluation result at MRF of Peganden to obtain the specific design criteria and other technical aspects. Initial study has done by taking solid waste sample of 120 houses for 8 days consecutively and then followed by an evaluation to get the data related to infrastructure and facility. Further observation on community participation is required to discover their level of knowledge, behavior and attitude on solid waste treatment, therefore as much as 130 questionnaire were given to the local community. According to the observation, the community of Yosowilangun, Tanggulrejo, and Gumeno which represent the density level of high, medium and low respectively, judged to have the highest assessment point. MRF development was prioritized by the level of density, in which the densest district became top priority. The design which being applied was that belongs to Peganden. There will be another 6 and 4 MRFs in the upcoming 2018-2023 and 2024-2027 period respectively.
**KEYWORDS**: Solid Waste, Material Recovery Facility, Community Participation

## INTRODUCTION

Manyar subdistrict is one of the subdistrict in Gresik which has a population as much as 111,205 inhabitants and has 3.34% / year of growth in these past 7 years [1]. Population growth, urbanization, and technological innovation were contributed in the increasing of solid waste generation [2]. The solid waste service in Manyar Subdistrict which currently as much as 40.4%, was still far from the target of 100% national solid waste service in 2019 [3]. Therefore necessarry optimization of Material Recovery Facility (MRF) in Manyar Subdistrict.

Solid waste management can be implemented by reducing, reusing and recycling solid waste. Efficient solid waste recycling can be done by maximizing the use of existing technologies for sustainable and environmentally profitable management [4,5]. One of the waste management implementation in Indonesia was through the provision of MRF. MRF has an important role in solid waste management system by improving the energy recovery and reducing the economic costs of the total waste management's chain [6]. Effective solid waste reusing and recycling may have a positive impact to job opportunity, economical development, and reduction of environmental pollution [7].

Currently, Manyar Subdistrict hasa MRF which located in Peganden Village. Peganden MRF which built in 2016 hassolid waste processing area as large as 198 $m^2$. MRF Peganden which planned to serve 600 families (2,400 inhabitants) has now been increased to as much as 1,117 (4,468 inhabitants). Existing MRF Peganden focus on sorting and selling. The application on MRF will become the evaluation basis, whether it is possible or not to be implemented for other subdistricts.

Financial has become the problem in MRF Peganden in which there are no willingness in the community to pay for monthly service charge, thus monetary deficit are being experienced by the administrator. The willingness of the citizens to pay was affected by the application of the policy of fines and penalties. The policy application of fines and penalties is effectively increasing the percentage of community willingness to pay for the application of this policy[8]. Policy makers need to be aware that the socio-economic characteristics and the quality of solid waste service will affect the willingness of citizens to pay [9]. In addition, organizer's expenses were used more for labor as there are no participation from the community. The majority of waste were reused and recycled [10]. The study of community participation will be implemented in another village to see if the community meets the criteria to receive the MRF development.

After the criteria design being obtained, the evaluation of existing MRF will be planned. Procurement of MRF will be prioritized for the village that has the highest participation willingness. MRF design planning was

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based upon existing MRF evaluation that meet the technical aspects and participation level, thus allowing MRF to operate optimally and financial problems can be eliminated.

## MATERIALS AND METHODS

### Data Collection

The calculation of solid waste generation was done for eight days andsampling was performed on 120 households with the assumption that each of them produce 1 kg of solid waste per day [11]. Unit of volume and weight used on the calculation were $m^3$/day and kg/day respectively.The measurement of solid waste density was being made after calculating the number of solid waste generation. Solid waste generated by 120 households taken were as much as 100 kg. The measurement was undergone for 3 days. Solid waste measurement which consist of sorting and weighing was being done for 3 days. Classification of household solid waste composition that can be separated are food wastes, yard wastes, plastic, paper, glass, textiles, rubber, wood, metal and other [12].
Measurement and calculation of the RF value done for 3 days by using the formula as follows

$$RF = \frac{V_2}{V_1} x\ 100\% \quad \text{.....(1)}$$

V1 = the weight of each type of household solid waste after sorting (kg)
V2 = weight of each type of household solid waste that can be used (kg)

### Technical Aspect

Technical analysis has undergone to obtain waste generation rate, waste compositiondensity, recovery factor and recycling potential in manyar subdistrict as well as evaluating solid waste treatment technology and other infrastructure that being utilized in betoyoguci and peganden MRF. Analytical technique were as follows

- ✓ Analysis of Mass Balance and Potential Domestic Solid Waste Recycling in Manyar Subdistrict
  From solid waste generation rate, waste composition and recovery factor, mass balance analysis can be conducted to find out the potential of solid waste recycling and the amount of the resulting residues in Manyar Subdistrict. Steps in conducting an analysis of mass balance are as follows.
  - From the results of the calculation of the Recovery Factor (RF) of each composition of waste, calculated the weight of the waste that can be recycled (kg) using the formula.
    Weight Solid Waste Recycled (kg) = RF (%) x Weight of Solid Waste Each Composition (kg)
  - Calculate Residual Solid Waste Each Composition
    Residues (kg) = weight of the solid waste before it is recycled (kg) – the weight of the solid waste that can be recycled (kg)
  - In the analysis of mass balance is necessary Weight Solid Waste Input = Weight Solid Waste Output + Weight Solid Waste Residue
- ✓ Analysis of Infrastructure and Facilities in MRF Betoyoguci and Peganden were being held to find out sorting rate, infrastructure and facilities of MRF which appropriate to apply to other villages in Manyar Subdistrict. Infrastructure and facilities that have been analyzed were dropoff and sorting, storage, composting, compost chopper machine and compost filter machine, storage leachate, residual container, office, bathroom, storage shed, small mosque and parking lot cart motor.

### Community Participation Aspect

An analysis of variable levels of community participation is carried out by the interview to solid waste-producing households. This includes 6 (six) indicator as follows : Solid waste sorting; Processing Solid Waste with Composting; Solid Waste Utilization of Economical Value; Waste taxes or service charge; The Desire Will be On-site MRF; Solid Waste Management participation.Each of these categories has three questions that are representing the knowledge, attitude and behavior of the community in solid waste management. The results of the interview were analyzed using Likert Scale. Likert scale is the kind of scale that has high reliability in the sort of man based on the intensity of certain attitudes. Likert scale was used to measure attitudes, opinions and perceptions of a person or a group of people about a social phenomenon [13]. Likert formula calculation results is as follows:

$$\text{The Value Of The Likert} = \frac{\Sigma\ (the\ number\ of\ answers\ x\ value)}{Highest\ score\ x\ amount\ of\ total\ respondents}\ x\ 100\% \quad \text{.....(2)}$$

Analysis of participation variable was conducted in the village of Betoyoguci and Peganden. The number of respondents in each villages is 20 households. An analysis of the community participation is also done in the village of Yosowilangun, Tanggulrejo and Gumeno which represent high, medium and low density respectively to represent the community's participation in each interval of population density. For the amount of sampling questionnaire, each village was 30 households. The analysis result in each village represents community

participation in another village with similar density range. The analysis results of three were being compared with those on Betoyoguci and Peganden to determine the priority areas of development of MRF.

**MRF Construction Design Planning**

Technical aspect analysis of MRF betoyoguci and peganden were being used as planning design in prioritized village. The data includes waste generation rate, composition, density, recovery factor, recycling potential, parsing rate, as well as required infrastructure and facility. The number of MRF required for other villages then be known after the calculation.

## RESULTS AND DISCUSSION

The collection of primary data in Manyar Subdistrict exhibit solid waste generation, density and sorting rate was 0,29 kg/person.day, 145,96 kg/m$^3$, 91,15 kg/hour respectively. Composition and recovery factor of household solid waste in Manyar Subdistrict can be seen in the following Table 1.

**Table 1. Composition and Recovery Factor of Household Solid Waste in Manyar Subdistrict**

| Type Of Waste | Composition (%) | Recovery Factor (%) |
|---|---|---|
| **Food Waste** | 59.35 | 48.21 |
| **Yard Waste** | 7.36 | 41.98 |
| **Plastic** | 7.23 | 72.90 |
| **Paper** | 4.34 | 64.42 |
| **Textile** | 4.52 | 0 |
| **Glass** | 3.37 | 45.10 |
| **Wood** | 2.16 | 0 |
| **Rubber** | 1.15 | 34.86 |
| **Metal** | 1.19 | 83.63 |
| **Other** | 9.33 | 0 |

**Existing Conditions Of MRF Peganden**

Solid waste processing area in MRF Peganden consists of dropoff and sorting area, storage area, storage leachate area, residual container area, compost chopper machine and compost filter machine area. Other than that, there are an office, bathroom, storage shed, small mosque, parking lot and MRF road access. Solid waste processing in MRF Peganden begin with collection. The collected solid waste was put in the area of reception and manually sorted. Sorting stage was done for recovering valuable stuff, while food waste, yard waste and solid waste that has no value were all being sent to landfill later on. Sorted materials were stored for 30 days. Transportation of containers to the landfill done every three days.

MRF Peganden currently serves 1,117 households with the weight of 1,183.81 kg/day. The recovery factor for food waste and yard waste is 0%, because MRF Peganden does not do composting. Plastic waste has RF of 1.81%, whereas paper, glass, rubber, and metalwere as much as 0.96%, 0.21%, 0.22%, and 0.52% respectively. Textile and wood does not have an RF value because there are no accomodation for those types of waste in Manyar Subdistrict and the surrounding area. Based on the recovery factor, solid waste that can be recycled in the MRF Peganden was 44.03 kg/day (3.72%) and that being transported to landfill was 1,139.78 kg/day (96.28%). Public awareness on the service charge of solid waste management in Peganden is very high. The percentage of its payment reached 96% with 10.000 IDR/family. month.

**Optimization of MRF Peganden**

Optimization is required to increase the amount of solid waste recycling and reducingthe disposal to landfill. The optimization utilize Recovery Factor data derived from primarycollection in Manyar Subdistrict. The results show that the optimization of solid waste that can be recycled in MRF Peganden in 2027 was 898kg/day (42,68%) and that being transported to landfill was1,207kg/day (57.32%). The mass balance of MRF Peganden can be seen in Figure 1.

Space requirement analysis was calculated based on the amount of solid waste generation that went to MRF, composition, density, recovery factor, labor hours, and processing solid waste. This analysis also calculated based on 10 years projection (year 2027). Optimization of land requirement on this MRF acquired from analysis that had already been done. Comparison with existing area and results can be obtained from the difference between the required area. Area requirement comparison of existing data and optimization plan can be seen in the following Table 2.

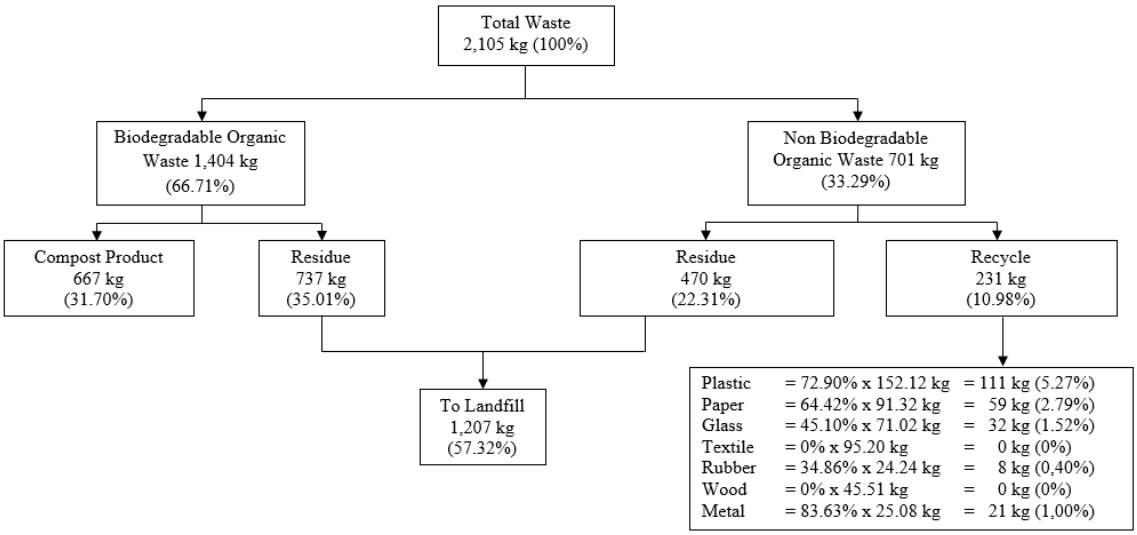


**Figure 1. Mass Balanceof MRF Peganden**

**Tabel 2. Area Requirement Comparison of Existing Data and Optimization Plan**

| No | Area | Existing Area ($m^2$) | Optimization Area ($m^2$) | Area Difference ($m^2$) |
|---|---|---|---|---|
| **1** | Office | 16 | 16 | 0 |
| **2** | Bathroom | 3 | 3 | 0 |
| **3** | Small Mosque | 3 | 3 | 0 |
| **4** | Storage Shed | 2 | 10.06 | -8.06 |
| **5** | - Dropoff and Sorting Area | 58.5 | 56 | 2.5 |
| | - Storage Area | 102 | 22 | 80 |
| | - Residual Container Area | 12 | 12 | 0 |
| | - Composting Area | 0 | 98 | -98 |
| | - Compost Chopper Machine Area | 2.25 | 2.25 | 0 |
| | - Compost Filter Machine Area | 8 | 8 | 0 |
| | - Storage Leachate Area | 0.79 | 0.79 | 0 |
| | - Road Access | 14.46 | 0 | 14.46 |
| | **Solid Waste Processing Area** | **198** | **198.25** | **-0.25** |
| **6** | Parking Lot Cart Motor | 10.5 | 16.5 | -6 |
| **7** | MRF Road Access | 145.5 | 139.5 | 6 |
| | **Total** | **378** | **386.31** | **-8.31** |

Based on table 1, the difference between optimization and existing land requirement in the year 2027 was -8.31 $m^2$. Deficiencies occur at the storage shed and solid waste processing area was -8.06 $m^2$ and -0.25 $m^2$ respectively. That land shortfall can be addressed by expanding solid waste processingarea so thatsolid waste processing landcan be ran optimally. The required extension of solid waste processing area was 11m x 1m.

**The Community Participation in The Village of Yosowilangun, Village of Tanggulrejo and Village of Gumeno**

Analysis of community participation in this research was conducted in the village of Yosowilangun (representing high density), Tanggulrejo (representing the medium density) and Gumeno (representing the low density) to represent the community's participation in each population density interval. There are as much as 30 questionaire that represents knowledge, behaviours and attitudes in solid waste management for each household. The comparison results were as follows.

- ✓ The knowledge of Village Yosowilangun society excels in 5 categories from a total of 6, namelysolid waste sorting, composting,utilization of economical value, service charge obligation and management.
- ✓ On the behavior side, Yosowilangun resident excels on service charge payment which as much as 8,000 IDR/family.month with payment percentage of 97% (routine), whereas in Tanggulrejo was 6,000 IDR/family.month with a percentage payout is 53% (sometimes) and in Gumeno was 5,000 IDR/family.month with the percentage payout is 57% (sometimes). Service charge payment and payout percentage were very important for the sustainability of the MRF as the income was derived from it.
- ✓ On the attitude side, Yosowilangun resident excels in all categories where the community strongly agree to pay for 10,000 IDR/family month, while community of Tanggulrejo and Gumeno were not as many that agree to

pay the same amount. For the solid waste processing category in the MRF. Yosowilangun people strongly agree (83%) to support MRF built by the government,Whereas People of Tanggulrejo and Gumeno who support MRF were just as much as 32% and 27% respectively.

**Development Strategy Of New MRF**

The determination of new MRF development location was based on community participation. The top priority was one that has the highest density intervals, and then followed by that has medium and low density. Service level of new MRF development was viewed upon community desire of it. On the high density interval, desire percentage of MRF was 83%, whilst on the medium and low interval were 32% and 27% respectively. Level of service at the end of the year planning (year 2027) to all villages planned 100%, therefore needed a strategy to increase the level of service of the MRF. Problems and strategy of improving community participation in Manyar Subdistrict can be seen in the Table 3.

**Table 3. Problems and Strategy Of Improving Community Participation in Manyar Subdistrict**

| No | Problem | Strategy |
|---|---|---|
| 1 | The role of the head of the village are minimal in the management solid waste | The increased socialization and coordination among all stakeholders on the importance of the management of persampahan for the progress of the region so as to gain attention in the form of priority allocation budget for investment or management costs solid waste |
| 2 | The society for less knowing the 3R program | The implementation of promotions that can give you an idea of "value" waste reduction at the source and its impact for health and environmental quality |
| | | Implementation of the 3R campaign widely through various mass media to reach out to the community from many quarters and build a social commitment |
| 3 | A small portion of the community has already done the program 3R but not done in constant | Develop and implement the system of incentives and disincentives in the implementation of 3R. Incentives can be either a reduction of the levy on solid waste, gift coupons shopping plastic bags, awards replacement level of villages and others |
| | | Boost community empowerment in order to exploit the economic value of waste 3R campaigns and promotions through the sale of handicraft products produced from recycled solid waste or in the form of compost |
| 4 | The public dispose solid waste at any place | Development of regulations as well as local regulations of both villages so that legal rules can be applied as it should be |
| | The community does not pay the levy in accordance with the applicable | |
| | The community does not routinely pay a levy | Encourage increased recovery of solid waste costs through increased public awareness to pay a levy |

Construction plan of new MRF adjusted to those optimized results at MRF Peganden. Solid waste volume that being managed by MRF Peganden in 2027 is 14,42 $m^3$/day with approximately 7.379 inhabitants and area of 378 $m^2$. The first step was projecting the number of population that have not been served by MRF. From the projection, MRF service were able to be estimated. The new MRF development is planned once in a year. The capacity of new MRF was appropriate to MRF Peganden. Development needs of new MRF and service levels can be seen in Table 4.

**Table 4. Development Needs of New MRF and Service Levels**

| No | Village | Service Level Existing MRF (%) | The Population Wants The MRF (%) | Stage I 2018-2024 | | Stage II 2025-2027 | |
|---|---|---|---|---|---|---|---|
| | | | | Underserved Population (Inhabitants) | Development of MRF | Underserved Population (Inhabitants) | Development of MRF |
| 1 | Betoyoguci | 69.12 | - | 1,750 | - | 1,966 | - |
| 2 | Banyuwangi | 40.98 | - | 1,712 | - | 2,602 | - |
| 3 | Betoyokauman | 50.73 | - | 2,012 | - | 2,589 | - |
| 4 | Peganden | 80.96 | - | 5,657 | - | 7,379 | - |
| 5 | Yosowilangun | 0 | 83 | 11,656 | 2 | 13,026 | - |
| 6 | Pongangan | 0 | 83 | 9,024 | 2 | 10,610 | 1 |
| 7 | Sukomulyo | 0 | 32 | 5,564 | | 10,197 | |
| 8 | Suci | 0 | 83 | 17,386 | 3 | 21,606 | - |
| 9 | Sembayat | 0 | 32 | - | - | 6,705 | 1 |
| 10 | Gumeno | 0 | 27 | - | - | 3,873 | 1 |
| 11 | Tanggulrejo | 0 | 32 | - | - | 2,897 | |
| **TOTAL** | | | | | | **83,451** | |

## CONCLUSIONS

Solid waste volume that being managed by MRF Peganden in 2027 is 14.42 $m^3$/day or 2,105 kg/day with approximately 7,379 inhabitants and area of 378 $m^2$. The solid waste that can be recycled in MRF Peganden in 2027 was 898 kg/day (42,68%) and that being transported to landfill was1,207 kg/day (57.32%). MRF development was prioritized by the level of density, in which the densest district became top priority. There are 7 and 3 MRFs will be built in 2018-2024 and 2025-2027 period respectively. With the addition of the new MRF, MRF service level in Manyar Subdistrict until the year 2027 was 64.61%

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## REFERENCES

[1] Badan Pusat Statistik Kabupaten Gresik, (2016), *Kecamatan Manyar Dalam Angka 2016,* Gresik.

[2] Bari, Q. H., Hassan, K. M., and Haque, R., (2012), "Scenario of Solid Waste Reuse in Khulna City of Bangladesh", *Waste Management,* Vol. 32, p. 2526-2534.

[3] Dinas Lingkungan Hidup Kabupaten Gresik, (2016), *Rencana Indukdan DED Persampahan Kabupaten Gresik,* Gresik.

[4] Demirbas, A., (2010), "Waste Management, Waste Resource Facilities and Waste Conversion Processes", *Energy Conversion and Management,* Vol. 52, p. 1280-1287.

[5] Mangkoedihardjo, S. (2007). Phytotechnology integrity in environmental sanitation for sustainable development. *Journal of Applied Sciences Research*, Vol. 3, No. 10, p. 1037-1044.

[6] Cimpan, C., Maul, A., Jansen, M., Pretz, T., and Wenzel, H., (2015), "Central Sorting and Recovery of MSW Recyclable Materials: A Review of Technological State-of-the-art, Cases, Practice and Implications for Materials Recycling", *Journal of Environmental Management,* Vol. 156, p. 181-199.

[7] Gundupalli, S. P., Hait, S., and Thakur, A., (2016), "A Review on Automated Sorting of Source-Separated Municipal Solid Waste for Recycling", *Waste Management.*

[8] Wang, Z., Dong, X., and Yin, J., (2016), "Antecedents of Urban Residents' Separate Collection Intentions for Household Solid Waste and Their Willingness to Pay: Evidence from China", *Journal of Cleaner Production.*

[9] Afroz, R., Hanaki, K., and Hasegawa, K., (2009), "Willingness to Pay for Waste Management Improvement in Dhaka City, Bangladesh", *Journal of Environmental Managemet,* Vol. 90, p. 492-503.

[10] Ardolino, F., Berto, C., and Arena, U., (2017), "Environmental Performances of Different Configurations of A Material Recovery Facility in A Life Cycle Perspective", *Waste Management.*

[11] Standar Nasional Indonesia (SNI) 19-3964-1994. *Metode Pengambilandan Pengukuran Contoh Timbulan dan Komposisi Sampah Perkotaan*.

[12] Tchobanoglous, G., Theisen, H., and Vigil, S.A., (1993), *Integrated Solid Waste Management: Engineering Principles And Issues*, McGraw Hill International Editions, New York.

[13] Sugiyono, (2012), *Memahami Penelitian Kuantitatif, Kualitatif dan R& D,* Alfabeta, Bandung.