



# **The Potential of Solid Waste and Greenhouse Gasses Reduction in Tambak Osowilangon Material Recovery Facility in Indonesia During the Covid-19 Pandemic**

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**Abstract:** Solid waste generation can increase due to people's activities that increase compared to the early pandemic in 2020. The solid waste management paradigm is no longer focused on landfilling waste in landfills. Solid waste reduction activities can extend the landfill's lifetime, one of the reduction activity facilities is Material Recovery Facilities (MRF). Surabaya, the capital city of East Java Province in Indonesia, has several MRF. One of them is Tambak Osowilangon . This study aims to determine the solid waste reduction in Tambak Osowilangon Material Recovery Facility during the COVID-19 pandemic and to predict greenhouse gas reduction based on solid waste. The triangular method calculates the greenhouse gases (GHG) prediction of solid waste management in Tambak Osowilangon MRF. Solid waste generation in Tambak Osowilangon MRF was produced at 2704.946 kg/day. The highest composition of solid waste was achieved by food waste (63%), and the existing reduction of solid waste in Ponds Osowilangon MRF is 56.08%. The total volume of GHG produced without reduction scenario is  $6.16 \times 10^6 \text{ m}^3/\text{year}$ , while the GHG produced from an existing reduction in Tambakosowilangon MRF is  $2.4 \times 10^6 \text{ m}^3/\text{year}$ . Solid waste management in Tambakosowilangon MRF can reduce 61.04% of the total GHG volume.

**Keywords:** *greenhouse gas; municipal solid waste; MRF; surabaya city; triangular method*

## **1. Introduction**

Surabaya is the capital city of East Java Province in Indonesia. It impacted economic growth and affected the increase of solid waste generation. Solid waste generation in Surabaya City in 2020 was 811,225.10 tons [1]. Solid waste generation can increase due to people's activities that increase compared to the early pandemic in 2020. The Municipal Solid Waste (MSW) management paradigm is no longer focused on landfilling waste in landfills but on increasing the percentage of solid waste reduction before it reaches the landfills. The landfill is the last step of solid waste management which receives solid waste from various sources [2]. Solid waste reduction activities can extend the landfill's lifetime. Solid waste reduction consists of source and regional reduction. The source reduction is composting individually and waste bank. Some countries, such as Malaysia, have problems with hundreds of tons of solid waste that are not accommodated in the waste transfer center because there is a gap between policies, so they must optimize the 3R process [3]. Surabaya city has several Material Recovery Facilities (MRF)

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locations. These MRF can reduce the solid waste generation in the Benowo landfill. One of these MRF is located at the Tambak Osowilangon.

The success of MRF operations consists of various supporting factors, such as funding, availability of supporting facilities, and community participation. Solid waste reduction at the Tambak Osowilangon Material Recovery Facility consists of biodegradable solid waste composting and separation which still has economic value. Composting can be done using bamboo to support oxygen circulation using the windrow composting method. Management of non-biodegradable waste, such as plastic, is done by converting it into plastic pellets [4]. This study aims to determine solid waste reduction in Tambak Osowilangon Material Recovery Facility during the COVID-19 pandemic and to predict greenhouse gas reduction based on the solid waste generation reduction at Tambak Osowilangon MRF.

GHG emissions are an essential component of MSW management. There are several methods to predict GHG emissions generation, such as life cycle assessment (LCA), Intergovernmental Panel on Climate Change (IPCC), and triangular method [5]. Triangular method uses a chemical reaction between rapidly and [6]slowly decomposable solid waste.

## **2. Methods**

### **2.1. Research Locations and Sampling Methods**

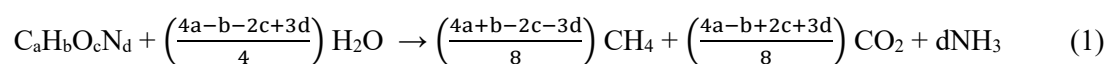
This research takes place at Tambak Osowilangon MRF in Surabaya City, Indonesia. It has an area of 2678.73 m<sup>2</sup>. Based on the Indonesian Standard for MRF criteria, the minimum area requirement of 200 m<sup>2</sup> [6] and Tambak Osowilangon MRF complied minimum criteria. The data collected in this study consisted of the generation, composition, density, and material recovery of solid waste facilitated in Tambak Osowilangon MRF. Data collection was carried out in 2021 during the Covid 19 pandemic. Waste generation data was compared in 2021 and 2020. According to Indonesian Standard Methods, sampling of density, composition, and recovery factors was collected in 2021 for 8 days.

### **2.2. Calculation reduction rubbish and house gas reduction glass**

Solid waste reduction is calculated by comparing waste that enters the Tambak Osowilangon MRF with total solid waste that is reduced with composting or separation. This reduction percentage of solid waste can be determined by comparing the amount of waste that enters Osowilangon MRF with the total solid waste that can be recovered or reduced.

GHG prediction from solid waste management at Osowilangon MRF based on the triangular method. GHG consists of methane gas and carbon dioxide gas. GHG emissions prediction are divided into rapid and slowly decomposable process. The quick decomposable process comes from degradable food, paper, cardboard, and garden waste. The slowly decomposable process comes from textiles, rubber, leather, and wood. Plastic waste can't be reduced.

GHG emission reduction was calculated by comparing 2 scenarios of solid waste management. The first scenario is all solid waste dumped in Benowo Landfill without reduction in Tambak Osowilangon MRF. The second one is an existing reduction in Tambak Osowilangon MRF. GHG emission prediction needs solid waste characteristics [7], as shown in Table 1. Reaction chemical from the decomposition process shown in Eq. (1). Period of gas production from slowly and rapidly decomposable waste needs 5 and 15 years.



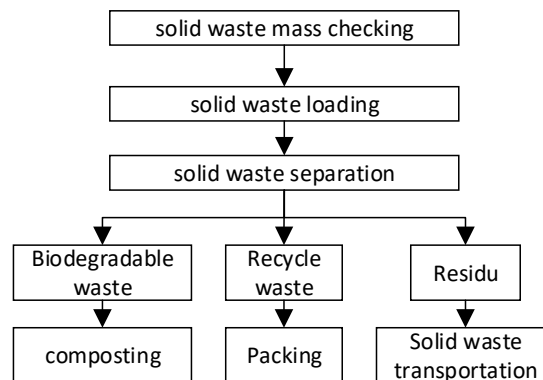
**Table 1.** Characteristics of Indonesian Solid Waste [8]

Components	Water Content (%)	Volatile Content (%)	Ash Content (%)
Biodegradable Waste	76,46	91.07	8.93
Paper Waste	42.74	86.91	13.09
wood	71.59	74.93	25.06
Textile Waste	64.38	77.92	22.07

### 3. Results and Discussion

#### 3.1. Service Areas and Waste Management Schemes in Tambak Osowilangon Material Recovery Facility

Tambak Osowilangon MRF started operating on 3<sup>rd</sup> January 2019. Initially, this MRF only sorted out plastic bottles from the Surabaya Busses operation. Before the Pandemic period, this MRF received waste using a transport vehicle like an arm-rolled truck with a 6 m<sup>3</sup> container filled with solid waste from road sweeping and non-residential solid waste with a percentage of residue solid waste could be recovered less than 30%. In 2021 the service area changed because it was quite far from Tambak Osowilangon MRF's location. The existing Service area consists of the Dr. Ramelan Hospital, the residential area of Kodam V Brawijaya, and street sweeping garbage. Existing solid waste collecting vehicles that come to Tambak Osowilangon MRF consist of an arm roll truck with a 6 m<sup>3</sup> container capacity and a compactor truck with a 10 m<sup>3</sup> container capacity. Fig. 1 shows the MSW management procedure in Tambak Osowilangon MRF.



**Fig. 1.** Solid Waste Procedure in Tambak Osowilangon MRF

Tambak Osowilangon MRF starts operating from 07.00 A.M to 04.00 P.M. Fig.1 shows the solid waste handling scheme in Tambak Osowilangon MRF with the following description:

1. Solid waste mass checking  
Garbage that enters the Tambak Osowilangon MRF is weighed, so that data on the generation and origin of the incoming waste is obtained
2. Solid waste loading  
Waste that has been weighed is received in the loading area. There are three conveyors for the following process, namely sorting.
3. Solid waste separation  
At this stage, the waste is divided into 3, namely:
  - Biodegradable waste must be shredded before composting. There is no addition of a bio activator to speed up the composting process. The composting method used in this MRF is windrow composting. Essential factors in windrow composting are oxygen, temperature, moisture, nutrients, substrate, and porosity [9].

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- The recycled waste consists of plastic bags, cardboard, paper, and plastic bottles. The waste is then packaged for the next step to be stored in the warehouse before being carried by a third party who will process it further
- The residual waste consists of materials that are difficult to compost and have no selling value and will be put into a container and then taken to the Benowo landfill.

**3.2. Comparison between existing conditions and legislation**

The legislation about MRF design parameters in Indonesia is based on The Indonesian Minister of Public Works Regulation No. 3 of 2013 about Solid Waste Facilities shown in Table 2.

**Table 2.** Comparison of Existing Conditions of Osowilangon MRF with Indonesian Solid Waste Law

Parameter	Existing	Suitability
Large of area is more than 200 m <sup>2</sup>	Osowilangon MRF has area about 2678.73 m <sup>2</sup>	√
Solid waste separation into 5 composition	Osowilangon MRF separates solid waste from more than 5 composition	√
MRF consists of:	MRF consists of:	
• Separation unit	• Separation manually with conveyor	√
• Composting unit	• Compositing unit with windrow composting method	√
• Biogas treatment unit	• Unavailable	-
• Warehouse and buffer zone	• There are warehouse and buffer zone	√
• neat (it does not interfere with the environmental aesthetic)	• It does not interfere with the environmental aesthetic	√
Unpermanent container for residu	Residu will be transported to Benowo Landfill	√
The distance of service area is not more than 1 km	The nearest service area has a distance of less than 1 km. The nearest service area distance about 10 m	√
Easy to access	Osowilangon MRF is easy to access because it facilitated with wide road	√
It does not pollute the environment	no waste pollutes the environment	√
It has collection and transportation schedule	Osowilangon MRF has area collection and transportation schedule	√

Based on table 1, it shows that there is one parameter that has not been fulfilled, they are the biogas processing facility.

**3.3. Generation and Composition of Solid Waste**

In this study, the waste density calculation was carried out based on 2 transport vehicles that entered the Tambak Osowilangon MRF. Garbage density from arm roll trucks with a capacity of 6 m<sup>3</sup> is 235.05 kg/m<sup>3</sup>, and compactor trucks are 394.34 kg/m<sup>3</sup>. A study in Surabaya depicted the solid waste density in arm roll trucks was 372.71 kg/m<sup>3</sup> and on compactor trucks. up to 742.44 kg/m<sup>3</sup> [10]. This comparison shows that the existing capacity of the two trucks in the Osowilangon MRF Tambak can be increased more than the existing. The solid waste density of vehicles affects transport efficiency and operational cost [11].

Fig. 2. shows that the enhancement of total rubbish for 1 year, p this because of increasing the MRF service area in 2021. Garbage entering the Osowilangon MRF on July 2020 was served with

a compactor truck with a capacity of 10 m<sup>3</sup> with build-up rubbish as big 71,100 kg /month or 2,350 kg/day. In 2021, a solid waste transportation vehicle in Tambak Osowilangon MRF is an arm roll with a 6 m<sup>3</sup> with solid waste generation about 45,130 kg/ month and a compactor truck with a capacity of 10 m<sup>3</sup> with solid waste generation about 114,360 kg/month, the total solid waste generation in 2021 is 159,490 kg/month or 5,316.3 kg/day. Solid waste generation in Osowilangon MRF increased about 2946.33 kg/day or 125.4% for one year.

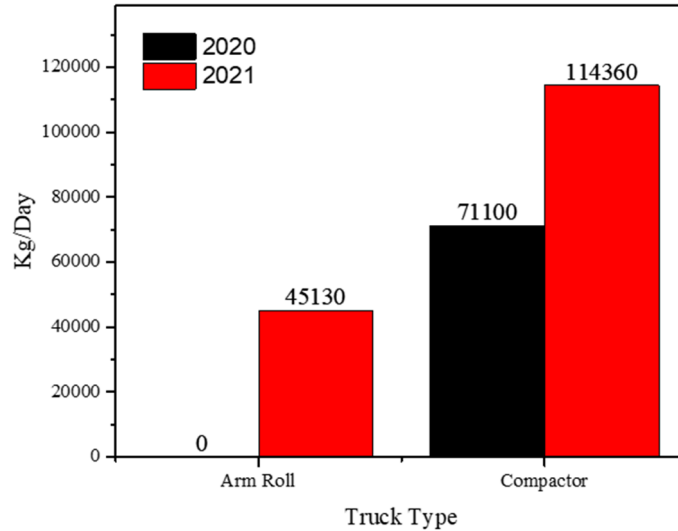


Fig. 2. Solid Waste Generation in Osowilangon MRF

The type of waste that dominates the composition of solid waste in Tambak Osowilangon MRF is biodegradable waste which will be used as raw material for compost consisting of food waste and garden waste by 63%, and other research shows the significant statement that the most extensive composition of Surabaya City waste is biodegradable waste worth over 50 % [12]. This research analyzed conditions of the Covid 19 Pandemic, where mask waste composition is around 0,16 % or 7.72 kg/day. Solid waste composition that enter Tambak Osowilangon MRF showed in Fig 3.

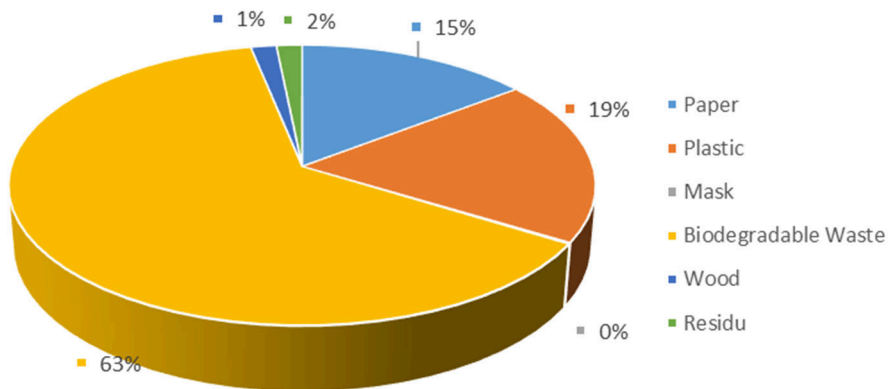


Fig. 3. Solid Waste Composition in Tambak Osowilangon MRF

### 3.4. Waste Reduction

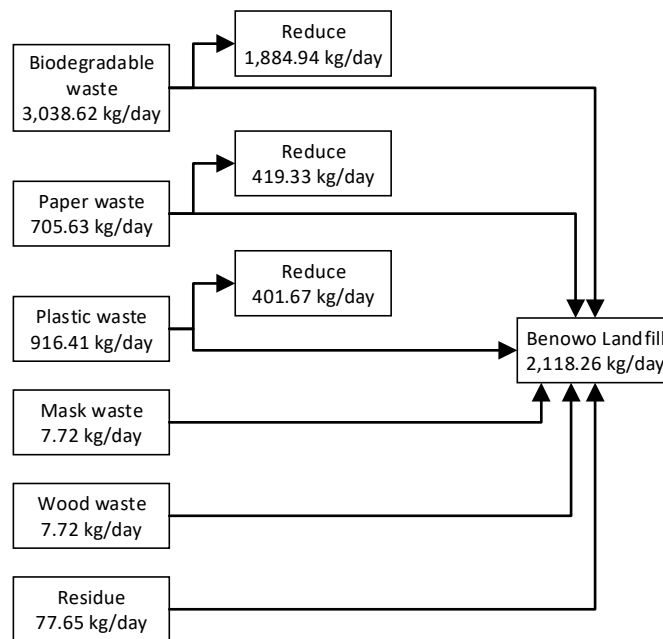
This percentage reduction of solid waste can be determined by comparing the amount of waste that enters Osowilangon MRF with the amount of waste that can be recovered or reduced. The

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Osowilangon MRF waste reduction activity is determined by composting biodegradable waste and recovering waste that has a selling value, such as plastic and paper. The total waste reduction carried out at Osowilangon MRF is as follows:

$$\begin{aligned} \text{Percentage of Existing reduction} &= \frac{\text{Waste Recovery (kg/day)}}{\text{Total Solid Waste (kg/day)}} \times 100\% \\ &= \frac{2704.946 \text{ kg/day}}{4823.2 \text{ kg/day}} \times 100\% = 56.08\% \end{aligned}$$

The amount of waste that can be reduced at Tambak Osowilangon MRF is 56.08% daily. Fig. 4 shows a mass balance of MSW management in Tambak Osowilangon MRF.



**Fig. 4.** Mass Balance of Solid Waste Management in Tambak Osowilangon MRF

**3.5. Greenhouse Gas Production**

Greenhouse gas estimation based on Triangular Methods consists of a slowly decomposable process and rapid decomposable reactions. This equation shows the chemical reaction of a slowly decomposable process and rapidly decomposable waste:

Rapid decomposable waste reaction:



Slowly decomposable waste reaction:

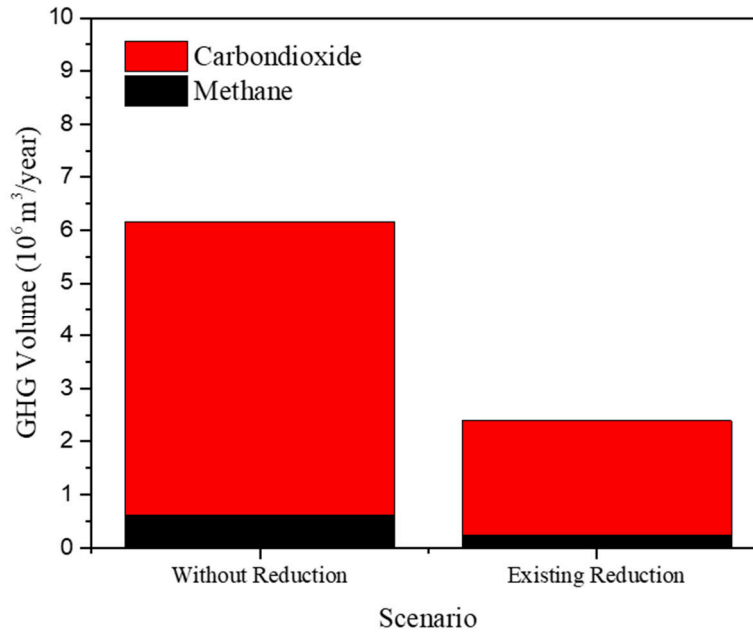


Based on coefficient moles obtained from stoichiometry, methane gas rate and carbon dioxide gas rate can be determined. Table 3 shows GHG rate from rapidly and slowly degradable waste. The total volume of GHG produced is counted based on the dried weight of solid waste. GHG emission comparison between first scenario that all waste dumped in Benowo Landfill, and another scenario GHG emission calculated based on total residue in Tambak Osowilangon MRF. Prediction of GHG volume emission showed in Fig 5.

**Table 3.** GHG Rate based on Solid Waste Degradability

Component	GHG Rate (m <sup>3</sup> /year.kg dried waste)	
	CH <sub>4</sub>	CO <sub>2</sub>
Rapidly degradable waste	0.473	4.339
Slowly degradable waste	0.493	4.565

Source: Author's Analysis



**Fig. 5.** GHG Volume Based on Without Reduction and Existing Scenario

Based on Fig. 5, the total volume of GHG emissions produced without the reduction scenario is  $6.16 \times 10^6$  m<sup>3</sup>/year, and GHG emissions produced from an existing reduction in Tambak Osowilangon MRF is  $2.4 \times 10^6$  m<sup>3</sup>/year. Tambakosowilangon MRF can reduce 61.04% of the total volume of GHG emissions.

#### 4. Conclusions

Solid waste generation in Tambak Osowilangon MRF is 2704.946 kg/day. Food waste is the primary component of solid waste (63%). The existing reduction of solid waste generation in Tambak Osowilangon MRF is 56.08 %. The total volume of GHG produced without a reduction scenario is  $6.16 \times 10^6$  m<sup>3</sup>/year, while the GHG produced from an existing reduction in Tambak Osowilangon MRF is  $2.4 \times 10^6$  m<sup>3</sup>/year. Tambak Osowilangon MRF can reduce 61.04 % of total GHG volume.

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