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WASTE MANAGEMENT SYSTEM IN PALEMBANG, INDONESIA AND THE POTENTIAL TO GENERATE GREEN HOUSE GAS EMISSIONS

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Abstract

The waste problem contributes significantly to the increase in Green House Gas (GHG) emissions which can cause global warming. Waste that is piled up will experience decomposition and produce emissions. The waste management system greatly determines the amount of greenhouse gases produced. This study aims to analyze the waste management system in Palembang City and its potential in producing greenhouse gas emissions. The results showed that waste management includes transportation to temporary shelters with low reduction rates, transportation to landfills and final processing. There was an increase in the volume of transport, namely 70% of the waste transported. The volume of waste in landfills continues to increase from year to year, reaching 327,768 tons/year in 2022. The current management system is very potential as a contributor to greenhouse gas emissions of 10,680,215.78 kg CH4/year consisting of emissions from composting, open burning and reduction in temporary shelters. The need for 3R improvement and final processing in landfill with closed burning with cost considerations.

Keywords: Waste, Management, Potential, GHG

1. INTRODUCTION

Garbage is waste in the form of solid and also semi-solid, from organic or inorganic materials, both metal and non-metallic objects, which can be burned and which cannot be burned. The physical form of these objects can change according to the way they are transported or how they are processed [1]. Municipal solid waste is a term that refers to materials disposed of in urban areas, especially household waste with occasional added commercial waste, which is collected and disposed of by local governments [2]. Waste arises from the rest of the production process and the remaining use of products, both from domestic/household activities, markets, and shops, sweeping roads and parks or, industries that produce solid waste from production residues [3]. [4] Underlined the importance of sustainable municipal solid waste (MSW) management adapted to population growth, urbanization, and living standards.

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The waste sector is not the largest contributor to GHG emissions, but has serious and complex issues. Municipal waste that is not managed properly can have a negative impact on groundwater flow and soil quality [5], as well as releasing harmful methane gas emissions in the waste treatment and disposal process[6] so that contribute greatly to climate change. According to the Intergovernmental Panel on Climate Change (IPCC) over the past 100 years the global warming potential of methane has become 28 times greater than that of CO2 [7]. Garbage can be a pollutant in the air and According to [8] waste can also be a pollutant in rivers.

Waste management is all activities carried out to handle waste from the time it is generated to its final disposal [9]. Meanwhile, according to [10] waste management is the management or control of waste generation, storage, collection, transfer and transportation, as well as processing and final disposal of waste in a manner that is in accordance with the best principles for health. Municipal waste management is still a challenge for cities, especially in developing countries. The greater the population of a city, the more complex the waste problem that must be overcome. Palembang City is a metropolitan city with a population of more than 1.6 million, which has various problems in waste management. Many efforts have been made to manage municipal waste, especially household-sourced waste, but there are still many problems such as piles of illegal waste, including TPS waste that is not transported to landfill, landfill that has not yet been sanitary landfill, low culture of sorting and reducing waste, and bad practices. Burning of waste (open burning) by the community.

Indonesia in terms of the waste sector including waste ranks fourth as the largest GHG emitter, with a contribution of around 8% [11]. Waste generated from residents' activities in urban areas is thought to have potential as a source of methane gas, which is a greenhouse gas that can cause the greenhouse effect and global warming [12].

On the one hand, waste management is still a challenge for cities, especially in developing countries. The greater the population of a city, the more complex the waste problem that must be overcome. Palembang City is a metropolitan city with a population of more than 1.6 million, which has various problems in waste management. Many efforts have been made to manage municipal waste, especially household-sourced waste, but there are still many problems such as piles of illegal waste, including temporary dump waste that is not transported to landfill, landfill that has not yet been sanitary landfill, low culture of sorting and reducing waste, and bad practices. Burning of waste (open burning) by the community. This study aims to examine the existing waste management system in Palembang City and its impact as a contributor to greenhouse gas emissions (GHG).

2. RESEARCH METHODS

Research design

This research is a descriptive and analytic observation research. The research was conducted in Palembang City. The implementation time is from December 2019 to June 2022. The

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research was carried out in two stages, namely in the first stage observing and collecting secondary data related to the waste management system in Palembang City and in the second stage carrying out analysis and calculation of Greenhouse Gas Emissions (GHG). Of the current waste management system (Baseline).

Method of Collecting Data

The data collection method is as follows:

Stage I

In the first stage collect and analyze waste management data which includes:

1) Conduct a field survey to obtain data on the distribution of temporary dump in Palembang City, both official and illegal temporary dump
2) Garbage transportation which includes the volume of the percentage of waste transported, the volume of waste in the landfill and waste generation.
3) Conduct a survey to take a sample of waste entering the landfill per day
4) Analyzing data on processed waste at temporary dump 3 R in Palembang City.

Stage II

In the second stage, calculating greenhouse gas emissions (GHG) as a result of the current waste management system in Palembang City, the calculations are as follows:

The second phase of the study conducted an analysis of greenhouse gas emissions. Emission factors use the default values provided by the 2006 Intergovernmental Panel on Climate Change (IPCC) which were updated in 2019 [7]. Activity data related to existing waste management, obtained through field surveys (primary data), and secondary data from the Palembang City Environment and Sanitation Service Greenhouse gas emissions from the MSW system are calculated using methods based on the IPCC guideline [7]. GHG emissions are estimated by multiplying the activity data by the emission factor. To equalize and accumulate each gas, the Global Warming Potential (GWP) metric for the 100 year horizon in the Fifth Assessment Report [7] is used. Namely: (a) GWP CO2 = 1; (b) GWP CH4 = 28; and (c) GWP N2O = 265.

In this study, potential GHG emissions were only carried out based on available data, namely:

1) The amount of waste stockpiled,

2) The amount of waste processed into compost and

3) The amount of unmanaged waste/illegal landfill. The assumptions and limitations used are:

- Palembang City's GHG emissions use South Sumatra's GHG emissions:
- Collection and transport GHG emissions are not accounted for;
- GHG emissions in the Waste Bank are not taken into account;
- All generated non-residential waste is transported to landfill

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Based on these assumptions and limitations, the GHG of Palembang:

$$\text{GHG Landfilling} = 26{,}82\ {}^{kg\ CH_4}/_{ton\ waste} \times landfilling\ {}^{ton\ waste}/_{year}$$

$$\text{GHG Compost} = 4\ {}^{kg\ CH_4}/_{ton\ organic} \times Compost\ waste\ {}^{ton\ organic}/_{year}$$

$$\text{GHG Open Dumping} = 26{,}82\ {}^{kg\ CH_4}/_{ton\ waste} \times Open\ Dumping\ ton\ waste/year$$

Total GHG Emissions = GHG Landfilling + GHG Compost + GHG Open Dumping

3. RESULTS

Temporary Collection and Shelter

Based on the field survey, it is known that there are 201 Temporary dump points spread across Palembang City (Figure 1). Temporary dump in the form of open concrete tanks is the most common, so that collected waste is prone to rainwater which has an impact on increasing the burden of transportation equipment, increasing leachate, odor pollution, becoming a breeding medium for insects, rodents, disturbing aesthetics, etc. temporary dump in good condition reached 75%, 16% lightly damaged and 9% heavily damaged. Out of the total temporary dump it is known that only 3 temporary dump implemented the lift container system. Need to improve temporary landfills that function 3R...

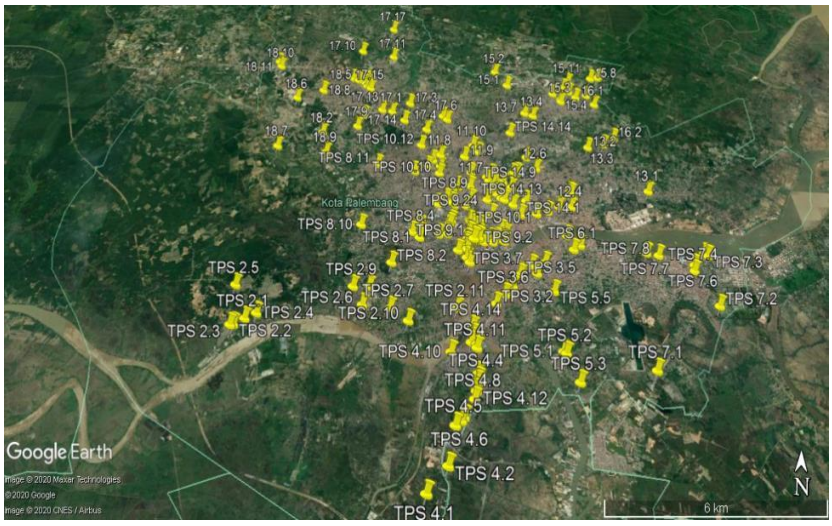

Figure 1: Distribution of Temporary dump in Palembang City (November 2020)

The reduction of municipal waste is estimated at 7% [13] so that there is 23% of waste generation that has not been managed. This data was verified by a field survey which found 370 points of illegal waste piles throughout Palembang City. The majority of illegal temporary dump points are located in the suburbs of Palembang City, which are not served by garbage transportation (Figure 2). Kertapati District, with a large area, has a few illegal temporary dump points, it seems that this correlates with the number of trash motorbikes. Indirect waste

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transportation, by relying on garbage motorbikes to bring garbage to temporary dump can be used as a good alternative, especially in the suburbs of Palembang City.

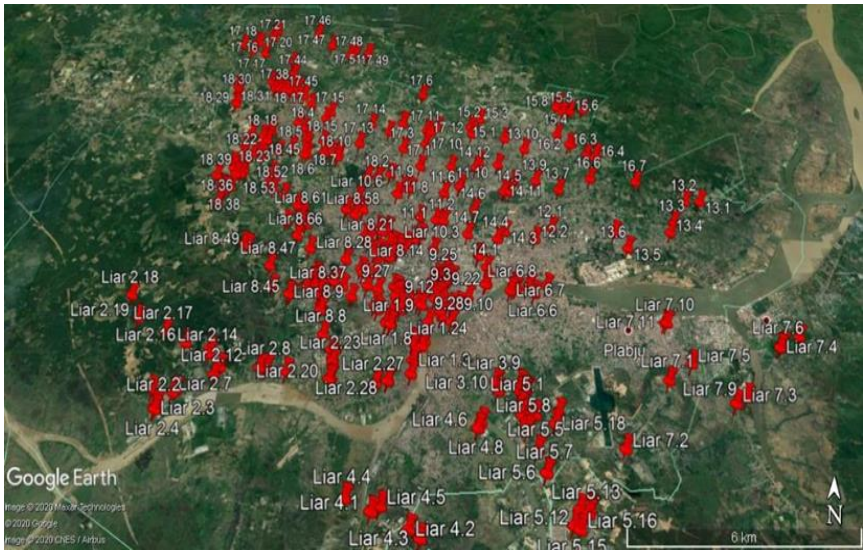

Figure 2: Distribution of Illegal temporary dump in Palembang City

Waste Reduction in Waste Banks and Temporary Dump 3R

Processed waste from temporary dump 3R in Palembang City in 2021 can be seen in Table 1. It shows that the low amount of processed waste from 3R, this is due to low 3R efficacy or many 3R facilities that are not functioning…

Table 1: Processed waste from 3R in Palembang City in 2021

Facility Type	Animal Feed Raw Materials (tons)	Compost Raw Materials (tons)	Recycle & Upcycle (ton)	Source of Energy (ton)
Unit Waste Bank	0,00	111,32	4.902,79	0
Main Garbage Bank	0,00	0,00	0,00	0
RTRW composting	70,09	69,02	0,00	1,1
Compost House	20,08	0,00	0,00	0
Organic Processing Center	0,00	0,00	0,00	0
Temporary Dump 3R	552,98	73,00	0,00	328,5
Recycling Center	0,00	0,00	0,00	0
Temporary Dump outside the landfill	0,00	0,00	0,00	0
ITF	0,00	0,00	0,00	0
Biodigesters	182,50	0,00	0,00	0,37
landfill	0,00	219,00	1.642,50	0

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Waste Transport

The waste transportation route in Palembang City can be seen in Figure 3, where waste from the source is transported to a temporary transportation site, then transported to Landfill Sukawinatan and Landfill Karyajaya depending on the location of the temporary dump. In general, the capacity to transport waste to the Landfill owned by DLHK Palembang City is only in the range of 57 volume of waste generation (70% by weight of waste generation). Apart from trucks (amrol and dump trucks) and motorbikes, one compactor unit and one Fuso unit are also owned. Especially for waste that is in rivers/streams, waste management (collection) is carried out by the PUPR Service, for further disposal to Landfill Sukawinatan and/or Landfill Karya Jaya.

Tabel 2: Estimation of Transported Waste to Landfill

Year	The volume of waste that goes to the Landfill (ton)	Population (person)	Estimation of waste generation (ton)	Estimated waste transported (%)
(1)	(2)	(3)	(4) = (3)*0,70*365*0,001	(5) = (2)/(4)
2017	249.018	1.623.099	414.702	60%
2018	264.859	1.643.488	419.911	63%
2019	296.783	1.662.893	424.869	70%
Source: Waste data goes to landfill [13].				

Observations showed that the average number of trips of transportation equipment that goes to the ladfill per day is: 145 trips of dump trucks, 46 trips of armroll trucks, 1 trip of compactor, 98 trips of pick-up/box cars, and 30 trips of garbage motorbikes (Table 3). Pick-up cars/boxes and garbage motorbikes are privately owned waste transportation vehicles. The observation results also show that the number of armroll trucks is not too much compared to dump trucks (only 32%) which are actually less than ideal in waste handling. Garbage transportation should preferably be of the arm roll truck type which can support the HCS (Hauled Container System) transportation pattern thereby reducing handling time but is more expensive in terms of operating and maintenance costs.

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Figure 3: Waste Transportation Routes in Palembang

Discussion of waste transportation is needed to verify the volume of waste that goes to the landfill. Verification is carried out for 2020, where a survey of waste transport entering the landfill is carried out. Based on SIPSN data (https://sipsn.menlhk.go.id), the volume of waste going to ladfill in 2020 was 310,295.05 tonnes/year, or an average of 850.13 tonnes/day.

Table 3: Results of waste sampling goes to Landfill

Survey Day	Waste weight (tons) per type of transportation			
	DLHK truck	Private Truck/Colt	Perkim & District Trucks	Total
Survey day -1 (05/12/2020)	632	224	25	881
Survey day -2 (06/12/2020)	501	153	10	664
Survey day -3 (07/12/2020)	681	240	11	932
Survey day -4 (08/12/2020)	594	211	25	830
average	602	207	18	**827**

Verification will be carried out in 2020 by conducting a sampling of waste transport that enters the Sukawinatan landfill (landfill Karya Jaya is not currently operating). Observations showed that the average number of trips of transportation equipment that goes to the landfill per day is: 145 trips of dump trucks, 46 trips of armroll trucks, 1 trip of compactor, 98 trips of pick-up/box cars, and 30 trips of garbage motorcycles, with an average of 100,000 tons of garbage entering weighing 827 tons/day (Table 3). Considering that the sampling was carried out for only 4 days, this value is quite consistent with data on the volume of waste going to landfillfrom DLHK.

Final Processing

Landfilling is a final waste processing method in Palembang City, where the landfilling location is known as the Waste Final Processing Site landfill .Palembang City has two landfills, namely: (a) Sukawinatan landfill (2°54'44.35"S, 104°44'56.66"E) and (b) Karya Jaya landfill (3°3'14.41"S, 104°42 '25.23"E). Currently, only landfill Sukawinatan operates using the landfilling method, with a small portion being processed through composting.

Meanwhile, the volume of waste that goes to the 2019-2021 landfill is taken from the Palembang City Environment and Sanitation Service Report. Because data on waste going to landfill in 2022 is not yet available, a surrogate data was carried out [7], namely (Σ population 2022 / Σ population 2021) * Σ waste going to landfill 2021.

Because the estimation of GHG in landfills starts from 2010, according to the national base year in the Updated NDC Indonesia (2022), to accommodate emissions from carbon stocks in landfill before 2019, the total potential of municipal waste generation and volume of waste going to landfill 2010-2018, estimated in the same way, that is based on a comparison of the total population. The trend of waste generation that goes to landfill has increased every year, see Figure 4.

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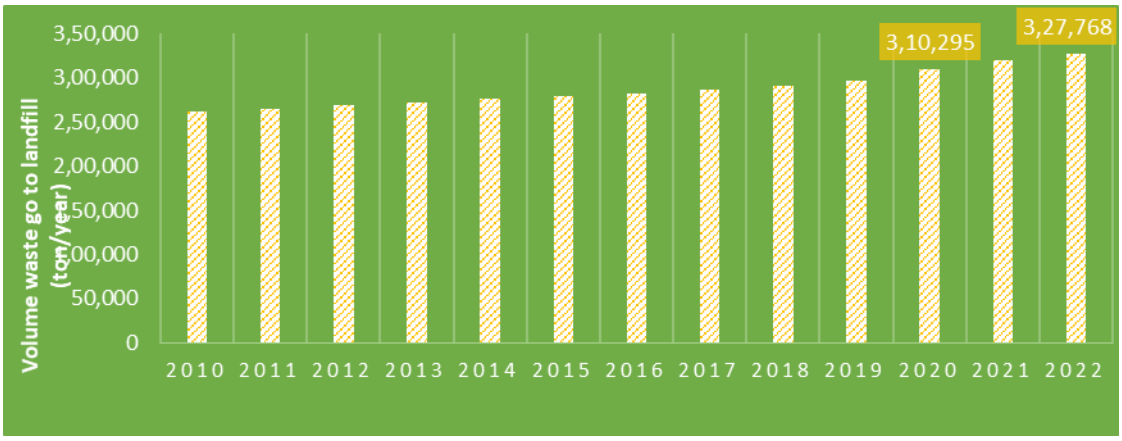

Figure 4: Trend of waste generation that goes to Landfill

Potential Greenhouse Gas Emissions of Current Waste Management Systems

In this study, potential GHG emissions were only carried out based on available data, namely: the amount of waste stockpiled, the amount of waste processed into compost and the amount of unmanaged waste/illegal TPS. The assumptions and limitations used are: GHG emissions from Palembang City using GHG emissions from South Sumatra; Collection and transportation GHG emissions are not taken into account; GHG emissions in the Waste Bank are not taken into account; all non-residential waste generation is transported to landfilling.

Total GHG emissions based on the sum of GHG emissions produced by GHG Lanfilling, GHG Compost and GHG open burning, the total for Palembang City in 2022 is 10,680,215.78 kg CH4/year. In detail can be seen in Table 4. This is the potential for GHG contributed by waste.

Table 4: Estimation of Greenhouse Gases generated from waste in Palembang 2022

Emission Source	GHG (kg CH4/tahun)
GHG Landfilling	7.241.729,886
Compost GHG	493.584
GRK Open Dumping	3.344.901,894
GKR Total	10.680.215,78

Based on Table 4,. The largest GHG emissions are contributed by waste generation in landfills, followed by open burning and a small amount produced by the composting process

4. DISCUSSION

In general, waste management in the city of Palembang still adheres to the concept of "collect-transport-storage at the landfill ". Organic and inorganic waste is collected at temporary dump in a mixed state. Waste from households is collected at temporary dump, to then be transported by garbage trucks to landfill Sukawinatan and/or landfill Karya Jaya. Waste management is a systematic, comprehensive and sustainable activity [14] concerning Waste Management, which includes: Waste minimization which consists of limiting the occurrence of waste, reuse and recycling and waste handling (Waste handling) includes: Segregation at source is the

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activity of grouping and separating waste according to type. Collection is the activity of taking and moving waste from the source of waste to a temporary shelter or waste processing site with the 3R principle. Garbage collection may not be mixed again after sorting and containerizing. /or the amount of waste.

In waste processing activities can include compaction, composting, material recycling and turning waste into an energy source. sanitary landfill and/or environmentally friendly technology. According to[15] , an example of a constraint faced by the government is the problem of temporary dump -3R facilities where only about 59% of the total temporary dump and 55% of the total temporary dump -3R built are currently reported to be active and the rest are inactive or unknown status. Likewise with final processing sites landfill, every year more and more sanitary and controlled landfill turn into open dumping facilities. Out of the total temporary dump it is known that only 3 temporary dump implemented the lift container system. It is necessary to increase temporary waste disposal sites that function as 3R. This is in line with the results of research by [16] and [17], which stated that there was an increase in the function of temporary waste disposal sites as integrated waste management sites with the 3R concept. Data on biological waste processing and 3R of Palembang City waste, which is used is data for 2021, so it is assumed that all years of study have the same volume of processing as this year. The informal sector is not included in this study because most of the waste managed by the informal sector is non-degradable waste (plastic and metal). The unavailability of data on the composition of waste managed by the informal sector is also an obstacle in including this sector in the scope of the study. This requires further study, because some waste managed by the informal sector can also be degraded anaerobically if landfilled in a landfill for example paper/cardboard waste. The low reduction of waste at temporary dump and waste banks causes an increase in waste generation at landfill. [18] revealed that landfills, which have so far been considered an efficient method of handling waste, can actually contribute to an increase in greenhouse gases. The same thing was stated by the Intergovernmental Panel on Climate Change or IPCC.

In 2019, the City of Palembang collected and processed ± 70% of the total municipal waste generation at the landfill [13], from an estimated 424,869 tons of waste generation. The city government's ability to transport waste also continues to increase. However, based on the transportation area, it is known that suburban areas are relatively unreachable. The problem of wide coverage of waste transportation is one of the main priorities because it encourages higher carbon emissions from unmanaged waste. Estimated waste transported can be seen in Table 2 showing an increase in estimated landfills from 2017 to 2019, this is due to an increase in population causing the volume of waste in landfills to increase. However, the percentage of waste transported has reached 70%, an increase of 10% from 2017. Based on these data, there is still a high amount of waste piled up in final disposal, this shows that temporary processing still needs to be improved. It is possible that the generation of municipal waste that goes to the landfill is greater or less than the estimate (70%). This is because the size of privately owned transport vehicles varies. Even so, not all cargo trucks have relatively the same density of waste due to environmental factors at the TPS. Waste handling is generally just thrown away without considering the impact on human health and the environment [19]. The 2020 waste-free target

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is interpreted as an effort to reduce waste generation, process waste, and reduce the negative effects of waste so as to minimize the amount of waste that goes to landfill [20]. According to [21] proposed alternative waste management based on the type of waste generated by the waste source. Garbage from metal groups is very dangerous if it pollutes waters and will disrupt ecosystems (Aida et al., 2022)[22].

Palembang City's greenhouse gas emissions due to waste management originate from various processes including landfilling, open burning, composting, open dumping and so on. The amount of GHG emissions in each region is different depending on various factors such as composition and climate. For example, in the United States it produces 26.93 kg CH4/ton of waste (landfilling), China 11.94 kg CH4/ton of waste (landfilling) [4], Denmark 1.23 - 4.28 tons of CH4/ tons of waste (landfilling) [23] and South Sumatra 26.82 kg CH4/tonne of waste (open dumping/Illegal TPS and landfilling) [24].

Based on the baseline scenario, the total climate impact from GHG emissions per tonne of the generated waste is 730.767 kg of CO2-eq/tonne, On BAU condition, less effective SWM management results in the high volume of untreated waste and open burned waste by the community. Landfills produce gas due to the anaerobic degradation process of biodegradable waste. The main components produced are methane (CH4) and carbon dioxide (CO2). Methane (CH4) is of more concern because it is a greenhouse gas and also has a potential power of 21 times stronger than carbon dioxide (CO2). The Interngovermental Panel on Climate Change (2006)[20] explains that carbon dioxide emitted from biologically solid waste management is not included in the inventory of greenhouse gases from landfills because carbon dioxide is categorized as biogenic origin and is calculated as a net emission. Other gases produced are also not counted because they are not significant. Landfills have become an option that many countries use because of their lower costs and easier operations [25] and Du, Menezes. et al. (2017)[26]. Based on observations of conditions in the field, there is waste treatment by burning it openly. Waste management by burning is an indicator that shows public awareness is still low in managing waste properly [27]. Solid waste at TPA has the potential to be a contributor to greenhouse gases. [28] and [29]There needs to be a strategy in waste management to reduce greenhouse gas emissions (GKR)[30],[31.

5. CONCLUSION

Existing waste management in Palembang City: In general, waste management in Palembang City still adheres to the concept of "collect-transport-storage at landfill. Organic and inorganic waste is collected at temporary dump in a mixed state. Waste from households is collected at temporary dump, to then be transported by trucks waste goes to landfill Sukawinatan and/or landfill Karya Jaya. The volume of waste generation increases every year, in line with population growth. The volume of waste in 2022 will reach 327,268 tonnes/year. In 2019, 70% of waste transported, however, has not reached the target. The estimated result of GHG emissions = 10,680,215.78 kg CH4/year, if this condition is allowed to continue to increase, high GHG emissions will have an impact on public health, namely dangerous for people with asthma, damage to lung tissue, respiratory problems, stroke, disease ischemic heart disease,

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chronic obstructive pulmonary disease (COPD) and lung cancer and can even cause death.The strategy for reducing greenhouse gas emissions needs to be done through a low-emission waste management model, one of which is by increasing reductions at the temporary dump level, resulting in a decrease in the amount waste transported to the landfill and reduce the amount of waste generation besides that it is necessary to apply the closed burning method and reduce waste generation in the landfill. It's just that you need to think about this method can increase costs.

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