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Methane Gas Management Policy Based on Emission Estimation at Gunung Kupang Final Processing Site Landfill

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Abstract. The waste sector contributes 21 times more Greenhouse Gas (GHG) in the form of methane gas than carbon dioxide gas. The problem of waste management in Indonesia is caused by several factors, including the need for more strict regulations and a management system at the landfill. Gunung Kupang Final Processing Site is a landfill that serves the Banjarbaru City area, where the waste that enters every day continues to increase and can potentially cause emissions. The management system implemented is still limited, namely composting and recycling methods. The management of methane gas produced from waste generation has not been maximized because there has yet to be a comprehensive measurement of methane gas. This study aimed to analyze the characteristics of waste generation and composition and the estimation of methane gas from the Gunung Kupang Final Processing Site using the LandGEM method. The urgency of measuring methane gas in waste management at Gunung Kupang Final Processing Site is the focus of this research, which is projected to encourage local governments to formulate appropriate and targeted waste management policies.

1. Introduction

Global warming is an increase in the average temperature of the Earth's atmosphere, oceans, and land. Researchers at the Center for International Forestry Research explain that global warming is caused by long-wave sun rays trapped by greenhouse gases. The increasing temperature of the Earth, floods, and other natural disasters are caused by climate change. The causes of climate change are diverse, but greenhouse gases are the leading cause. Methane gas is a greenhouse gas produced by landfill waste and other factors. Methane is produced through waste biodegradation under anaerobic conditions with the help of microbes [1].

Waste generation can be interpreted as community activities that increase the amount of waste in volume units and per capita weight per day or expand roads and buildings [2]. The amount of waste generation has a different volume/weight for each source component due to differences in the level of community consumption, the size and rate of population growth, lifestyle, and how the population is handled [3]. Waste characteristics can be interpreted as biological, chemical, and physical properties, which are used to determine treatment facilities, plan final disposal facilities, and estimate the feasibility of waste reprocessing.

A place used as a final disposal site and can accommodate large amounts of waste from a temporary Final Processing Site is called a Final Processing Site. 90% of landfills in Indonesia still use an open

dumping system, which can cause water, water, and soil pollution [4]. Final Processing Site procedures are different from other procedures. One of these procedures is the location of the final Processing Site, which must be isolated, and the provision of complete facilities to not cause pollution to the final Processing Site environment and its surroundings [5].

Based on Law no. 18 of 2008, waste management is a systematic, comprehensive, and continuous activity which includes waste reduction and handling. The waste sector contributes 21 times more Greenhouse Gas (GHG) in the form of methane gas than carbon dioxide gas. This could lead to more severe global warming.[6].

Municipal waste management throughout Indonesia is an actual problem with the increasing amount of waste in Indonesia due to several factors, one of the most significant factors being the increase in population. On average, waste management problems in Indonesia are caused by several factors, namely the lack of a firm legal basis, the lack of effort in composting, inadequate landfills, and the lack of a management system at these landfills.[7]. It is stated that four aspects need to be considered in order to determine waste processing technology, namely social, economic, environmental, and technical aspects.

Most waste in Indonesia's Final Processing Sites is not processed first. It is directly dumped into the ground without adequate layers so that the materials contained in the waste can cause soil pollution and trigger environmental pollution.[8]. One example is the accumulation of organic waste, which can produce methane gas and cause global warming, which is already at an alarming stage [9]. In addition to global warming, the various impacts caused by methane gas cause the need for early detection of the amount of methane gas produced by several sectors, especially the landfill sector, which accommodates large amounts of waste [10]. China and America are even having difficulty managing methane gas in landfills, a challenge for all countries worldwide [11]. Landfills can produce methane gas emissions, estimated at 3-19 percent from anthropogenic sources worldwide.

Final Processing Site Gunung Kupang is a Final Processing Site in Banjarbaru City. Gunung Kupang Final Processing Site is divided into two cells, with the second cell still operating from 2021 until now. The process of methane gas at Gunung Kupang Final Processing Site is carried out by converting methane gas into biogas. There is no other method to treat methane gas. This is considered relatively ineffective because biogas production in Gunung Kupang is minimized. The landfill manager has never created a system for measuring the amount of methane gas in the Gunung Kupang landfill, so an appropriate management strategy has not been found.

In previous research conducted at the Gunung Kupang landfill in 2021, waste management through composting and recycling still produces gas emissions, although it is less than not processing it at all.[12].

The role of local governments in protecting and managing the environment through waste management policies must be seriously considered, bearing in mind the impact of methane gas produced from the final Processing Site has increased the Earth's temperature, which has an impact on climate change, the health of living matters, crop failures, and so on. The urgency of measuring methane gas in waste management at Gunung Kupang Final Processing Site is the focus of this research, which is projected to encourage local governments to formulate appropriate waste management policies.

2. Methods

This type of research is qualitative-quantitative research. This research aims to calculate the production potential of methane gas emissions at the Gunung Kupang landfill using the LandGEM method and to determine the appropriate strategy for managing methane gas. Furthermore, through a sociological approach, waste management policies will be studied, becoming the legal umbrella for local governments to determine the appropriate strategy. Methane gas production is calculated using the LandGEM method using two parameters, namely CAA-Conventional and Inventory Default.

2.1. Research time

The research was conducted from January 2023 – June 2023.

2.2. *Research Equipment*

Research Equipment divided into laptops or printers for working on reports, stationery and Microsoft applications, software in the form of the LandGEM (Landfill Gas Emission Model), and equipment for sampling, including rubber gloves, hanging scales, bamboo baskets, 500-liter density box, sickles, stationery, masks, safety shoes/boots, etc.

2.3. *Data*

The primary data is the generation and existing conditions of the Gunung Kupang landfill waste processing. In contrast, the secondary data consists of the planned year of operation, the design capacity of the Gunung Kupang Banjarbaru landfill, the determination of the model parameters for the Gunung landfill, and the methane gas management method.

2.4. *Data Collection Techniques*

In this research, data collection techniques are divided into 5 data: observation or survey, interview, experiment, documentation, and literature study. Preliminary observations or surveys are carried out to determine preliminary data that needs to be obtained in the form of the latest conditions of the research site, in this case, the Gunung Kupang Final Processing Site. The interview is one of the processes in the preliminary survey conducted by interviewing the person in charge of the Gunung Kupang Landfill Final Processing Site. The experiment was conducted as field research with an eight-day sampling process to determine the amount and composition of waste generation at the Gunung Kupang Final Processing Site. Documentation of the course of the research process and results is carried out to support the validity of the data.

2.5. *Procedures*

The procedures that must be carried out to obtain research results can be explained as follows: The first step is sampling waste generation and composition using the SNI method 19-3964-1994, namely conducting waste sampling for eight consecutive days with a density of 1 quintal per day. The next step is to calculate data on waste going to the Gunung Kupang Final Processing Site, population projections and landfill waste generation using arithmetic, geometry and least square methods are then selected based on the correlation factor (r) closest to number 1, the estimated service life of the Final Processing Site landfill is based on the Murtudo formula of 1996, analysis of estimated methane gas production at Gunung Kupang landfill using the LandGEM method, determine the appropriate policy based on the results of an analysis of methane gas from the Gunung Kupang Final Processing Site are the last step.

3. **Results and Discussion**

3.1. *Measurement of Methane Gas Using the Land GEM Method*

The average waste generation will vary due to several factors, including population size and growth rate, season, lifestyle, population mobility, and food handling methods.[13]. This study uses primary data in the form of population data for Banjarbaru City and population projections from 2014-2024. The least-square method is used in calculating population projections with an amount of 0.9322 and has the highest value from other methods.

Gunung Kupang Final Processing Site waste processing data is the second primary data used for waste processing in the form of composting for kitchen waste and recycling for plastic waste. The amount of waste used as compost is 249.862 tons/year or 0.685 tons/day, while the recycled waste is 65.932 tons/year or 0.181 tons/day. The impact that arises from the absence of waste management is pollution, which can damage the balance of nature. It is not easy to handle and tends to be irreversible. Therefore, waste management is essential.

The required LandGEM data inputs are the year of opening and closing of the Gunung Kupang landfill, projected data for landfill waste generation, selection of default parameters, and determination

of model parameters. The parameters used in the calculations using the LandGEM- v303 model are the CAA model parameters. This is because the default CAA parameter is a parameter that is more commonly used. After all, it suits any region and already uses specific values.

The Constant Value (K) used in the Conventional default CAA is 0.05 per year, while the default inventory is 0.04/year. The methane forming capacity (Lo) value at the default CAA Conventional is 170 m³/mg. Figures 1 shows LandGEM input parameters on first landfill.

Figures 1. First landfill LandGEM input parameters
(Source: Research Data. 2023)

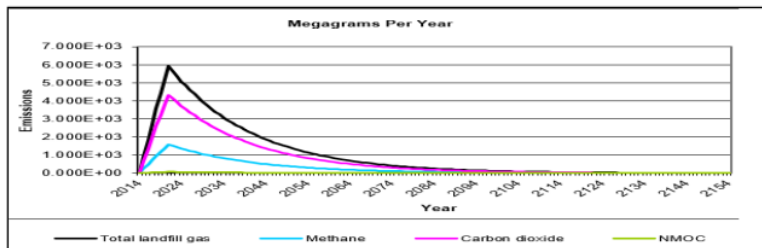
After data input, Table 1 shows the results that appear on the 'Result' tab and can be viewed along with the graph. The results of calculating the potential methane gas emission in the Gunung KupangFinal Processing Site landfill using LandGEM-v303 software for the default CAA parameter is 3.96 Gg/year. This means that methane's reserve or potential content in the Gunung Kupang Final Processing Site is 3.96 Gg/year.

Table 1. Input Projection of First Landfill Cell Waste Generation (2014-2020)

Year	Mg/Year	Gg/Year
2014	160	0.00
2015	166	0.17
2016	344	0.34
2017	537	0.54
2018	745	0.74
2019	967	0.97
2020	1.204	1.20
Total		3.96

(Source: Research Data. 2023)

Figures 2 shows the results graph of calculating methane gas in the first landfill cell at LandGEM is as follows:



Figures 2. First CAA-Conventional Landfill Cell Default LandGEM Results
(Source: Research Data, 2023)

The second landfill of Gunung Kupang Final Processing Site is estimated to have an operational period from 2021-2024. Figures 3 shows the second landfill LandGEM input parameters and methane gas potential using conventional default CAA parameters on LandGEM-v303:

Year	Input Units (Mg/year)	Calculated Units (short tons/year)
2021	56.839	62.523
2022	61.523	67.675
2023	66.576	73.234
2024	70.056	77.062
2025		
2026		
2027		
2028		
2029		
2030		
2031		
2032		
2033		

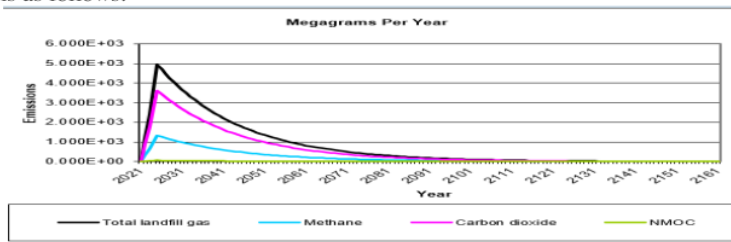
Figures 3. Second landfill LandGEM input parameters
(Source: Research Data, 2023)

Table 2 shows the calculation result on the 'Result' sheet and shown along with the graph on the 'Graphs' sheet. The total results of calculating the potential emission of methane gas in the second landfill cell of the Gunung Kupang Final Processing Site for the conventional default CAA parameter is 1.935 Gg/year. The following is the complete calculation result for 2021-2024

Year	Mg/Year	Gg/Year
2021	0	0.0000
2022	315	0.3152
2023	641	0.6410
2024	979	0.9789
Total		1.9351

Table 2. Input Projection of First Landfill Cell Waste Generation (2021-2024)
(Source: Research Data, 2023)

Figure 4 shows the graph of the results of calculating methane gas in the second landfill cell at LandGEM is as follows:



Figures 4. Second CAA-Conventional Landfill Cell Default LandGEM Results
(Source: Research Data, 2023)

1. 3.2. *Waste Management Policy*

Law number 18 of 2008 concerning Waste Management mandates the government and other related parties to be proactive and more responsive to waste management issues with strategic and participatory policies for the community. However, the reality that is currently happening shows a contradiction between the actions taken by the government and the spirit contained in the law. This is indicated by the low awareness of government officials and other stakeholders about their role in handling waste to realize good environmental quality and insight.

The increase in methane gas in the Gunung Kupang Landfill indicates an increase in the waste produced by the community. The current pattern of waste management still needs to be integrated between the community as a producer of waste and the government as a provider and manager of waste facilities. From the community's point of view, there is still a perception that waste is material that is no longer used, and it is the government's responsibility to manage it and clean it up. Efforts made by the government through the 3R program, namely Reduce, Reuse, and Recycle, are considered less successful in dealing with waste problems in Indonesia because implementing this program depends on community participation. Lack of awareness and community participation is the main problem in the failure of the 3R program.

Waste management is very complex and dynamic. It is complex because it involves many interested parties such as government, community, industry, traders and NGOs. It is dynamic because the volume of landfills will change over time. This fact means that waste management can only be carried out with a more technical approach (starting from the container, collection, and transportation to processing at the Final Processing Site) but must be carried out by involving the community as the primary source of waste generation.

The most significant change is the change in the paradigm of waste management policy, which refers to the transformation paradigm. Among them are related to policy ideology, policy orientation, and spirit, as well as the basic concept of waste management policy. Spirit in Law No. 18 of 2008 concerning Waste Management and Government Regulation No. 81 of 2012 indicates that waste management no longer requires one party's exclusivity of waste management policies. The general public and the business world are also positioned to have sovereignty, which is as essential as the government, so they must play a role and be responsible for waste management.

The effectiveness of waste management can only be achieved through 3 (three) pillars, namely the government, the wider community, and the business world, which work in an integral (integrated), comprehensive (overall), and mutualistic (mutually beneficial) manner. Implicitly, this concept carries the principle of cooperation in waste management as a strategic social capital.[14]

4. Conclusion

The results of the study carried out resulted in two conclusions. The first conclusion is based on the LandGEM method. In 2022, the second landfill cell at the Final Processing Site of Gunung Kupang will produce an estimated methane gas emission of 0.3152 Gg/year. The results of calculating total greenhouse gas emissions in the existing conditions from the latest landfill activities, namely in 2021 – 2024 Final Processing Site Gunung Kupang, is 1.935 Gg/year.

The second conclusion is that the effectiveness of waste management can only be achieved through 3 (three) pillars, namely the government, the wider community, and the business world, which work in an integral (integrated), comprehensive (overall), and mutualistic (mutually beneficial) manner. Changes in the paradigm of waste management policy refer to the transformation paradigm, including those concerning policy ideology, policy orientation, and spirit, as well as the basic concept of waste management policy.

The limitation of this research lies in the weak regulations governing waste management in Banjarbaru City, which procedurally forms the legal basis for determining management steps and strategies, one of which is the methane gas measurement strategy at Gunung Kupang Final Processing Site.

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