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Estimation of Greenhouse Gas Emissions in Waste Management at Basirih Landfill Banjarmasin South Kalimantan Indonesia

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ABSTRACT

Methane gas (CH_4) is one of the main Greenhouse Gases (GHG), after carbon dioxide (CO_2) which contributes greatly to global warming. The presence of methane gas in the atmosphere increases ± 0.6% per year. In the final processing stage of waste at the landfill in conditions without oxygen (anaerobic), the waste that is stockpiled will produce methane gas (CH_4). Landfill Basirih is the only TPA serving the City of Banjarmasin, with the waste coming in every day continuing to increase and has the potential to generate emissions. The aim of this study is to estimate greenhouse gas emissions from biological waste management activities and from waste collection activities, as well as analyzing a comparison of the increase in GHG emissions based on an inventory of the last 10 years at the Basirih TPA. The method used in this research is the Intergovernmental Panel on Climate Change (IPCC) method. In 2021 the processing of biological waste at the Basirih TPA will produce 0.00584 Gg/year of GHG emissions and 0.38876 Gg/year of greenhouse gas emissions resulting from waste collection activities. The average amount of increase in greenhouse gas emissions in the last 10 years is 0.02615 Gg/year with a percentage of 13.01 % / year.

Keywords: Biological waste processing, emissions, methane, landfilling, waste.

INTRODUCTION

Greenhouse Gases (GHG) are gases that cause an increase in the average temperature on earth (BAPPENAS, 2014). Methane gas (CH 4) is one of the main greenhouse gases, which contributes greatly to global warming. The presence of methane gas in the atmosphere increases by ± 0.6% per year (Aifah et al., 2021). The waste/waste sector is one of the sectors that is the largest contributor to GHG emissions in Indonesia.

Final Processing Site (landfill) is a place where waste will reach the final stage of its management (Prabowo et al., 2019). The city of Banjarmasin has facilities to accommodate waste generated by the community in the form of a Final Processing Site with the name Basirih landfill which has a land area of 39.5 Ha and an effective area of 20 Ha of landfill. Landfill has various ways of managing existing waste, such as landfilling, composting, waste recycling, methane gas management and others. Garbage that enters and is stockpiled every day has the potential to produce gas emissions (Hutagalung et al., 2020). Under anaerobic conditions, landfills will produce methane gas (CH_4) (Anifah et al., 2021). In addition to CH_4, landfill also produces greenhouse gases such as biogenic carbon dioxide (CO_2) and non-methane volatile organic compounds, as well as small amounts of nitrogen dioxide (N_2O), nitrogen oxides (NOx) and carbon monoxide (CO).

Intergovernmental Panel on Climate Change (IPCC) is a method for quantifying

greenhouse gas emissions. IPCC 2006 estimates the inventory of a country or a certain area in terms of anthropogenic emissions of greenhouse gases from sources to absorption for various sectors including the waste sector. (Chaerul et al., 2020). The 2006 IPCC Guidelines provide a choice of different Tiers (levels of detail in the database) used to predict greenhouse gas emissions. There are 3 Tiers defined in the 2006 IPCC method, namely Tier 1 (using mostly default data), Tier 2 (using some country specific data based on historical data for the last 10 years) and Tier 3 (using all specific data).

Based on Indonesian Presidential Regulation No. 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions and Presidential Regulation No. 71 of 2011 concerning Implementation of the National Greenhouse Gas Inventory, then this research becomes an interest to be carried out in order to support the national government program to reduce greenhouse gas emissions, especially in the waste sector. The purpose of this study is to calculate the greenhouse gas emissions produced by the Basirih landfill from biological waste processing and landfilling activities. In addition, this study will compare the amount of greenhouse gas emissions based on an inventory of the last 10 years at the Basirih landfill, so that it can be seen how much the increase has occurred in that period.

MATERIALS & METHODS

The research was conducted at the Basirih landfill, Banjarmasin City, which was carried out for 3 months with the implementation of field research carried out within a period of 2 weeks with primary data collection activities for calculating greenhouse gas emissions in waste / waste management. The data needed are data on the existing condition of waste management, data on waste generation and composition, TPA profile, data on the number of served population, and the 2006 IPCC default parameters. The 2006 Intergovernmental Panel on Climate Change (IPCC) method is used as a reference for calculating gas emissions. greenhouse produced at the Basirih landfill. In this study, the value of the specific emission factor was used which was calculated by means of the waste dry weight test.

Estimation of greenhouse gas emissions from the Basirih TPA can be estimated using the IPCC method based on First Order Decay (FOD). This method assumes that methane is formed from the slow decay of Degradable Organic Carbon (DOC) from solid waste. The DOC value is obtained from a calculation in which one of the data is the DOCi value on a wet weight basis. DOCi based on wet weight used in this study is the existing DOCi from TPA Basirih. DOCi on the basis of wet weight is obtained from calculating data such as the wet weight fraction of waste, the dry weight fraction of waste, and the DOCi fraction on the dry weight basis of waste. The dry weight fraction of waste is obtained from laboratory tests to measure the dry matter content in waste. Emissions of CH_4 , from solid waste disposal sites can be carried out with a Tier 1 calculation level that is based on on the FOD method which uses existing data on the Basirih TPA and some IPCC default parameters for Indonesia (Southeast Asia) due to limitations in providing specific data available in South Kalimantan.

This research requires several pieces of equipment including stationery for note-taking, Microsoft applications, laptops and printers for processing data and reports, spreadsheets and software. Intergovernmental Panel on Climate Change (IPCC) for the calculation of greenhouse gas emissions.

RESULT

Waste Generation and Composition at the Basirih TPA

The waste in Basirih landfill is waste that is transported by the garbage collection fleet from the waste collection point in the service area. The amount of incoming waste

can be determined by weighing it at the weighbridge.

Table 1. Amount of Waste Going to Basirih Landfill in 2021

No	Month	Amount (Tons)
1	January	11,596,740
2	February	10,934,650
3	March	12174,790
4	April	11,754,450
5	May	12019,620
6	June	11972,620
7	July	12,839,930
8	August	12185,440
9	September	12,650,720
10	October	12,686,870
11	November	12,404,350
12	December	15,788,980
Total		149.009,160

Waste composition data is needed to determine and determine the amount of greenhouse gas emissions in waste processing activities. Based on IPCC 2006, the composition of waste is divided into 11 components, namely food waste (kitchen), paper and cardboard, diapers, wood, parks and gardens, textiles, rubber and leather, metal, glass, plastic, and other waste. The percentage of measurement results for the composition of waste that goes to the Basirih landfill can be seen in Table 2.

Table 2. Percentage of Waste Composition at TPA Basirih

Composition	Percentage
Food Waste	47.91%
Garden Trash	8.31%
Paper & Cardboard	9.78%
Rubber & Leather	0.44%
Wood	1.67%
Metal	0.38%
Glass	1.16%
textiles	1.89%
nappies	8.07%
Plastic	19.81%
Etc	0.58%
Total	100%

Calculation of DOCi value on wet weight basis and DOC waste

The value of DOCi (fraction of degradable organic carbon in waste component i), while DOC (Degradable Organic Carbon) is the organic carbon contained in waste and can be decomposed biochemically (IPCC 2006 GL). These two values are one of the factors that affect the amount of methane gas emissions that will be produced.

Table 3. DOCi and DOC Waste Values

Composition	Trash Weight Fraction	Dry Matter Content Fraction	IPCC Dafault Dry Weight Base DOCi (%)	IPCC Default Dry Weight Base DOCi Fraction	Wet Weight DOCi Fraction	DOC
	A	B		C	D=BxC	D=AxD
Kitchen Trash	0.479	0.11	38.00	0.38	0.04	0.019
Garden Trash	0.083	0.27	49.00	0.49	0.13	0.011
Paper & Cardboard	0.098	0.87	44.00	0.44	0.38	0.037
Rubber & Leather	0.004	0.94	47.00	0.47	0.44	0.002
Wood	0.017	0.81	50.00	0.50	0.41	0.007
textiles	0.019	0.74	30.00	0.30	0.22	0.004
nappies	0.081	0.43	60.00	0.60	0.26	0.021
Plastic	0.198	1.00	0.00	0.00	0.00	0.000
Metal	0.004	1.00	0.00	0.00	0.00	0.000
Glass	0.012	1.00	0.00	0.00	0.00	0.000
Etc	0.006	1.00	0.00	0.00	0.00	0.000
Total DOCs						0.101

Estimation of Greenhouse Gas Emissions from Waste Management at TPA Basirih

Waste processing such as composting activities needs to be done in order to reduce the volume of waste that will be stockpiled in landfills. The existence of this waste treatment will also reduce methane emissions. At TPA Basirih there is biological waste processing in the form of composting which is carried out at the Compost House. Processed waste is waste obtained from market garbage trucks, chopped from the Antasari Market chopping house in the form of food scraps.

Table 4. Estimated GHG Emissions from Composting Activities at TPA Basirih

Biological Processing Systems	Waste Category	Total Waste Composted (Gg/Year)	$CH_{4\ emission}$ ($Gg\ CH_4$)
Compost	Food Waste	1,460	0.00584

Table 5. Estimation of GHG Emissions from Waste Landfill Activities at TPA Basirih

Composition	Amount of Waste Entered Landfill (Gg/year)	Composition of Waste (%)	Composition of Waste (Gg/year)	(CH_4) (Gg/year)
Food Waste	147,23	47,91	70,54	0.29043
Garden Trash		8,31	12,23	0.01423
Paper & Cardboard		9.78	14.40	0.04354
Rubber & Leather		0.44	0.65	0.00000
Wood		1.67	2.46	0.00150
textiles		0.38	0.56	0.00328
nappies		1.16	1.71	0.03578
Plastic		1.89	2.78	0.00000
Metal		8.07	11.88	0.00000
Glass		19,81	29,17	0.00000
Etc		0.58	0.85	0.00000
Total Emissions in Landfills				0.38876

Estimation of greenhouse gas emissions from waste management activities at the Basirih TPA with the processing of biological waste of 1.460 Gg/year in the form of compost produces GHG emissions of 0.00584 (Gg CH_4) . Garbage that is not processed or stockpiled in the landfill zone is 147.23 Gg/year resulting in emissions of 0.38876 Gg/year. Based on the calculation results of GHG emissions from composting and landfilling activities, after adding them up, it can be seen that the GHG emissions produced in the existing conditions of the Basirih TPA are. The results of the sum can be seen in Table 6.

Table 6. Estimation of Greenhouse Gas Emissions in Existing Conditions at Basirih TPA

Emission Source	Greenhouse Gas Emissions (gg/year)
composting	0.00584
Hoarding	0.38876
Total	0.39460

Increase in GHG Emissions Based on Inventory for the Last 10 Years at the Basirih TPA

Degradable Organic Carbon data, DOCf (Fraction of DOC that can decompose), MCF (CH_4 Correction factor for aerobic decomposition in the year of deposition , as well as F (Fraction of CH_4 generated landfill gas) . Based on the calculation results, an estimate of Greenhouse Gas (GHG) emissions at the Basirih TPA for the last 10 years is obtained. The year of calculation starts from 2012 to 2021. The calculation results can be seen in Table 7.

Table 7. Estimation of GHG Emissions for the Last 10 Years at the Basirih Landfill

Year	Garbage Generation	Composting Emissions (Gg)	Landfill Emissions (Gg)	Total CH4 Emissions (gg)
2012	141,781	0.00556	0.12755	0.13311
2013	143,834	0.00564	0.21679	0.22243
2014	124,384	0.00488	0.28074	0.28562
2015	162,791	0.00640	0.30687	0.31327
2016	159,488	0.00624	0.36178	0.36802
2017	121,574	0.00476	0.39740	0.40216
2018	123,399	0.00484	0.38404	0.38888
2019	135,535	0.00532	0.37804	0.38336
2020	126,590	0.00496	0.38753	0.39249
2021	149,009	0.00584	0.38876	0.39460

Source: Calculations for 2022, Basirih Landfill Inventory Data, Mahyudin 2016 (DISERTATION).

The amount of greenhouse gas emissions that has been calculated before, both from biological waste processing activities (composting), landfilling activities, as well as the total of these two activities will be displayed in the form of a line chart which can be seen in Figure 1, Figure 2, and Figure 3.

Figure 1. Increase in CH_4 Emissions from Composting Activities

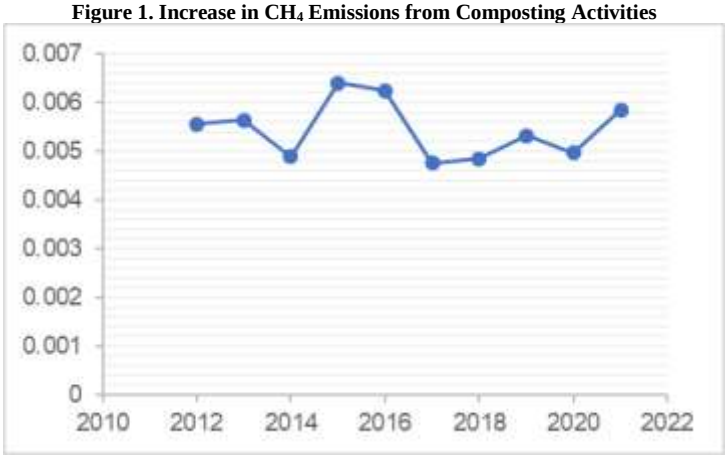


Figure 2. Increase in CH_4 Emissions from Landfill Activities

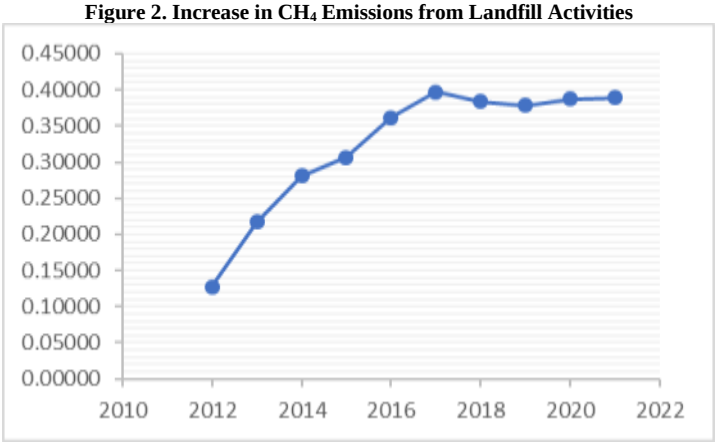
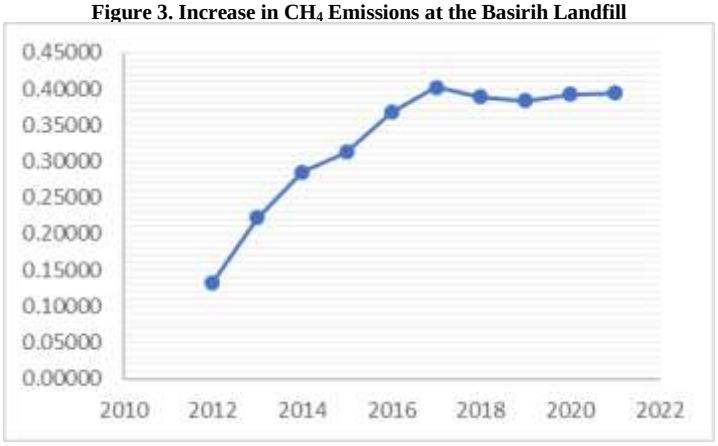


Figure 3. Increase in CH_4 Emissions at the Basirih Landfill



DISCUSSION

Based on data from the Basirih landfill (2021), waste generation at the Basirih landfill in 2021 is 149.009,160 tons/year or 408.244 tons/day. In 2021 there will be an increase in waste generation when compared to 2020, namely the amount of incoming waste is only 126.590,110 tons. The increase in the amount of waste generation in 2021 is due to the increasing population of the City of Banjarmasin. According to Sofriadi et al (2017), rapid population growth has the potential to increase the problem of uncontrolled waste generation, because the presence of waste not only disrupts environmental health, but can also cause greenhouse gas emissions. The higher the amount of waste generated, the greater the greenhouse gas emissions that will be released into the air.

The highest percentage of waste composition is organic waste which is

dominated by food waste as much as 47.91%, while the least percentage of waste composition is metal waste which includes inorganic waste which is as much as 0.38%. The percentage of the composition of the waste is dominated by food waste, because the leftover food waste is just thrown away without being processed before it goes to the TPA, while metal waste has the least presence because before it enters the TPA the metal waste has been used by scavengers at the TPS or people who sell directly to third parties. The results obtained are similar to the waste composition survey in the JICA-KLH-ITB Pilot Project, BLH North Sumatra, and South Sumatra BLH (2011) in KLHK (2012), where food waste is the largest component of waste with a percentage of >50%, while metal waste is the component of waste with the smallest composition, namely 0%.

Based on Table 3, the highest DOCi value on a wet weight basis is the rubber waste component of 44%, while the lowest is the waste component that is not easily decomposed such as plastic, metal, glass and others by 0%. The wet weight basis DOCi values obtained were then compared with the IPCC default data, where from these data there were both significant and insignificant differences. This difference can be caused because the data taken is data based on the existing conditions of the Basirih TPA, while the IPCC default data is assumed data if there is no existing data from the TPA. The DOC fraction of waste is the sum of the DOC of all components. Based on the calculation results, the DOC fraction of waste formed at TPA Basirih is 0.1 01 Gg C/Gg of waste.

The amount of waste that is processed into compost at the Basirih TPA is 1,460 tonnes/year or 1,460 Gg/year. This composting activity will produce greenhouse gas emissions. Calculation of estimated CH 4 gas emissions from composting activities can be calculated using the IPCC method. Based on the calculation results, it was found that the CH 4 emission formed from composting activities at the Basirih TPA was 0.00584 (Gg CH 4).

Activities in the waste landfill zone will produce GHG emissions in the form of methane gas (CH 4). Waste that is not processed through waste processing activities such as composting will be disposed of directly into landfills at the Basirih TPA. The amount of waste that enters the Basirih TPA in 2021 is 149,009.160 tonnes/year or 149.01 Gg/year. This value is then reduced by the amount of waste that is processed by composting activities of 1.460 Gg/year, so that the amount of waste dumped in landfills is 147.55 Gg/year. Given the activities of the informal sector at TPA Basirih, namely scavengers who participate in the collection and classification of waste as potential recycling. Based on Rahmatina's research (2021) the total waste reduction by scavengers is 324.5 tonnes/year or 0.32 Gg/year. So that the total amount of waste stockpiled in landfills is 147.23 Gg/year. The results of calculating GHG emissions from waste collection activities can be seen in Table 5.

GHG emissions resulting from waste landfill activities at the Basirih TPA are 0.38876 Gg/year. There are differences in emissions produced from each waste component. This is due to the difference in the DOC value of each waste composition. In accordance with KLHK (2012) which states that DOC is a waste characteristic that affects the amount of CH4 gas that can be formed. Then, the amount of DOC also depends on the composition (% by weight) and the dry matter content of each waste component. The composition of waste that contributes to greenhouse gas emissions according to the IPCC is the composition of food waste, parks & gardens, paper, wood, textiles, nappies, and rubber & leather. These wastes are wastes that are easily decomposed so that they release or emit methane gas into the air.

It can be seen from the data that there has been an increase in greenhouse gas emissions from year to year, the average

increase in GHG emissions at the Basirih TPA is 0.02377 Gg/year. 2012 was the year when the lowest GHG emission value was formed, while 2017 was the year when the highest GHG emission was formed at the Basirih TPA. This can be influenced by the large amount of waste generation that enters the landfill zone. Even though in 2017, waste generation at TPA was 121.57 Gg which is certainly smaller than in other years. However, the amount of emission in year T will affect the amount of emission in year T+1. As mentioned in the IPCC (2006) that the month when the gas formation reaction will begin is 13 months. Therefore, the amount of waste generated in the previous year greatly influenced the emissions produced in year T. Based on Khatulistiwa et al (2015) stated the relationship between waste generation and greenhouse gas emissions, namely, the greater the existing waste generation, the greater the potential CH4 emissions that will be formed.

Emissions generated from the Basirih landfill each year have a considerable value and the amount continues to increase every year. Based on Figure 1, If you pay attention, it can be seen that the most significant increase in CH 4 emissions from composting activities occurred in 2015 where there was an additional CH 4 emission value of 0.00152 Gg. This value has increased by 31.15%. Meanwhile, the most significant decrease occurred in 2017, where the decrease occurred by 0.00148 Gg or decreased by 23.72%. The average increase in GHG emissions from biological waste processing activities is 1.69%/year.

Based on Figure 2, It can be seen that the most significant increase in CH 4 emissions from landfill waste activities occurred in 2013 where there was an additional CH 4 emission value of 0.08924 Gg. This value has increased by 69.97%. Meanwhile, the most significant decrease occurred in 2018, where the decrease occurred by 0.01336 Gg or decreased by 3.36%. The average increase in landfill gas emissions is 0.02612 Gg/year, with an increase percentage of 13.44%/year.

Based on Figure 3, The resulting GHG emissions are the sum of biological waste processing activities and landfill activities. The most significant increase in CH 4 emissions at TPA Basirih occurred in 2013 where there was an additional value of CH 4 emissions of 0.08932 Gg or around 67.11%. This value is influenced by the amount of waste that is composted as well as the amount of waste generation and composition. In accordance with Mutia's research (2018) which states that because the more organic content in waste, it will affect the amount of methane gas that will be produced. Meanwhile, the most significant decrease occurred in 2018, where the decrease occurred by 0.01328 Gg or decreased by 3.30% from the previous year. The average amount of increase in CH 4 gas emissions is 0.02615 Gg/year, with an increase percentage of 13.01%/year.

CONCLUSION

Based on the description of the results and discussion, several conclusions are obtained as follows:

1. In 2021, the processing of biological waste at the Basirih TPA in the form of composting activities will produce greenhouse gas emissions of 0.00584 Gg/year, while from waste landfill activities produces greenhouse gas emissions of 0.38876 Gg / year. The calculation results of the total greenhouse gas emissions in the existing conditions at the Basirih TPA are 0.39460 Gg / year.
2. Increase in greenhouse gas emissions at the Basirih TPA occurred in 2013, which was 0.08932 Gg / year. Meanwhile, the most significant decrease occurred in 2018, where the decrease occurred by 0.01328 Gg/year. The average amount of increase in greenhouse gas emissions in the last 10 years is 0.02615 Gg/year with a percentage of 13.01 % / year.

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