IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

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To cite this article: S Hariyanto *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **245** 012020

IOP Conf. Series: Earth and Environmental Science **245** (2019) 012020 doi:10.1088/1755-1315/245/1/012020

The potential of methane gas production at Klotok Landfill Kediri City

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Abstract. This research aimed to determine CH_4 levels and its potential of usage in Klotok Landfill Kediri City. The measurement of CH_4 was performed at six points, three points at Klotok I and Klotok II Landfill in each cell. CH_4 was measured using portable gas detector with the MQ-04 type of gas sensor. The measurement of CH_4 was performed in seven times of observation in the morning and in the evening. The average of CH_4 levels at Klotok I Landfill were (1.8±0.71); (62.46±3.19); and (3.07±2.65) %Vol, respectively. The highest CH_4 levels at Klotok I Landfill was in Cell 2, which was almost similar to Klotok II Landfill. The CH_4 levels in each measurement points in the Klotok II Landfill were (63.21±2.61); (62.46±4.70); and (19.76±17) %Vol, respectively. The highest CH_4 levels at Klotok II Landfill was in Point 1. The CH_4 levels were affected by environmental condition in terms of soil temperature, soil moisture, and pH of soil, etc; the existence of methanogenic microorganisms, and the composition of waste in the landfill. A high CH_4 levels at Klotok Landfill Kediri City can be utilized as an alternative fuel for renewable energy source appropriate with the concept of green technology.

1. Introduction

CH_4 is one of the greenhouse gases that are 20 to 30 times stronger than CO_2 gas that causes global warming [1]. It is capable of absorbing and passing the radiation of the sun (shortwave) as well as reflecting the long wave radiation emitted on the surface of the earth; this results in an increase in temperature [2]. CH_4 is proven to be very hazardous if a landfill is not equipped with gas management facilities. Explosions in landfills may occur due to the chemical reaction between the air and CH_4 emitted by the waste. Those large tonnages of waste do not have a proper ventilation, causing the CH_4 gas to be trapped inside and keep increasing in volume as the gas becomes trapped and the volume continues to increase along with the garbage that keeps piling up. When large volumes of gas are in contact with the air, a flame will appear, followed by explosion [3][4].

CH_4 is one of the biogases that can be used as both fuel and alternative energy sources. It serves as an alternative energy sources for electric power generator, heat generator, and LPG gas that is widely utilized for domestic purposes. Burning 1 cubic foot (0.028 m^3) of biogas produces heat energy of 10 Btu (2.25 kcal). This is equivalent to 6 kWh / m^3 electrical energy or 0.61 l of gasoline; 0.58 l kerosene; 0.55 l diesel; 0.45 LPG (Natural Gas); 1.50 kg firewood; and 0.79l bio ethanol [5].

On average, every ton of solid waste generates 50 kg of CH4 gas [2]. The waste that piled up in Klotok Landfill of Kediri City in 2014 reached 242.4 tons/day. This indicates that by 2014, 12,120 kg of CH_4 gas had been emitted by Klotok Landfill [6]. If not properly managed, the gas may possess a potential hazard to human health and environmental sustainability.

Because of those factors, we investigated the potential of CH_4 gas that was formed from waste piles in Klotok II Landfill of Kediri City in order to determine the model of proper waste management that can be considered as environmentally friendly (green technology).

2. Research Methods

The CH_4 gas content measurement in this study used portable combination gas detector for seven times of measurement. This tool is designed and assembled by researchers at the Electrical Laboratory of State University of Malang. The portable combination gas detector catches CH_4 gas and temperature with the gas analogue sensor. The gas sensor of CH_4 and the temperature contained in this tool are MQ-04 or TGS2501.

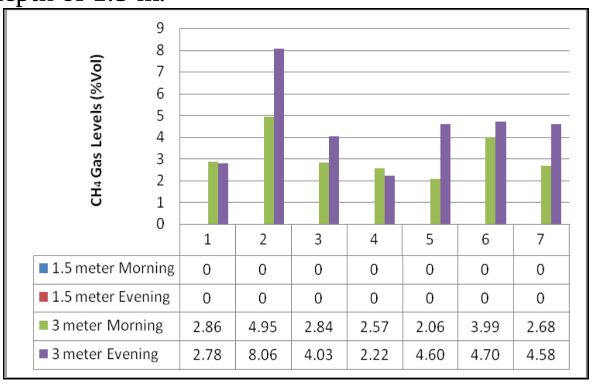
The measurement of CH_4 gas content in Klotok I Landfill was performed at three points in each cell. Pipes were planted at depths of 1.5 m and 3 m. The pipe used in this research is a type of High Density Polyethylene (HDPE) PVC pipe with a diameter of 4 inches. The CH_4 gas level measurement in Klotok II Landfill was done at three points of CH_4 gas collection pipes. The main pipe was cut and then connected with other pipes. Data collection points of CH_4 gas in Klotok II Landfill were determined by the age of waste in each cell.

3. Result and Discussion

3.1 CH_4 Gas Content From Waste Pile At Klotok I Kediri

This research was conducted at Klotok Landfill Kediri with six points of data collection, three points in Klotok I Landfill and three points at Klotok II Landfill. The measurement of CH_4 gas was done conducted in a day; morning and evening. Klotok I Landfill is a passive zone of landfill that has been functioning since 1992. Klotok I Landfill consists of three cells with each having different ages, characteristics of piles, and area. Cell 1 is a cell that has the oldest waste piles of ± 13 years of age with an area of 0.83 ha. Cell 2 that is as wide as 0.62 ha contains dump that is approximately eight years old. The cell with the youngest waste pile at Klotok I Landfill Kediri is Cell 3, which is more or less five years of age with the width of 0.65 ha.

CH_4 gas is still produced in Cell 1. This is due to the decomposition process of waste (organic material) by microbes (bacteria) at a depth of 3 m, contrary to the depth of 1.5 m which has no CH_4 gas. The time required by the (methanogenic) bacteria to form CH_4 in degradation is longer than aerobic bacteria and facultative anaerobic bacteria [10]. The condition that exists in this cell revealed that there were many pipes that collected CH_4 gas, indicating that there was a previous harvest. This indicates that there is a new waste piling process in Cell 1, causing no production of CH_4 gas at a depth of 1.5 m.



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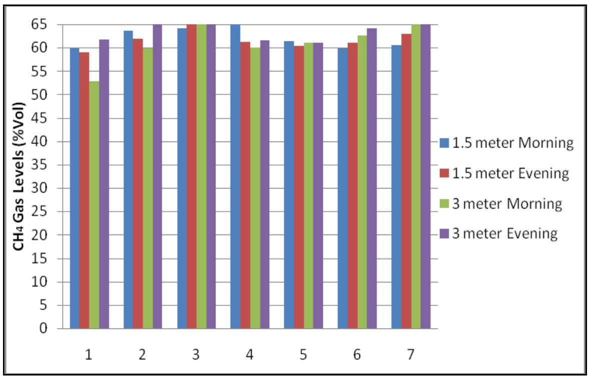

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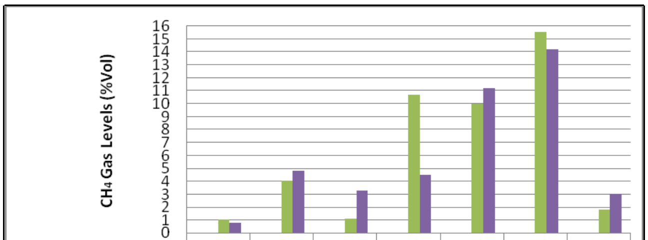


	1	2	3	4	5	6	7
1.5 meter Morning	0	0	0	0	0	0	0
1.5 meter Evening	0	0	0	0	0	0	0
3 meter Morning	1.04	4.03	1.10	10.66	10.00	15.57	1.84
3 meter Evening	0.78	4.84	3.28	4.50	11.18	14.19	3.05

(c)

4 4 4

Figure 1. CH gas content at Klotok I Landfill (a) CH gas content in Klotok Cell 2 (b) CH gas content in Klotok I Cell 3 (c)

CH_4 gas is abundantly produced in Cell 2 due to the process of waste decomposition (organic matter) by microbes in anaerobic conditions [3]. CH_4 gas formation in the landfill was affected by the degradation of organic matter from other waste in the landfill [7]. The observation point at Cell 2 was located not far from Cell 3 that was currently receiving a new pile of waste. New waste piles in Cell 3 indirectly affected CH_4 gas that was produced in Cell 2. The gas production would be restricted for a while due to the cell covering [8]. The gas level of CH_4 can be considered high in Cell 2. This is also caused by the absence of gas harvesting process that is done on full extent. In addition, there are still not many CH_4 gas catcher pipes that was installed. The condition indicates that the process of gas harvesting was not. As a result, the unreleased CH_4 gas content was still high.

The absence of CH_4 gas content at 1.5 m depth can be caused by various factors, including the physical condition of the environment such as abiotic factors; temperature, and soil pH balance that did not support methanogenic bacteria to grow. Methanogenic bacteria are activated at an environmental temperature of 30ºC-50ºC, while the optimal temperature in CH_4 gas formation in landfill is between 30ºC - 45ºC [9]. In addition, the absence of CH_4 gas at a depth of 1.5 m can also be caused by its volatile nature in the ambient air, so the CH_4 gas that is formed on the top layer of waste landfill will easily evaporate and disappear [3].

The fluctuating CH_4 gas level in this cell that becomes suddenly high on the 6th observation was due to the waste reaccumulation. At the time of observation, there was a recent piling activity in Cell 3 for about 2 weeks. This activity certainly affected the existence of organic materials, environmental conditions, and the decomposing microorganisms, thus affecting the production of CH_4 gas. Some of these conditions are shown in Figure 2.

(a) (b)

Figure 2. (a) Cell 3 condition at Klotok I Landfill with newly accumulated waste and (b) the height of waste pile during the measurement of CH_4 gas in Cell 3.

3.2 CH_4 Gas Content Taken From The Waste Pile At Klotok II Landfill Kediri City

Point 1 of the CH_4 gas content measurement was in Cell 2 of Klotok II Landfill with the waste pile aged approximately six months. The second point of data collection was in Cell 1 of Klotok II

Landfill with waste pile that ages approximately three months old. The cell with the most recent waste pile was Point 3, aged about one month.

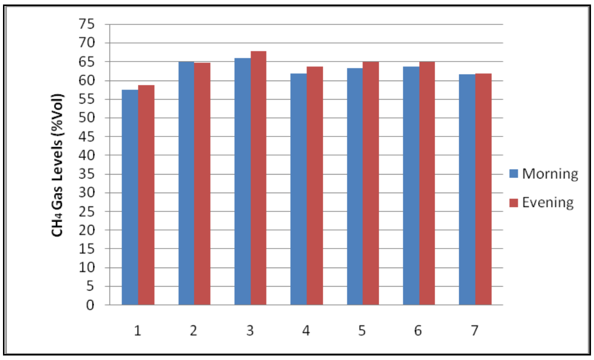
CH_4 gas production in a landfill is affected by the process of waste degradation by bacteria [7]. Under certain conditions, such as different waste compositions, pH, and unsuitable temperature of the waste pile. Hence, the process of waste degradation at the stage of acidogenesis requires more time. This will lead to CH_4 gas production that will decrease initially and will increase eventually with the passage of time, following degradation process at the methanogenesis stage [7].

According to Fig. 3, it can be seen that the average CH_4 gas content that was produced per day in Cell 3 Klotok II Landfill of Kediri was approximately 19.76 ± 17% volume. Point 3 in Klotok II Landfill was aged approximately one month old. This waste pile was considered as the newer one. The final waste collection process at this point was performed around one month prior to the observation. This disabled the process of waste degradation to be done optimally and caused an unstable production of CH_4 gas as the result of organic waste decomposition process by microbes [10].

Based on Figure 3, in Klotok I Landfill, there was still a high level of CH_4 gas production in Cell 2 that was almost as large as in Klotok II Landfill. Therefore, CH_4 gas was still potentially harvested in this landfill passive zone. This caused the waste degradation process at Klotok I Landfill to be not optimal, enabling the production of CH_4 gas as a result of organic waste decomposition [10].

At Klotok II Landfill, there was a process of CH_4 gas production with different levels at each observation point. What influenced this was the age of the waste pile [11]. Under certain conditions, such as different waste compositions and mismatching pH and temperature of the waste pile. Hence, the process of waste degradation at the stage of acidogenesis required more time. This would lead to CH4 gas production that would decrease initially and eventually increase along with the passage of time of the degradation process at the methanogenesis stage [7].

Klotok Landfill of Kediri City, especially Klotok II Landfill, has a high level of CH_4 gas. This condition, if not managed and utilized properly, may cause serious damage to the environment, as well as global warming. CH_4 gas has a very high potential to be utilized as alternative fuels, such as the fuel for household stoves that have been applied in small areas around Klotok Landfill.



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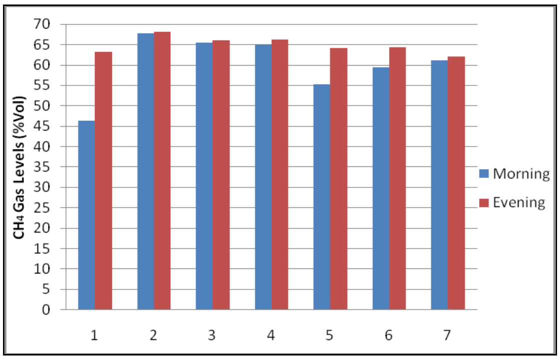

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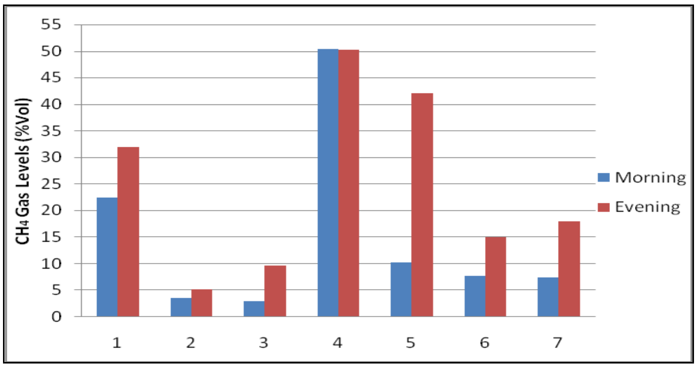

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Figure 3. (a) CH_4 gas levels at Klotok II Landfill Point 1, (b) CH_4 gas levels at Klotok II Landfill point 2, (c) CH_4 gas levels at Klotok II Landfill point 3.

Every 6-8 m^3 of CH_4 gas that emitted from garbage entering Sumur Batu Bekasi Landfill can be used as alternative fuel to operate stoves for 15 hours [3]. If the average daily use of the stove is 4 hours, the Klotok Landfill in Kediri is able to produce alternative fuel as a renewable energy source that can be used for 3,400 hours or about ± 9 years. In the long term, CH_4 gas has the potential to be used for renewable energy. The use of this renewable energy also serves as the application of environmentally friendly technology in order to prevent damages and negative impacts on the environment (green technology).

4. Conclusion

The average of CH_4 levels at Klotok I Landfill on three points of measurement at Cell 1, Cell 2, and Cell 3 were (1.8 ± 0.71); (62.46 ± 3.19); and (3.07 ± 2.65) % Vol, respectively. The highest CH_4 levels at Klotok I Landfill was in Cell 2, which was almost similar to Klotok II Landfill. The CH_4 levels in each measurement points 1, 2, and 3 in the Klotok II Landfill were (63.21 ± 2.61); (62.46 ± 4.70); and (19.76 ± 17) % Vol, respectively. The highest CH_4 levels at Klotok II Landfill was in Point 1. A high CH_4 levels at Klotok Landfill Kediri City can be utilized as an alternative fuel for renewable energy source appropriate with the concept of green technology.

5. Acknowledgment

The writers express their gratitude to the Solid Waste and Environmental Technology Team, Environmental Science and Technology Program, Department of Biology, Faculty of Science and Technology, Airlangga University; Research Team of State University of Malang, Robot Laboratory; Klotok Landfill Kediri; and Environment, Cleanliness, and Urban Planning Office of Kediri City that has assisted this research.

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