Bio-drying Technology of Solid Waste to Reduce Greenhouse Gas

by Badrus Zaman

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Badrus Zaman[1*], Wiharyanto Oktiawan[1], Mochtar Hadiwidodo[1], Endro Sutrisno[1], Purwono[2]

[1]Department of Environmental Engineering, Faculty of Engineering, Diponegoro University, Semarang - Indonesia
[2]The State Islamic Institute of Surakarta-Indonesia

Abstract. Bio-drying technology is a solid waste treatment with a decentralized system, in which solid waste will undergo biological-mechanical bioconversion. The heat generated from the aerobic decomposition process of organic compounds combined with excess air serves to drain solid waste. The bio-drying process will emit VOCs and other gases that potentially cause global warmings such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) gases. The research method used variation of airflow from 0, 2, 3, 4, 5, and 6 l/m. N_2O gases were analyzed using Chromatography gas. The results showed that the bio-drying process was able to reduce the water content from 69% to 40% by the thirtieth day. N_2O concentration difference between control (no aeration) and waste with bio-drying processing is 534.69 ppb and 175.48 ppb respectively at 1st day. N_2O concentration are known when the bio drying process uses a 4 l / m discharge.

Keywords: **bio-drying ; N_2O ; global warming;greenhouse gas; solid waste**

1. Introduction

Urban population growth is positively correlated with increased production of biodegradable solid wastes which inhibit management for negatives such as odor and pollution, soil, air, and gas [1]. Landfill and combustion methods are currently not optimal. Other places (TPA) are getting smaller, alternative placement of new landfill will be difficult and expensive. According to (Scheutz et al., 2014; Tom et al., 2016) gas emissions from landfills of approximately 40-60% consist of methane (CH_4), and the remainder is largely carbon dioxide (CO_2). If not properly managed, it has the potential to explode and become a strong environmental threat because CH_4 is a powerful greenhouse gas (GHG).
Waste management technology that is interesting in recent years is biodrying (Biological drying) where waste will undergo mechanical-biological bioconversion [2]. The amount of solid waste that will enter the landfill will be reduced significantly and increase the amount of waste that is recycled by separating materials (iron, glass, and non-metal) that are not completely separated [3]. Bio-drying (biological drying) is an automatic and natural heating process, in which the drying process is reinforced by biological heat released at the on-site decomposition of organic matter. Therefore, Bio-drying becomes an attractive alternative to treating solid waste [4].

In the biodrying process, volatile organic compounds (VOCs) will be released into the air such as chlorine, foul-smelling compounds (sulfur), terpenes, aromatics, and ketones. This VOC is one of the main problems with air pollution [5]. [6] also compared emissions of non-methane organic compounds in aerobic and anaerobic conditions. According to He, 2010 at the beginning of the biodrying process, sulfur compounds and terpenes were mostly released into the air, while aromatic compounds and ketones were emitted later during the biodrying process. .
According to published literature it is rare to find research discussing the potential of the biodrying process for global warming. Global warming is an increase in the average temperature of the earth's surface due to excessive concentration of greenhouse gases. Global warming is caused by increased emissions of gases such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and chlorofluorocarbons (CFC) or so-called GRK / GHGs so that solar energy is trapped in Earth's atmosphere [7]. Among the GHGs, N2O gas has a glabal warming potentian (GWP) value of 234 times greater than CO2 gas.
Thus, in this research, Bio-drying process is done to treat solid waste using Bio-drying technology which is focused on the analysis of greenhouse gas emission of dinitrooksida (N2O).

* Corresponding author: badruszaman2@gmail.com

2. Method

2.1. Characteristics of solid waste

Solid waste samples used in this study came from the residential complex KORPRI, Tembalang, Semarang, Central Java, Indonesia with coordinates -7.061131, 110.446709. Component of solid waste consists of waste kitchen (food waste), paper, plastic, metal and others according to existing solid waste. This solid waste is sorted first to determine the percentage of each component (%).

2.2. Research monitoring

Temperature parameters are recorded every 15 minutes. The temperature measurements use a waterproof stainless steel temperature sensor with a precision of 0.01 oC. Recorded data will be stored in SD Card in xlsx format. Temperature range between -50 °C to 200 °C. The sensor probe is placed at the top, center and bottom of the reactor, and the average value is recorded.

2.3. Sampling and analysis methods

During the Bio-drying study, water content parameters were analyzed on a daily basis. Water content is measured using gravimetric method. 20 g samples were collected from three different depths (upper, middle and lower) and mixed for triplo triplo (triple) water analysis with standard deviation set <5%. The N_2O gas was analyzed using Shimadzu 14A capillary gas chromatograph equipped with FTD at 250 ° C. Limit of Detection N_2O: 39.22 ppb. Greenhouse Gases (GHG) sampling is conducted at the highest temperatures.

3. Results and discussion

3.1. Composition of solid waste

The solid waste composition used in this study is shown in Table 1. The composition illustrates the diversity of community activities in the sampling location. Based on Table 1 can be seen that the percentage of leaves (49.98%) most compared to other types of waste. Plastic waste has the lowest percentage of 8.64% (w / w). The water content after solid waste is mixed and then regulated by increasing the water up to 69%. Water content management aims to evaluate the performance of Bio-drying to treat solid waste with high water content.

Tabel 1. The composition of solid waste originating from Tembalang KORPRI Housing complex, Semarang (w / w)

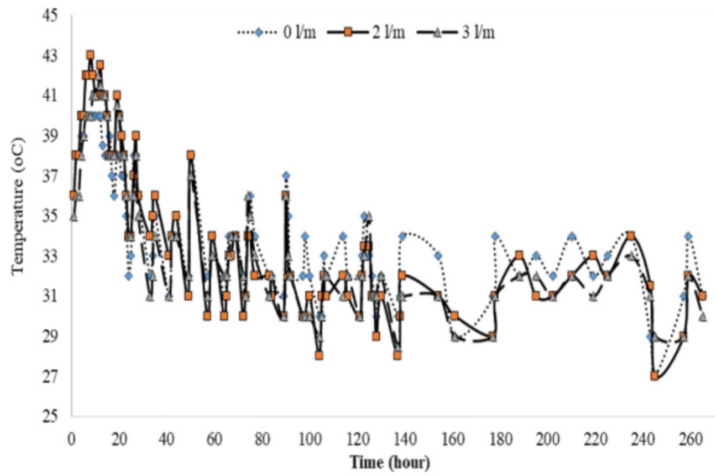
No	Type of solid waste	Water content (%)	Percentage (%)
1	Leaf	13,3	49,98
2	Food waste	32,3	10,59
3	Paper	11,3	4,26
4	Plastic	12,1	8,64

3.2. The temperature of the solid waste

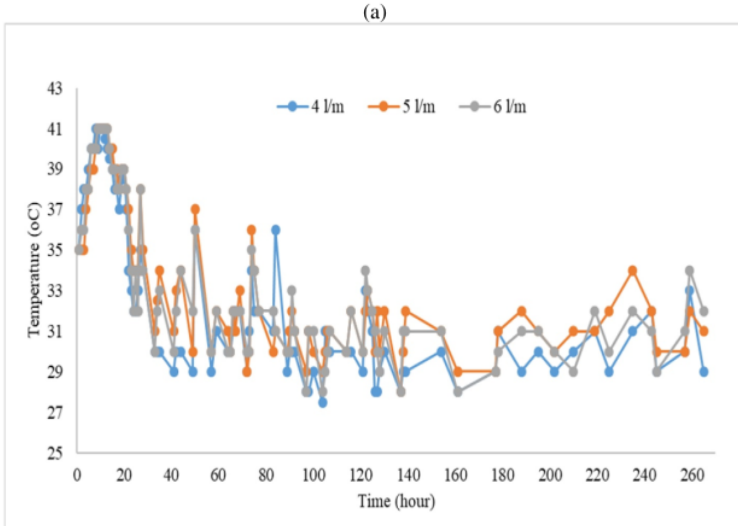
The temperature of solid waste during Bio-drying process is shown in Fig. 1. The maximum temperature of the solid waste in the early process of bio-drying at 36°C. Including temperature high enough for the solid waste hydrolisis process is carried out first before the Bio-drying process. This is according to research [8], which states hydrolysis aims to accelerate the leaching so that the allowance of water in solid waste faster. The temperature continues to increase and peak at the 12th hour of 42,5°C. The temperature of the reactor is achieved by Bio-drying with aeration flow 3 l / min. The increase in temperature is a result of the decomposition of organic compounds such as amino acids, glucose, organic acids etc. [9]. The compounds are easily metabolized and mineralized by heterotrophic bacteria. Metabolic activity and high exothermic process that increases the temperature of solid waste at the Bio-drying process. For example catabolism reactions in the bacterial cells. decomposition of glucose ($C_nH_{2n}O_n$) on aerobic conditions release heat of 896 kJ as the following reaction:

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O\ \square G^o = -\ 2{,}872\ \text{kJ}$$
(heat)

The maximum temperature is categorized mesophilic (30^0C-45^0C). Hours 42^{nd} until all 110 decline tended to be stable at a temperature range of 39-36 °C. According to [10] bio-drying temperature decrease which gradually is an indication that the activity of microorganisms is going well. When the temperature dropped dramatically indicating the process fails.



(a)

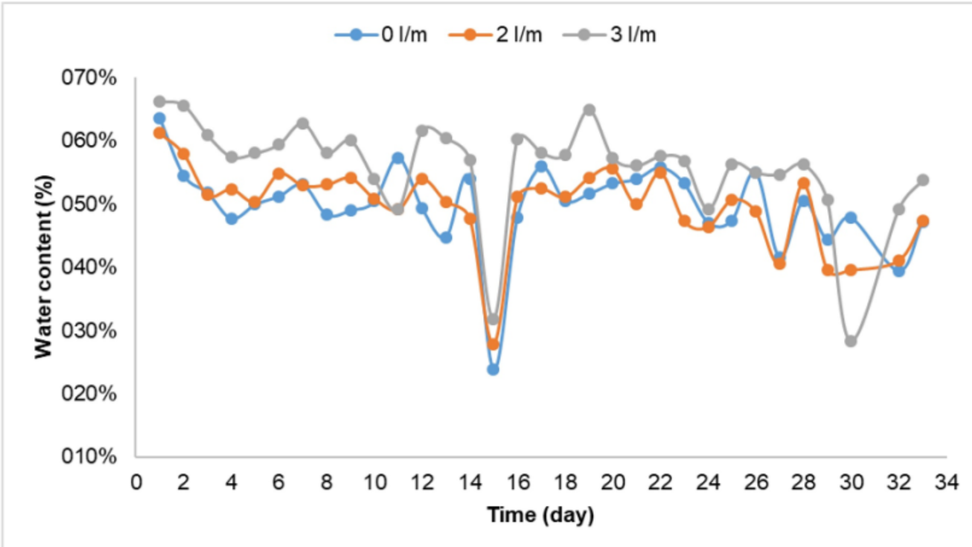


(b)

Fig. 1 Solid waste temperature profile during the Bio-drying process observed per 15 minutes for different air flow variations. (a) air flow 0 l / m, 2 l / m, 3 l / m and (b) 4 l / m air discharge, 5 l / m, 6 l / m.

3.3. Water content

Water content indicates the amount of water content present in solid waste. The solid waste water content is regulated by adding water to the moisture content of the solid waste mixture by 69%. Water content management aims to evaluate the performance of Bio-drying to treat solid waste with high water content. The results of MSW solid waste water content are shown in fig. 2. Based on the measurement data of water content on the first day until the thirtieth, the water content of reactor 1 to reactor 6 has decreased regularly. The Bio-drying process can decrease the water content from 69% to 40% by the thirtieth day. The solid waste water content is not homogeneous throughout the reactor. The bottom tends to be drier than the top. According to [8] the lower garbage is drier than the top. Rubbish at the top is wetter because the water vapor carried by the airflow will condense the top of the rector and reenter into the reactor. The success point of Bio-drying is no leachate at all (zero leachate).



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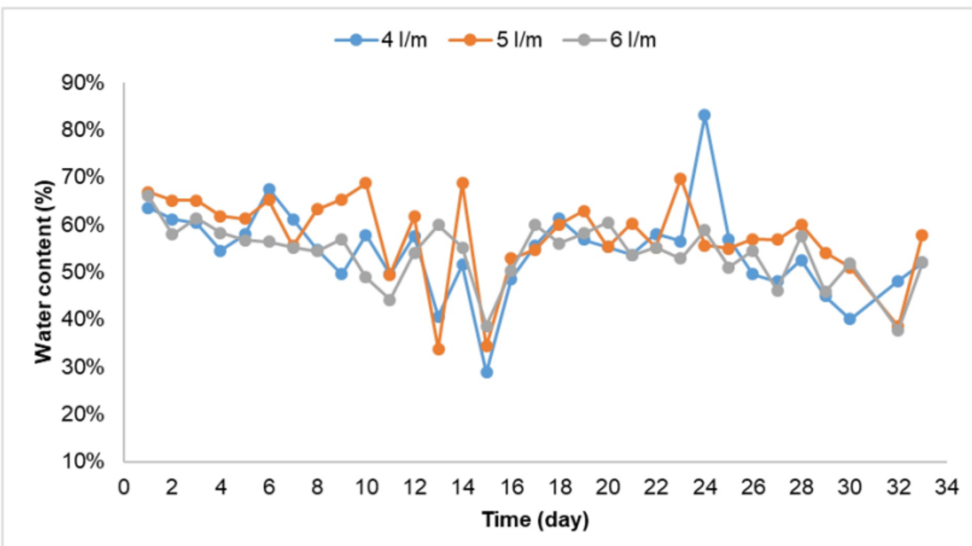

(b)

Fig. 2 Graphic reduction of solid waste water content during the Bio-drying process observed per day for different air discharge variations. (a) air flow 0 l / m, 2 l / m, 3 l / m and (b) 4 l / m air discharge, 5 l / m, 6 l /.

3.4. *N_2O* emissions during the bio-drying process

Air emissions are measured to determine the impact of solid waste Bio-drying processes on greenhouse gas-causing gases, especially N_2O gas. The measurement of the gas is carried out at 1st day and when the temperature reaches its peak (42,5^{o}C). The result of N_2O gas emission measurement is shown in fig. 3.

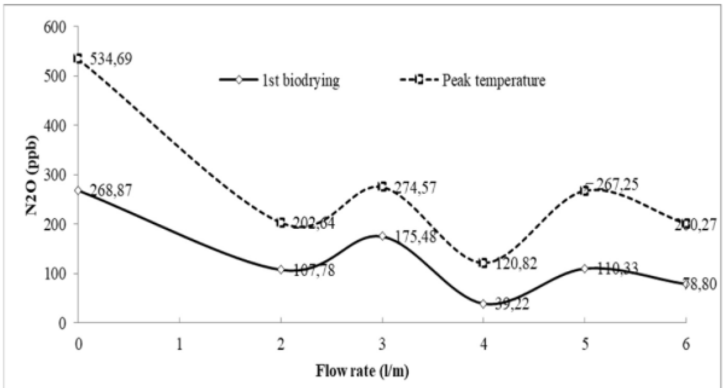

Fig. 3 Graph of N_2O content (ppb) at 1st day and when temperature reaches its peak

N_2O concentration difference between control (no aeration) and waste with bio-drying processing is 534.69 ppb and 175.48 ppb respectively at 1st day. Concentration of N_2O levels are known when the bio-drying process uses a 4 l / m discharge. The decomposition process (without Bio-drying as well as Bio-drying) produces greater N_2O emissions in the event of peak temperature (Thermofilik). According to [10] nitric oxide emissions are generally higher during thermophilic composting. Nitrous oxide emissions as a by-product of microbial metabolism during nitrification and denitrification. Nitrification involves the oxidation of ammonium to nitrate. The heterotrophic nitrification process, which contributes to N_2O emissions.

4. Conclusion

Greenhouse gas emissions such as N_2O are proven to reduce the use of bio drying technology. The conclusion of this study is the difference in N_2O concentration between control (without aeration) and waste with bio-drying processing were 534.69 ppb and 175.48 ppb respectively on the first day. N_2O concentration is known when the bio-drying process uses a 4 l / m discharge.

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References

1. Burton, C.H., Turner, C., Manure Management Treatment Strategies for Sustainable Agriculture, second ed. Silsoe Research Institute (2003).
2. Rada, E. C., Ragazzi, M., V. Panaitescu. MSW bio-drying: an alternative way for energy recovery optimization and landfilling minimization, *U.P.B. Sci. Bull.,* Series D, Vol. 71, Iss. 4, (2009)
3. Negoi, R. M., Ragazzi, M., Apostol, T., Rada, E. C., & Marculescu, C. Bio-drying of Romanian Municipal Solid Waste: An analysis of its viability. *UPB Sci. Bull. Serie C, 71*, 193-204. (2009).
4. Tom AP, Pawels R, Haridas A. Biodrying process: A sustainable technology for treatment of municipal solid waste with high moisture content. Waste Manag. 49:64-72 (2016). doi: 10.1016/j.wasman.2016.01.004
5. He, P J, Shao L M, Qu X, Li G J, Lee D J. Effects of feed solutions on refuse hydrolysis and land fi ll leachate characteristics. *Chemosphere,* 59(6): 837–844. (2005).
6. Staley B F, Xu F X, Cowie S I, Barlaz M A, Hater G R, Release of trace organic compounds during the decomposition of municipal solid waste components. *Environmental Science & Technology*, 40: 5984–5991. (2006).
7. Muhi, A.Hanapiah. Pemanasan Global (Global Warming) (Skripsi). Institut Pemerintahan Dalam Negeri (IPDN). Jatinangor. (2011).
8. Kutzner HJ, Microbiology of composting. in: *Biotechnology* (Rehm HJ, Reed G. eds.) *Vol. 11c: Environmental Processes III*, pp 35–100, Weinheim (2000): Wiley-VCH
9. de Bertoldi, M., Vallini, G., Pera, A. The biology of composting: a review. *Waste Manage. Res.* 1, 157–176. (1983).
10. Paul A. Roelle, Viney P. Aneja. Nitric oxide emissions from soils amended with municipal waste biosolids. *Atmospheric Environment.* 36 137–147 (2002)

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