Utilization of non-woven geotextile as insulation on bio-drying reactor

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Abstract. All Utilization of municipal solid waste into fuel requires a pre-treatment process to decrease the moisture content in the solid waste. Bio-drying is a drying method that utilizes microbiological activity of aerobic bacteria to increase the calorific value by decreasing the moisture content in municipal solid waste. The temperature formed in the bio-drying reactor maintained so that the drying process runs effectively by using good insulation. In this research use of nonwoven geotextile as insulation with 600 gsm based polyethylene terephthalate (PET). PET became from a recyclable plastic bottle waste that has low conductivity properties so it is expected to maintain the temperature conditions inside the bio-drying reactor. The results showed that this insulation can reduce moisture content was 51% to 18% and volatile solid loss 86% to 78% for 25 days drying process. Application of nonwoven geotextile insulation is expected to be a solution in the development of bio-drying so that the utilization of bio-drying as solid waste pre-treatment to refuse derived fuel (RDF) can be developed in Indonesia.

1. Introduction
The growth of municipal waste, especially waste generation becomes a very serious problem for developing countries [1]. In 2016, Indonesia produces 24.4 million tons of waste per year, an increase of 13 million tons of garbage production in 2017 to 38.5 million tons [2]. Large waste growth every year will reduce the capacity and carrying capacity of landfills (TPA). Utilization of waste by using thermochemical technology is one alternative to help reduce the amount of waste that goes into the landfills. The heat generated from this waste combustion reaction is then used to run turbines that are converted into electrical energy. Utilization of solid waste into energy sources referred to as refuse-derived fuel (RDF). RDF is waste that has been processed so that the calorific value can reach an average of 4,335 kcal/kg and the moisture content is below 20% [3]. Parameters that affect RDF quality such as particle size, chlorine levels, sulfur content, and high moisture content make garbage need pretreatment before it can be made into RDF [4]. Drying technology in general aims to reduce moisture content by using heat generated from the degradation process of microorganisms [5].

The principle of reducing the moisture content of the waste matrix through two major steps is: (1) the moisture molecules evaporate (ie, convert the phase from liquid into gas) from the surface layer of the waste into air; and (2) the evaporated moisture is transported through the matrix by the air stream and released through the air vents. In a limited amount, there will be leachate derived from a small

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portion of condensed moisture vapor [6]. The low moisture content in the drying process can increase heating value from RDF [7]. The amount of organic waste content affects the rate of decomposition or rate of biodegradable VS in the biodrying process, besides the high organic waste impact high moisture content in the city waste [8]. The decrease in moisture content is influenced by air flow rate, air vents, garbage composition, especially organic fractions that become the basic materials of the biodrying process [9]. The high temperature produced in the biodgradation process becomes the determinant of the rate of decreasing the moisture content in the drying process.

To maintain the temperature in the reactor so that the heat produced does not come out of the system, it needs insulation. The temperature at the maximum biodrying reactor reached 64.25 °C at the bottom layer of the reactor and 59 °C at the top layer of the reactor and experienced an efficiency decrease in moisture content 78.5% [10]. The high temperature produced will determine the rate of reduction of moisture content in the drying process. The temperature that can be achieved in the biodrying process is 70 °C [11]. The performance of insulation in holding temperature is highly dependent on the material used. This type of textile material is a key factor in heat retention performance. The performance in retaining heat in the textile material is highly dependent on the type of constituent fibers. The heat transfer will depend on the level of aeration and the level of heat loss in the reactor wall and the reactor cover conditions. Each material has its own characteristics in isolating heat, depending on the weight, contact with the material as well as the heat conductivity properties it possesses [12]. The factor that plays an important role in the heat transfer process of an object is thermal conductivity. Thermal conductivity is the transfer of heat through a material layer with a fixed stability proportional to the temperature and surface area. The properties of nonwoven geotextile materials have thermal conductivity constants of 0.07 W/mK - 0.83 W/mK [13]. Thus, the main objectives of this work were to test the application of geotextile non-woven base PET material became to cover insulation on the biodrying reactor to maintaining heat balance for decrease moisture content MSW feedstock.

2. Material and methods

2.1 Feedstock preparation
In this study use feedstock from organic mixture of garden waste and food waste. Feedstock weighing approximately 30 kg. The composition is 40% dried leaves, 30% green leaves, and 30% food waste for each reactor. Then all feedstock mixing by hand until the moisture appeared evenly distributed.

2.2 Setup reactor design
The reactor design -figure 1 located in the environmental laboratory at the University of Indonesia. The reactor made from styrofoam and for cover insulation use geotextile nonwoven 600 gsm and reactor without cover insulation as a blanko. The air compressor uses MultiPro Air compressor and connected with air flowmeter with aeration 0.005m³/kg sample. To take samples made sample holes in different places. The reactor was equipped with a temperature sensor to connect to an Arduino data logger. Temperature recorded every hour during a drying process. This reactor is also equipped with a leachate storage.

2.3 Initial condition
Before running the reactor, the initial conditions examine in the laboratory early content such as moisture content, volatile solid, and C/N. The reactor operation for 25 days with ventilation air flow 30 minutes on and 3 hours off. During the drying process the moisture content and volatile solid always check reguraly. Turning process will be done 2 times during the drying period. Turning is done outside the reactor to make it more homogeneous This is done to ensure that the activity of microorganisms takes place optimally. Table 1 present the initial condition data. The temperature always monitored daily with sensor probes located in the middle of a waste core.
3. Results and Discussion

In this observe a correlation of temperature rise and temperature capability reside in a reactor with decreasing daily moisture and volatile solid on feedstock. Temperature is the key parameter for moisture evaporation and organics degradation during biodrying. Figure 2 present the temperature rise that occurs during the drying process. The highest temperature increase up to 66 °C which happened at reactor 1 and the highest temperature at reactor 2 reaches a temperature of 64 °C and this highest temperature occurs on the 3rd day on each reactor. In previous research, the temperature on drying process can reach 70 °C [11]. The rapid rise in temperature is an indication of the degradation of microorganisms from organic matter as well as the release of heat [6]. This temperature rise is in accordance with previous research the food waste used in the drying process show the temperature profile without going through the lag phase process which has a low temperature, but the temperature reaches the highest point in a short duration (from day 1 to day 4.5) and the temperature slow down first stirring [14]. This decrease in temperature is due to the saturation of the microorganisms of the decomposition and the increase in substrate cavity density so that the oxygen does not flow evenly. In this condition, it is present that the temperature inside Reactor 2 can last longer in the reactor as seen from the smaller temperature drop compared to Reactor 1.

Figure 1. Reactor Design

Table 1. Initial condition feedstock.

|                       | Reactor 1 (R -1) blanko | Reactor 2 (R -2) 600gsm |
|-----------------------|--------------------------|-------------------------|
| Moisture content      | 51 %                     | 51%                     |
| Volatile solid        | 86,2%                    | 86,2%                   |
| C/N                   | 21,3%                    | 21,3%                   |
Stirring performed on days 10 and 15 make increase the reactor temperature and then decrease until the operation is complete. This stirring ensures the distribution of moisture and nutrients in the sample to be homogeneous thus increasing the activity of microorganisms [15]. Figure 3 present moisture removal during a drying process. in this research, the decrease of moisture content in reactor 2 is 33% with initial moisture content 51% to 18% at the end of period biodrying and in reactor 1 moisture removal is 30% with initial moisture content 51% to 21% during 25 days drying process. Not much different from the research done by [11] showed a decrease in moisture content from the biodrying process with an initial value of 73.0% to 48.3% after 18 days. In previous research decrease, moisture content does the same for 7 - 15 days and get moisture removal result of 25 - 30% [6].

![Figure 2](image1.png)  
**Figure 2.** The temperature profile during 25 days the drying process in the reactor  

![Figure 3](image2.png)  
**Figure 3.** Profile of moisture content decrease during 25 days the drying process in the reactor

The reduction of moisture content in the feedstock occurs due to two ways, the first reduction of this moisture occurs due to the use of moisture content by aerobic microbiological activity and secondly, the reduction of moisture content due to high temperatures. With the existence of a temperature relationship that persists in the reactor by insulation hence causes the reduction of moisture content in reactor 2 is greater than reactor 1 at the end of the drying process. This explains that the aerobic reaction of microorganisms produces heat and aeration that occurs in addition to helping to provide oxygen for aerobic activity, also helps to move the heat of heat generated into the moisture mass of the sample and turns into moisture vapor which is then helped out by the flow of air from below reactor. This causes the moisture content in the sample to decrease at the end of the reactor operation. This is in accordance with previous research that by maintaining the temperature that occurs in the reactor drying then the level of decrease in moisture content will be greater [1]. The longer time to stay in the biodrying process the greater the decrease in moisture content [10]. Figure 4 show reduction volatile solid. In this study, volatile solid reduction in reactor 1 of 17% and a decrease of a volatile solid level at reactor 2 by 8% from an initial level of 86%. The volatile solid decrease in this study is better than the previous volatile solid decrease of 25 -29 % [16]. The high degradation volatile solid determines the energy lost, otherwise, when used in slow drying process it will limit the degradation of volatile solid so that energy will be stored [9].

The highest decrease of volatile solid volume occurred on the second day to day 6. This is in accordance with previous research, in the hydrolysis phase is the active phase of degradation of microorganisms [18]. In the next phase or phase feeding microorganisms develop massively and consume the availability of easily degradable organic, so there is still a decrease in vs. levels in the garbage. Volatile solid degradation occurs because of the activity of microorganisms that use Carbon as energy and Nitrogen as the development of cell tissues [4]. The success indicator of the biodrying process is a decrease in moisture content till below 20% and the low level of volatile solid degradation so that in the final product there will be an increase in calorific value [7]. In this study the best drying process occurred in reactor 2 by using insulation because in the final product there was a decrease of
moisture content below 18% and the decrease of solid volatile content was only 8% compared to reactor 1 which did not use insulation which decreases moisture content to 21% and decreases volatile solid at 18% for 25 days.

Figure 4. Profile of volatile solid decrease during the 25 days drying process

4. Conclusions
Increasing the calorific value of waste as the final product of biodrying is a key success factor of the drying process. In this study, the use of non-woven geotextile insulation managed to maintain the temperature in the reactor so as to reduce the moisture content from 51% to 18% with a low volatile solid degradation rate of 86% to 78%. Further research on geotextile thickness optimization of the non-woven thickness will be required as an insulation to determine the optimum thickness in maintaining the heat balance in the reactor.

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