Effect of Aeration on Bio drying of Municipal Soid Wastes for Utilization as Refuse Derived fuel (RDF)

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Abstract

This research aims at transforming municipal solid wastes (MSW) into refuse derived fuel (RDF) by bio-drying. The process utilizes heat from microbial activities to remove moisture from MSW. Lysimeter experiments were performed under different aeration modes, continuous and intermittent at the same amount of air supply. Lysimeter experiments were conducted at different aeration rates of 0.1, 0.2, 0.5, 1.0 and 2.25 L/min and compared to that employing natural aeration. Different aeration modes, i.e. continuous aeration, intermittent aeration of 1 hour on and 1 hour off, intermittent aeration of 3 hour on and 3 hour off were compared over 14 day period. The experimental results revealed that 0.2 and 0.5 L /min aeration rates could promote bio-drying process resulting in homogeneous reduction of moisture content along the height of solid wastes. Meanwhile, intermittent aeration yielded higher moisture content in the upper part than the bottom part of the lysimeter. This was due to the condensation and accumulation of evaporated water at the upper part when the aeration was stopped resulting in non-uniformed reduction of moisture. Using bio-drying process, the results showed that moisture content of wastes could reduce by 40.6-94.5% yielding remaining moisture of 14.77-37.74% and 4.35-26.47% in treated wastes at aeration rate of 0.2 and 0.5 L /min., respectively after 14 days. The lower heating value (LHV) of treated wastes was 4384.83-6418.50 kcal/kg and the emissions of greenhouse gases (methane, carbon dioxide, nitrous oxide) were lowered at the aeration rate of 0.2 L /min when compared those at the aeration rate of 0.5 L /min.

Keywords: Bio-drying process; Mechanical biological treatment; Municipal solid wastes; Refuse derived fuel

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Introduction

Municipal solid wastes (MSW) has increased rapidly in the urban area where population and economic condition is growing. Majority of MSW compositions are food wastes, plastics, papers and other packaging materials and they are commonly disposed in landfills or open dumpsites. Modern waste management strategy is focusing on the avoidance of solid waste disposal by recycling or transforming them into other useful products. One option is to convert MSW into refuse derived fuel (RDF) for recovering energy from wastes. In Thailand, RDF from MSW has high potential to use in cement kilns and industrial boilers (Nithikul, J., and *et al*., 2011). Nevertheless, pre-treatment may be required for solid wastes with high moisture content before converting them to RDF. Bio-drying is one of the techniques that can remove moisture from wastes at low operating cost. The moisture reduction by bio-drying process relies on microbial activities which generates heat from aerobic decomposition of organic wastes. The produced heat is then utilizes in evaporation of water and the water vapor is transported from the waste matrix by the air flow (He, P., and et al., 2013). In order to have effective bio-drying process, the amount of supplied air should be optimized in order to preserve organic matter in the wastes while allowing bio-drying to proceed utilizing heat released from aerobic microbial activities under limited air supply without allowing significant loss of heat through convective air flow. In this study, we investigate the effect of aeration on bio-drying of MSW in laboratory scale lysimeter experiment.

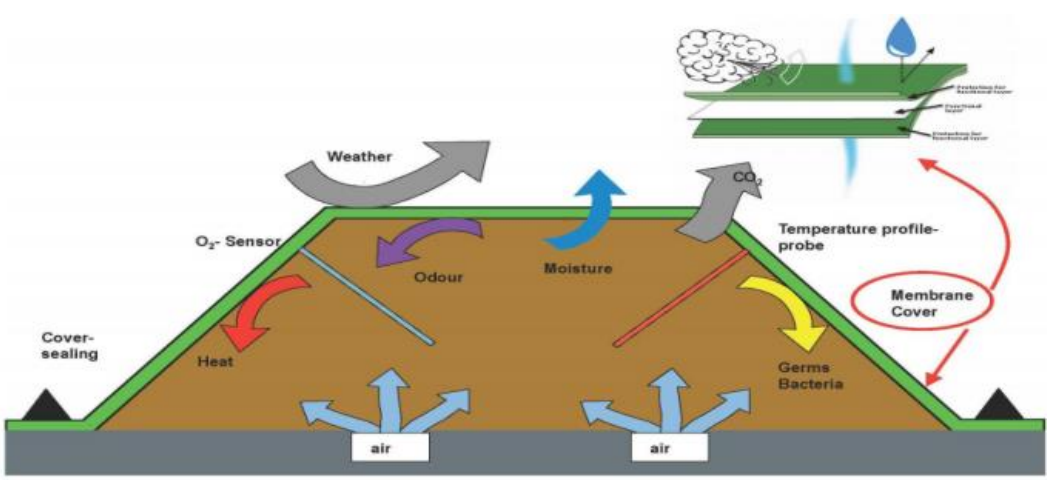


Figure 1 Cross sectional of biodrying process
From http://www.mmthailand.com

Materials add Methods

Laboratory scale lysimeter having 0.30 m diameter and 1.50 m height dimension were used (Figure 3). The lysimeter was equipped with moisture and temperature sensors and placed on a weighing machine. The control lysimeter was operated without aeration (only allowing natural ventilation) while the others were operated at air flow rate of 0.2, 0.5, 1 and 2.25 L/min., respectively. The lysimeter was loaded with MSW obtained from a town in Thailand at 22.0 kg equivalent to 325 kg/m^3 density.The Characteristics of east show that table 1 The lysimeter was operated for 14 days during which moisture content, temperatures and wet weight of wastes were recorded. Gas samples were collected and analyzed for CH_4 , CO_2 , O_2 , N_2O composition. At the end of experiment, the wastes were taken out from the lysimeter and analyzed for moisture, volatile matter, and ash and heating value following Standard Methods

Materials

- Biodrying Lysimeter
- MSW from Nonthaburi Provincial administration Organizations
- Gas Flow meter
- Moisture Sensors
- Thermometer Sensor
- Bomb Calorimeter, Gas Chromatography, Data Logger etc.

Table 1 The composition of waste

Composition	Wet weight (%)
Organic waste	42.53
Plastics	27.33
Papers	13.60
Rubbers	3.07
Metals	1.87
Clothes	0.53
Cement , Ceramic	0.87
Wood	2.87
Glasses	4.93
Other	2.40

Methods

1. MSW preparation collected from Nonthaburi Provincial administration Organizations by quartering method show that (Fig.2)

2. Laboratory scale lysimeter experiment (Fig.3)

The lysimeter was equipped with moisture and temperature sensors and placed on a weighing machine. The lysimeter was operated at different aeration patterns. The first time (0.2 ,0.5 ,1,2.25 L/min and Natural aeration flow) and The last operated at different aeration mode i.e.continuous mode at 0.2 L/min, intermittent mode at 0.4 L/min (1 h on/ 1 h off) and 0.4 L/min (3 h on/3 h off) respectively.

3. Parameter analysis

At the end of experiment the wastes were taken out from the lysimeter and analyzed for moisture content ,VS ,Ahs C,H,O,N and heating value , Gas samples were collected and analyzed for CH_4 , CO_2 , O_2 , N_2O composition.

Figure 2 MSW in experiment collected from Nonthaburi Provincial administration Organizations by quartering method.

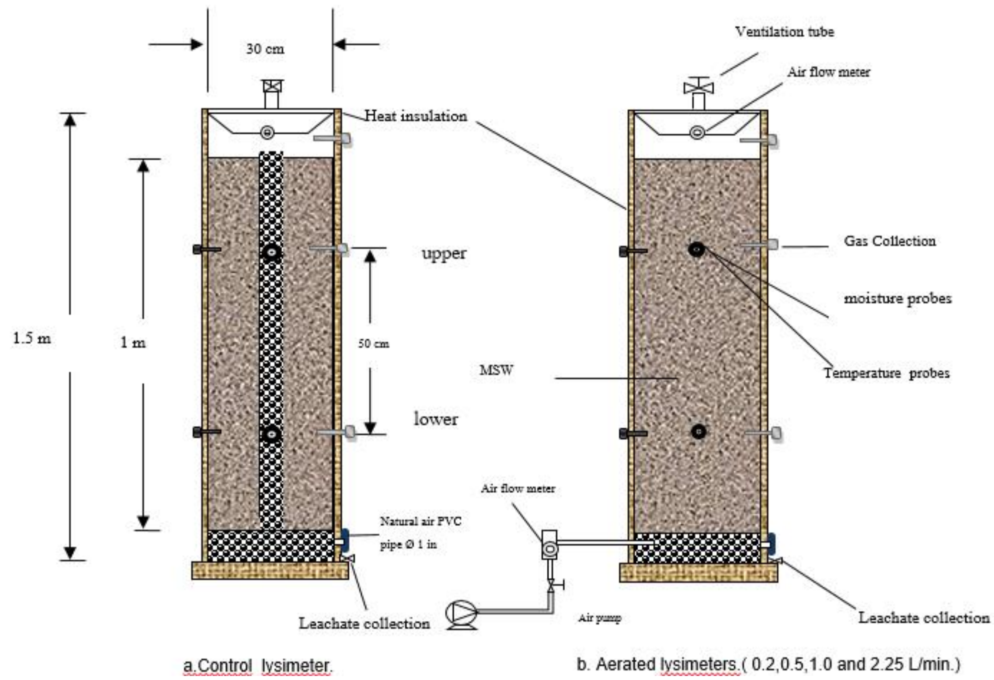
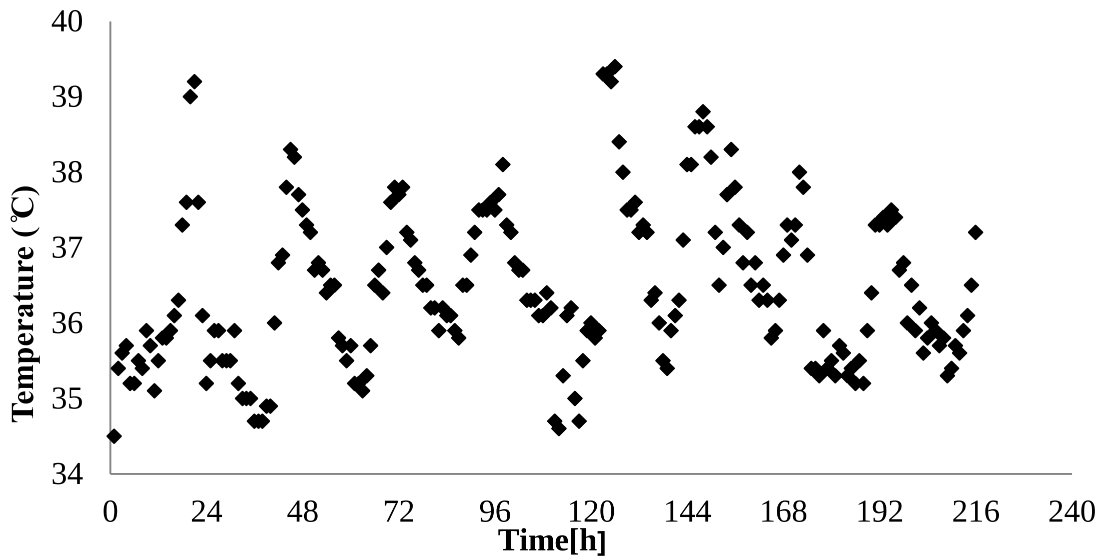


Figure 3 Schematic of biodrying lysimeter a) Control , b) Aerated.

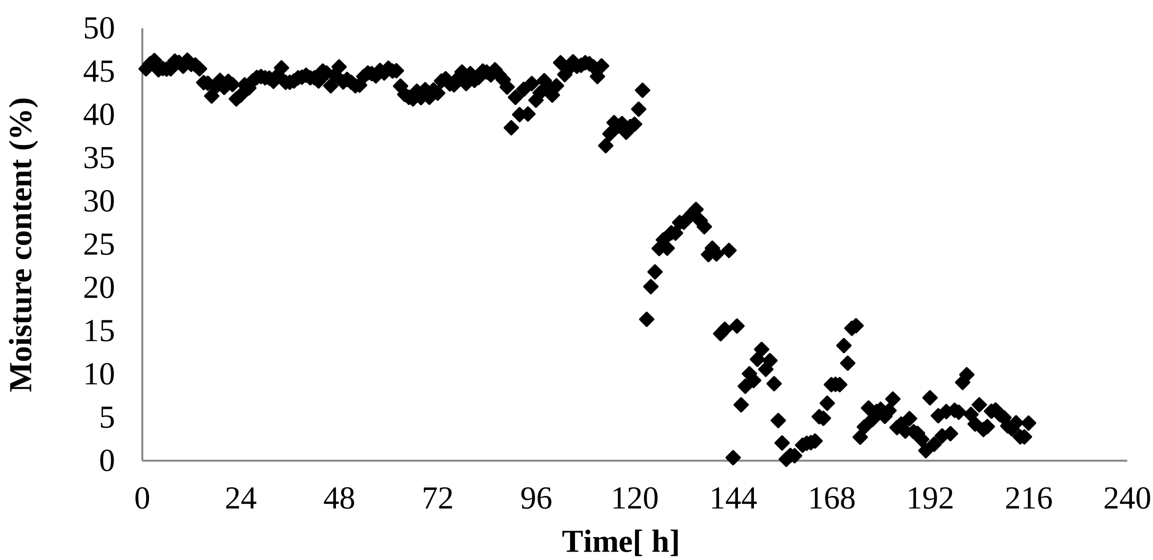
Results and Discussion

Fig.4a) and 4b) show the variation of temperature and moisture content in the lysimeter operated at an air flow rate of 0.2 L/min. It was found that the waste temperature varied mostly between 35-39 °C in daily pattern whereas moisture content in wastes decreased drastical at the 5th day and remained relatively constant after 7 days. Development of bio-drying in the lysimeter was promoted from the heat released from aerobic decomposition of organic wastes which could be developed within 5 days. Similar moisture and temperature pattern was observed in the lysimeter operated at the aeration rate of 0.5 L/min.

When the lysimeter was operated at higher aeration rate of 1 and 2.25 L/min, physical evaporation of wastes was promoted as evidenced by sudden drop of moisture content in the wastes to 20-40% on the first day and gradually declined afterwards. Similar condition was found in the control lysimeter in which the moisture gradually declined from 40% to 15% at the end of the experiment. Therfore, the experiment results suggested that the aeration rates of 0.2 and 0.5 L/min could promote biodrying condition in the lysimeter and the optimum aeration rate was 0.2 L/min in this study


40
39
38
37
36
35
34
Temperature (℃)
0
24
48
72
96
120
144
168
192
216
240
Time[h]

(a)


50
45
40
35
30
25
20
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0
Moisture content (%)
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24
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96
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168
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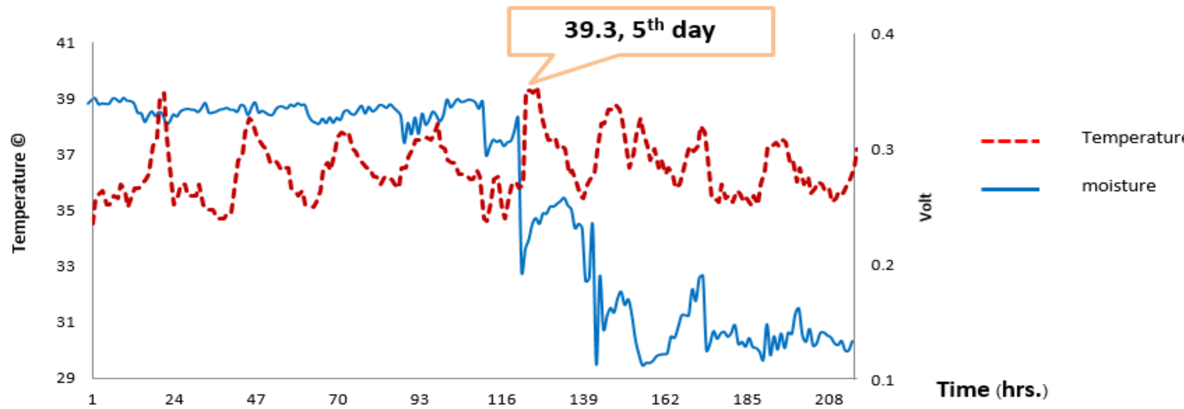
Time[h]

(b)



(c)

Figure 4 Vacation of temperature (a) , moisture content (b) & (c) of solid wastes in the lysimeter operated at air flow rate of 0.2 L/min

Table 2 shows the comparison of moisture content and heating value of wastes before and after biodrying process at different aeration rates. The moisture content in MSW could be reduced from 65.2% to 11.9-15.7% in the lysimeter. The aeration rate of 0.2 L/min yielded moisture content in treated waste (11.9%) with heating value of 4630 kcal/kg. Meanwhile, higest aeration rate of 2.25 L/min gave highest remaining heating value as the moisture loss was mainly due to physical evaporation.

Analysis of gas samples collected from the lysimeter operated at aeration of 0.2 L/min revealed lowest O_2 (15%) and highest CO_2 concentrations (initially 2-4% then increased to 10%) as compared to the other lysimeters. CH_4 was found generally at low concentration (less than 10 ppm) but occasionally peaked in the control lysimeter (up to 30 ppm). Meanwhile, N_2O was detected at lower concentration in most lysimeters among which slightly higher concentrations (up to 2.5 ppm) were detected in the lysimeters operated at higher aeration rates.

Table 2 Comparison of moisture content and heating value of wastes in the lysimeter operated at different aeration rates.

Lysimeter	Heating Value(kcal/kg wet wt.)	Moisture content (%)
Before biodrying	3361	65.2
Control	4258	15.7
0.2 L/min	4630	11.9
0.5 L/min	4748	13.9
1 L/min	5226	12.5
2.25 L/min	6105	14.1

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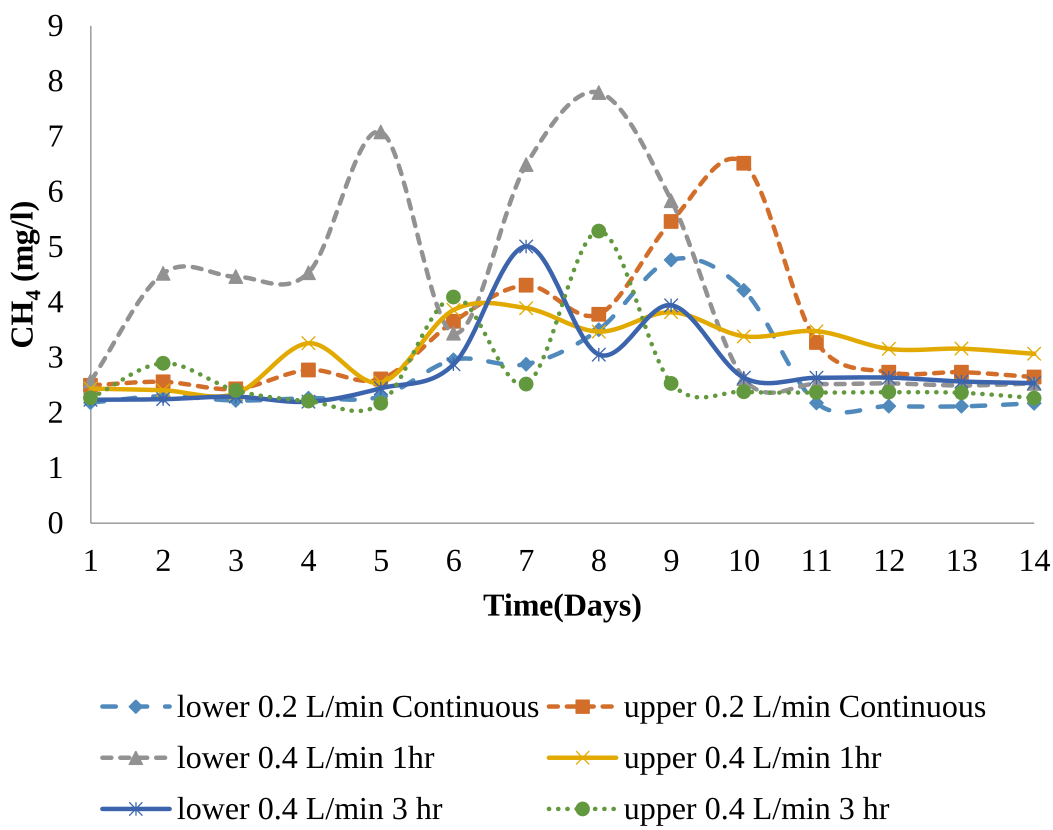

Figure 5 Methane concentration of different aerated mode at 14 days

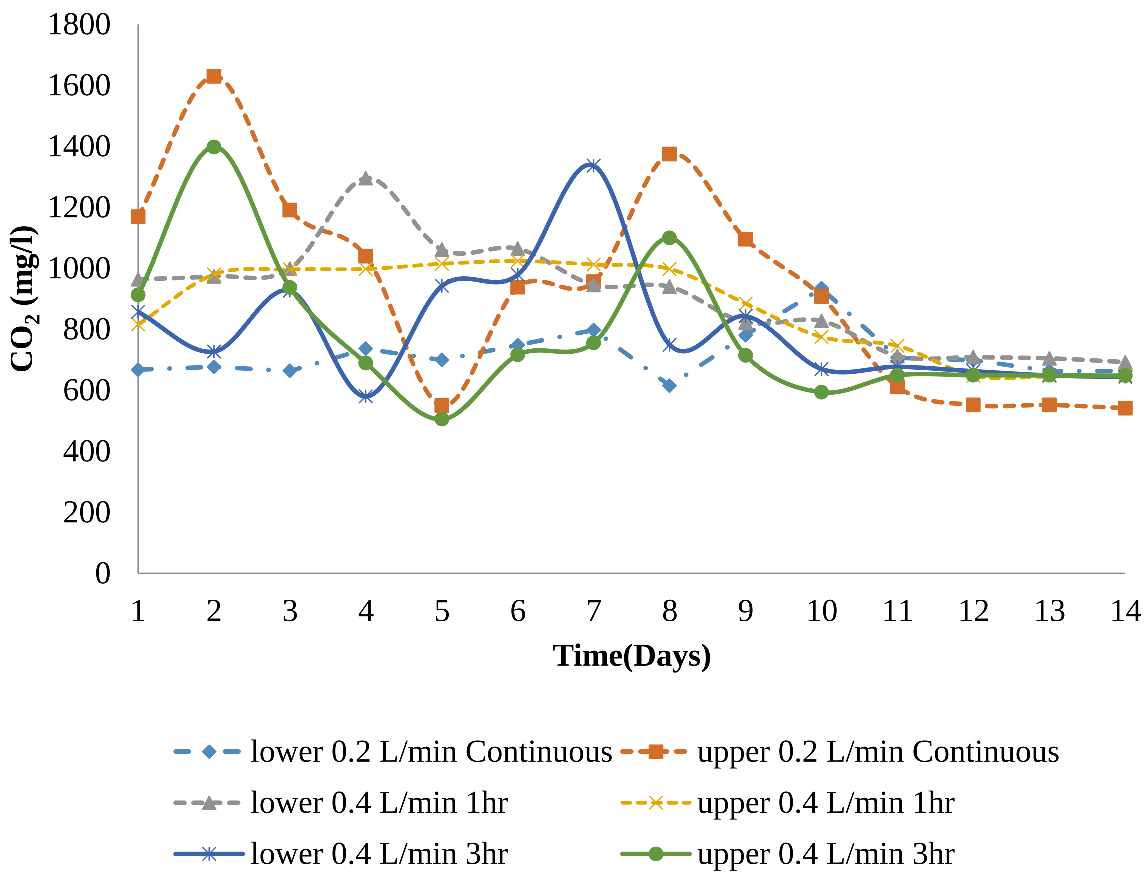

Figure 6 Carbon dioxide concentration of different aerated mode at 14 days

Conclusion

Bio-drying of MSW could be successfully developed in the lysimeter operated at aeration rates of 0.2 and 0.5 L/min. The lysimeter operated at continuous aeration of 0.2 L/min yielding treated MSW with moisture content of 18.2-18.5% .Calorific value of 4,573-4,845 kcal/kg. Meanwhile, intermittent air supply produced inconsistent bio-drying of MSW due to condensation of moist vapor.

The continuous aeration at 0.2 L/min is prospering air volume and easily operate. This MSW that was operated by bio-drying process became dried within 5^{th} -7^{th} day without prolong operation. Heat generated from aerobic decomposition could reduce moisture content from 65.2% to 11.9% within 7 days at the air flow rate of 0.2 L/min yielding treated wastes with heating value of 4,630 kcal/kg.

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