ORGANIC WASTE’S POTENTIAL AS RENEWABLE ENERGY AT SUPIT URANG LANDFILL IN MALANG CITY

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ABSTRACT
This research are to know the correlation of the number of population with the amount of waste in Malang city and biogas potential at Supit Urang landfill. Then also counting the percentage of biogas which has been used as gas fuel by citizens around the landfill and as electrical energy potency. The average amount of waste in Malang city is 410,45 ton per day. Organic waste composition at Supit Urang landfill is 64,9% or in the average it’s about 137.989,57 kg per day. From that amount, the average of biogas which is produced is 19.146,57 m³ per day or about 574.397,05 m³ per month. Biogas utilization is for fuel gas by 408 houses near the location of that landfill, that’s about 18.385,19 m³ per month or about 3,2%. Therefore that’s still has 96,8% biogas potential or about 556.011,86 m³ per month which has not been utilized yet. That potency can produce electrical energy 2.613.255,75 kWh per month or 3.63 MW. If the average efficiency level of conversion from biogas to electricity is 35%, the electric potential become 914.639,51 kWh per month or as big as power station with energy 1,27 MW.

Keywords: waste, global warming, greenhouse gas emission, biogas, renewable energy.

INTRODUCTION
Population growth will cause an increase in the amount of waste. If not anticipated with the right waste management, it will cause various problems. As the heaping of waste at landfill can cause environmental problems, that are vegetation damage, water pollution by leachate, air pollution by unpleasant odors, risk of asphyxiation risk of explosion and combustion, and greenhouse gas emissions (Popov, 2005 in Abreu, et al, 2011). Greenhouse gas emissions like carbondioxide gas (CO₂) and methane gas (CH₄) emit to the atmosfer so can cause ozon layer getting thinner and thinner. Accordingly there will be an increase in the earth temperature known as global warming.

The main contributor to the greenhouse effect is methane emission from landfill (Scharff and Jacobs, 2006). Methane gas emission 21 times more dangerous than CO₂ emission (Czepiel, et al., 2003). Popov (2005) in Abreu, et al (2011) explained that CH₄ and CO₂ can be generated within 20 years, but their emissions can continue for 50 years or more.

Kyoto Protocol and Waste To Energy Program support each country and government to reduce greenhouse gas emission and utilize the waste as energy source. Therefore, waste management at landfill need to be done, one of that by using the biogas which are produced as renewable energy. This purpose is to prevent greenhouse gas emission and global warming and also reduce the using of source energy from fossil like petroleum and coal.

Global warming as environmental problem has happened at all part of the world. Greenhouse gas emission has a risk of causing global warming not only from waste heap, but also as the side effect from using fossil energy. The reserve of the source of fossil energy getting decrease, but renewable energy still have great potency as be seen at Table 1.
Biogas is generated from anaerobic waste decomposition process. Chemical reaction on that process is:

\[ \text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 3\text{CH}_4 + 3\text{CO}_2 \]


Sudrajat (2006) explained that the anaerobic composting process on organic waste go through four steps, which are:

a. Hydrolysis process

In this process, there is a decomposition of polymer organic material to monomer which can easily leach and results in amino acid, volatile acid, glycerol, etc. Fat is described by lipolytic bacteria with lipase's enzyme, while carbohydrate is described by cellulolytic bacteria with cellulose enzyme, and protein is described by proteolytic bacteria with protease's enzyme.

b. Acydogensis process

In this process, there is organic monomer decomposition becoming organic acids (as format acid, acetic, butirat, propionat, valeriat) and alcohol by acidogenic bacteria. Other results from that process are \( \text{CO}_2 \), \( \text{H}_2 \), and methanol.

c. Acetogenesis process

In this process, organic acid and alcohol is changed as acetate, format, methanol, \( \text{CO}_2 \) and \( \text{H}_2 \) by acidogenic bacteria.

d. Metanogenesis process

In this process, acetate is changed as \( \text{CH}_4 \), \( \text{CO}_2 \), and \( \text{H}_2\text{O} \) by metanogenic bacteria. Nearly about 70% methane are formed from acetates, whereas the other 30% are from format acid, \( \text{CO}_2 \), and \( \text{H}_2 \).

Biogas at landfill consist of 55- 65% \( \text{CH}_4 \), 35-45% \( \text{CO}_2 \), 0-1% \( \text{N}_2 \), 0-1% \( \text{H}_2 \), and 0-1% \( \text{H}_2\text{S} \) (Polpraset, 1996 in Abreu, et al, 2011). Methane...
is the main component from biogas. On hall temperature and standard pressure, this gas is colourless and does not have bad smell. This gas is inflammable.

According to Sudrajat (2006), the composition and calor of biogas are:

- $\text{CH}_4$: 50 – 85%
- $\text{CO}_2$: 15 – 50%
- $\text{H}_2\text{S}$: < 1%
- Calor value: 20 – 25 MJ/m$^3$ ($47.0 – 8.000$ kkal/m$^3$)

**Biogas Potential Counting**

The method to calculate energy for anaerobic digestion from organic waste are (Frear, et al in Sulistyo, 2010):

\[
\begin{align*}
\text{TS} &= 27.7\% \times Q \\
\text{VS} &= 74.1\% \times \text{TS} \\
\text{VBS} &= 0.676 \times \text{VS}
\end{align*}
\]

where:
- $Q$ is waste amount (kg/day)
- TS is total solid (kg/day)
- VS is volatile solid (kg/day)
- VBS is biogas production volume (m$^3$/day)


Biogas which will be utilized as electrical energy must be treated to increase its quality and consequent energy efficiency. The stability of efficiency level can be reached by adding blower so that biogas flow can give an adequate energy (Pierpaoli and Diotallevi, 2007). Conversion of biogas to electrical energy has efficiency level 30-40% (Eurelectric, 2003).

### Table 2. Biogas Conversion, and Using

<table>
<thead>
<tr>
<th>Using</th>
<th>Energy 1 m$^3$ Biogas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>Lamp 60 – 100 watt up to 6 hours</td>
</tr>
<tr>
<td>Cooking</td>
<td>cooking 3 kinds of foods for 5 – 6 person</td>
</tr>
<tr>
<td>Energy</td>
<td>Charge 1 handphone up to 2 hours</td>
</tr>
<tr>
<td>Electricity</td>
<td>4,7 kWh electrical energy</td>
</tr>
</tbody>
</table>

Source: Suriawiria (2005) and Suhendra (2008) in Hanif (nd)

**MATERIALS AND METHODS**

Methods of this research are mix methods between qualitative and quantitative method. The location of this research at Supit Urang landfill in Malang city.

Primary data collected with questionnaire and secondary data from Hygiene and Urban Landscaping Department Malang City. Samples are used to calculate the percentage of biogas which is used as gas fuel by citizens around landfill and the biogas potential as electrical energy using slovin formula, that are:

\[
n = \frac{N}{1 + Ne^2}
\]

where:
- $n$ is sample measure
- $N$ is population measure
- $e$ is error

The number of population around Supit Urang landfill which are using biogas as gas fuel are 408 houses from 5 region that are region 3, 4, 5, 7 and 8. With 10% error, sample measure is:

\[
n = \frac{408}{1 + 408(0.1)^2} = 80.31 = 81
\]

Sample obtained with purposive stratified random sampling method of each region, that are:

### Table 3. Sample Number in Each Region

<table>
<thead>
<tr>
<th>Region</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>7</th>
<th>8</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>70</td>
<td>88</td>
<td>107</td>
<td>76</td>
<td>67</td>
<td>408</td>
</tr>
<tr>
<td>Sample</td>
<td>14</td>
<td>17</td>
<td>22</td>
<td>15</td>
<td>13</td>
<td>81</td>
</tr>
</tbody>
</table>

Source: analysis result
The analysis to know the correlation between the number of population and the amount of waste in Malang city, then the amount of organic waste and biogas potential uses SPSS version 19. Biogas potential analysis to know the percentage of biogas which are used as gas fuel, and the percentage of biogas potency as electrical energy uses Microsoft Excell.

RESULT AND DISCUSSION
Population Number and Waste Amount
Based on data from Statistics of Malang City, Malang City’s population number 2013 is 840,800 with the average of growth rate per year is 0.81%. The average of waste amount in Malang City is 410.45 ton/year.

Correlation between population number with waste amount is 0.892. This value is adequately high and significant with p-value of 0. The correlation between organic waste and biogas potential is 1. This value is so high and significant with p-value of 0 as seen at Table 4.

<table>
<thead>
<tr>
<th>Variabel</th>
<th>Pearson Correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Number – Waste amount</td>
<td>0.892</td>
<td>0.000</td>
</tr>
<tr>
<td>Organic Waste – Biogas Potency</td>
<td>1.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Source: analysis result

An increase in the number of population will cause an increase in the amount of waste. It happens because waste results from human life activity. Therefore, if the population number increase, waste amount also increase too. The increasing of organic waste cause greater biogas potential. It happens because biogas results from organic waste fermentation.

Eddine and Salah (2012) stated that the composition of MSW is closely related to lifestyle of the residents and economic development. In general, the composition of MSW in Malang City with eleven major categories of waste was identified: organics, paper and cardboard, plastics, glass, metals, textile, rubber, bones, hazardous waste, inert, and residues that can be seen at Fig 2.
Waste Management

Waste service at Malang City have reached 96.5% regions service. Meanwhile 3.5% regions is river boundary that is difficult to reach, because that regions are so steep.

Malang City have 1 landfill and 69 dumps. Malang City also have 1 waste transition station. Waste transition station is built as one of strategy to economize waste transportation which goes to landfill. Four times ritasi of waste transportation can be economized as once ritasi only, with waste condensation mechanism from waste volume about 40–50 m$^3$ become 9.2 m$^3$.

Waste are taken from dumps which are scattered at every district in Malang City. Part of that waste (from 4 districts) is transported to go to waste transition station. Meanwhile the others directly go to landfill.

Several waste management process was begun from family scale, that are sorting inorganic waste, composting, and also worm conducting. Meanwhile the residue are taken in to Supit Urang landfill. Waste at Supit Urang are flattened then condensed and buried every 1 meter. Biogas's catching pipe is placed in the already buried waste.

Biogas's Potential at Supit Urang Landfill

The average of waste amount at Malang City is 410.45 tons/day with organic waste composition at Supit Urang landfill reaching 64.9% or average about 137,989.57 kg/day. From that amount, the average of biogas resulted is 19,146.57 m$^3$/day or about 574,397.05 m$^3$/month.

In average, people utilizes biogas's stove up to 4.5 hours per day or 135,19 hours/month. If each 1 m$^3$ biogas can be utilized to cook up to 3 hours therefore biogas need for one house is about 1,5 m$^3$/day or 45,06 m$^3$/month. Biogas already being utilized by 408 houses around landfill or about 612,84 m$^3$/day or about 18,385,19 m$^3$/month. The percentage of biogas's utilization as gas fuel by citizen is 3.2%.

Therefore, there's still available biogas potential of about 556,011.86 m$^3$/month. That potential has not been utilized yet as is so big, that is about 96.8%. If that potential are used as electrical energy, with assumption 1 m$^3$ biogas has the same measure as 4.7 kWh, that biogas's potential can produce electrical energy as big as 2,613,255,75 kWh/month or about 3,63 MW. If the average of efficiency level of conversion biogas to electricity is 35%, so the electric potential becomes 914,639,51 kWh per month or as big as power station with energy 1,27 MW.
Table 5. Biogas Potency Analysis

<table>
<thead>
<tr>
<th>Year</th>
<th>TS (kg/day)</th>
<th>VS (kg/day)</th>
<th>Biogas Potency/ VBS (m³/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>41.154,72</td>
<td>30.495,65</td>
<td>20.615,06</td>
</tr>
<tr>
<td>2002</td>
<td>41.154,72</td>
<td>30.495,65</td>
<td>20.615,06</td>
</tr>
<tr>
<td>2003</td>
<td>49.148,95</td>
<td>36.419,37</td>
<td>24.619,50</td>
</tr>
<tr>
<td>2004</td>
<td>44.824,55</td>
<td>33.214,99</td>
<td>22.453,33</td>
</tr>
<tr>
<td>2005</td>
<td>36.585,53</td>
<td>27.109,88</td>
<td>18.326,28</td>
</tr>
<tr>
<td>2006</td>
<td>35.181,82</td>
<td>26.069,73</td>
<td>17.623,14</td>
</tr>
<tr>
<td>2007</td>
<td>32.761,54</td>
<td>24.276,30</td>
<td>16.410,78</td>
</tr>
<tr>
<td>2008</td>
<td>32.328,11</td>
<td>23.955,13</td>
<td>16.193,67</td>
</tr>
<tr>
<td>2009</td>
<td>31.709,49</td>
<td>23.496,74</td>
<td>15.883,79</td>
</tr>
<tr>
<td>2010</td>
<td>35.008,94</td>
<td>25.941,63</td>
<td>17.536,54</td>
</tr>
<tr>
<td>2011</td>
<td>35.192,17</td>
<td>26.077,39</td>
<td>17.628,32</td>
</tr>
<tr>
<td>2012</td>
<td>41.500,47</td>
<td>30.751,85</td>
<td>20.788,25</td>
</tr>
<tr>
<td>2013</td>
<td>40.349,43</td>
<td>29.898,93</td>
<td>20.211,68</td>
</tr>
<tr>
<td>Average</td>
<td>38.223,11</td>
<td>28.323,33</td>
<td>19.146,57</td>
</tr>
</tbody>
</table>

Source: Analysis result

CONCLUSIONS

Based on this research, it can be concluded that:

1. Population number and waste amount has high positive correlation that is 0.863 with significant level (p value) of 0. Meanwhile organic waste amount and biogas potential also has high positive correlation that is 1 with significant level (p value) of 0.

2. The percentage of biogas which has already been utilized as gas fuel by citizen is just 3.2% or about 612,84 m³/day or 18.385,19 m³/month.

3. The percentage of biogas that has not been utilized yet are still so big, that is 96.8%. If it is converted as electrical energy the biogas potential can produce electrical energy as big as 914.639,51 kWh per month or about 1,27 MW.

REFERENCES


