Jurnal Presipitasi
Vol. 12 No. 2 September 2015, ISSN 1907-187X

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 m^3 per day or about 574.397,05 m^3 per month. Biogas utilization is for fuel gas by 408 houses near the location of that landfill, that's about 18.385,19 m^3 per month or about 3,2%. Therefore that's still has 96,8% biogas potential or about 556.011,86 m^3 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 asphyxiaton risk of explosion and combustion, and greenhouse gas emisisions (Popov, 2005 in Abreu, et al, 2011). Greenhouse gas emissions like carbondioxide gas (CO_2) and methane gas (CH_4) 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 CO_2 emission (Czepiel, et al., 2003). Popov (2005) in Abreu, et al (2011) explained that CH_4 and CO_2 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.

Table 1. Primer Energy Source in Indonesia (2005)

Fossil Energy				
Energy type	Resource	Reserve	Product ion (per year)	Ratio Reserve/ Prod (without exploration) year
Petroleum	86,9 billion barel	9,1 billion barel	387 million barel	23
Gas	384,7 TSCF	185,8 TSCF (P1 + P2)	2,97 TSCF	62
Coal	58 billion ton	19,3 billion ton	132 million ton	146

Renewable Energy		
Non Fossil Energy	Potency	Rigged Capacity
Water Energy	75,67 GW	4,2 GW
Heat Energy	27,14 GW	0,852 GW
Micro hydro	0,46 GW	0,084 GW
Biomass	49,81 GW	0,302 GW
Sun shines Energy	4,80 $kWh/m^2/day$	0, 008 GW
Wind Energy	9,29 GW	0,0005 GW

Source: Ministry Of Energy and Man Resource (2005) in Ministry Of Research and Technology (2006)

Efforts on energy conversion need to be done by encouraging green energy as renewable energy from organic waste biomass. It aims at getting energy sustainability. Government is expected to have a program for conversion from petroleum fuel to gas fuel and from waste to energy to reach sustainable development.

In the year of 2013 and 2014, Malang City government get appreciation of Adipura Kencana because of the success on waste management programs like Malang Waste Bank and biogas utilization at Supit Urang landfill. Biogas from the landfill has been utilized by the citizens around the landfill location as energy source, that is, as gas fuel.

The purpose of this research are not only to know the correlation of the number of population with the amount of waste in Malang City and biogas potential at Supit Urang landfill, but also to count the percentage of biogas which has been used as gas fuel by citizens around the landfill and as electrical energy potency.

Biogas's Forming Process

Biogas is generated from anaerobic waste decomposition process. Chemical reaction on that process is:

$$C_6H_{12}O_6 \rightarrow 3CH_4 + 3CO_2$$

According to Popov (2005) in Abreu, dkk (2011), anaerobic process happened for 10 – 50 days.

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 cellulotytic bacteria with cellulose enzyme, and protein is described by proteolytic bacteria with protease's enzyme.

b. Acydogenesis 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 CO_2 , H_2 , and methanol.

c. Acetogenesis process

In this process, organic acid and alcohol is changed as acetate, format, methanol, CO_2 and H_2 by acetogenic bacteria

d. Metanogenesis process

In this process, acetate is changed as CH_4, CO_2, and H_2O by metanogenic bacteria. Nearly about 70% methane are formed from acetates, whereas the other 30% are from format acid, CO_2, and H_2.

Biogas at landfill consist of 55- 65% CH_4, 35-45% CO_2, 0-1% N_2, 0-1% H_2, and 0-1% H_2S (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:

CH_4 : 50 – 85%
CO_2 : 15 – 50%
H_2S : < 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):

$$TS = 27{,}7\% \times Q \quad (1)$$

$$VS = 74{,}1\% \times TS \quad (2)$$

$$VBS = 0{,}676 \times VS \quad (3)$$

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)

Lil, et al (2010); Yu, et al (2010); Schnurer and Jarvis (2010); Tatlidil, et al (2009); and Rao, et al (2000) in Ngumah (2013) stated that coefficient are used to estimate Biochemical Methane Potential (BMP) of biogas from organic waste of Municipal Solid Waste (MSW) is 66%.

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

Using	Energy 1 m^3 Biogas
Lighting	Lamp 60 – 100 watt up to 6 hours
Cooking	cooking 3 kinds of foods for 5 – 6 person
Energy	Charge 1 handphone up to 2 hours
Electricity	4,7 kWh electrical energy

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 questionaire 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:

$$n = \frac{N}{1 + Ne^2} \quad (4)$$

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

Region	3	4	5	7	8	Total
Population	70	88	107	76	67	408
Sample	14	17	22	15	13	81

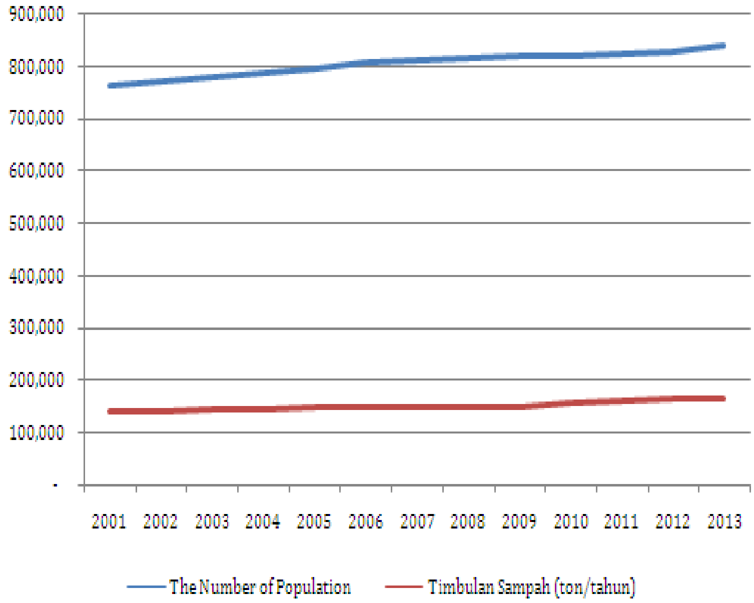
Source: analysis result

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.



Source: Statistics of Malang City and Hygiene and Urban Landscaping Department Malang City (2014)
Fig. 1 Population number and waste amount Malang City

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.

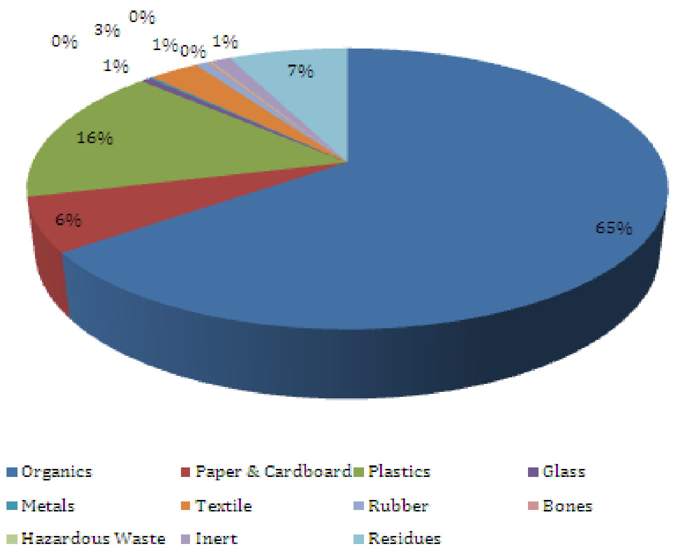
Table 4. Correlation Analysis

Variabel	Pearson Correlation	p-value
Population Number – Waste amount	0.892	0.000
Organic Waste – Biogas Potency	1.000	0.000

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.



Source: Ministry of Public Worksand KfW German Development Bank (2011)
Fig. 2 Waste Composition in Malang City

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

Year	TS (kg/day)	VS (kg/day)	Biogas Potency/ VBS (m^3/day)
2001	41.154,72	30.495,65	20.615,06
2002	41.154,72	30.495,65	20.615,06
2003	49.148,95	36.419,37	24.619,50
2004	44.824,55	33.214,99	22.453,33
2005	36.585,53	27.109,88	18.326,28
2006	35.181,82	26.069,73	17.623,14
2007	32.761,54	24.276,30	16.410,78
2008	32.328,11	23.955,13	16.193,67
2009	31.709,49	23.496,74	15.883,79
2010	35.008,94	25.941,63	17.536,54
2011	35.192,17	26.077,39	17.628,32
2012	41.500,47	30.751,85	20.788,25
2013	40.349,43	29.898,93	20.211,68
Average	38.223,11	28.323,33	19.146,57

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 m^3/day or 18.385,19 m^3/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 2.613.255,75 kWh/month or about 3,63 MW. With 35% as the efficiency level of conversion biogas to electricity, the electric potency become 914.639,51 kWh per month or about 1,27 MW.

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