Benefits of using biogas technology in rural area: karo district on supporting local action plan for greenhouse gas emission reduction of north sumatera province 2010-2020

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Abstract. Indonesia committed to reduce its greenhouse gas (GHG) by 26% in 2020. At the UNFCCC (Conference of the United Nation Framework Convention on Climate Change) held in Paris in December 2015 Indonesia committed to reduce GHG; one way by promoting clean energy use for example biogas. Agricultural industry produces organic waste which contributes to global warming and climate change. In Karo District, mostly the people were farmers, either horticulture or fruit and produces massive organic waste. Biogas research was conducted in Karo District in May until July 2016 used 5 digesters. The purpose was to determine benefits of using biogas technology in order to reduce GHG emissions. The used design was Completely Randomized Design (CRD) with treatments: T1 (100% cow feces), T2 (75% cow feces + 25% horticultural waste), T3 (50% cow feces + 50% horticultural waste), T4 (25% cow feces + 75% horticultural waste) and T5 (100% horticultural waste). Parameter research were gas production, pH and temperature. The research result showed that T1 produced the highest methane (P<0.05) compared to other treatments while T2 produced methane higher (P<0.05) compared to T4 or T5. There was no difference on methane production between T4 and T5. As conclusion application of biogas on agricultural waste supported local action plan for greenhouse gas emission reduction of North Sumatera Province 2010-2020. From horticultural waste, there were 2.1 x 10^6 ton CO2 eq in 2014 which were not calculated in RAD GRK (Regional Action Plan for Greenhouse Gas Emissions Reduction).

1. Introduction

Associated with Indonesia was rated as the biggest four GHG emitter together with India, China, USA, Indonesia National Development Planning Agency formulated such policy in order to reduce greenhouse gases in Indonesia. In addition, President of Republic Indonesia committed to reduce greenhouse gases 26% by 2020 by its own effort and another 15% by international support[1].

In bottom level, such policy were implemented by Article 6 paragraph (1) of Presidential Regulation of the Republic of Indonesia Number 61 Year 2011 on the National Action Plan for Greenhouse Gas Emission Reduction. It was stated that to reduce the Greenhouse Gas emissions in each province, the Governor of each province should compose the Regional Action Plan for Greenhouse Gas Emissions Reduction (RAD GRK). In definition, RAD GRK was a document with the objective to reduce GHG
emissions pursuant to national commitments until 2020 in the form of policy directions, strategies and programs include activities[2].

To achieved the target, RAD GRK need to supported by the local government, the private sector and communities. In North Sumatera Province, associates with composing on the Local Action Plan for Greenhouse Gas Emissions Reduction on North Sumatera Province of 2010-2020, Governor of North Sumatera province stipulated several regulations, for examples scope of activities of RAD GRK which comprises agriculture, forestry and peat land, energy and transportation, industry and waste management. Moreover, international support such as JICA and USAID supported in the form of guiding target achievement. The Regional Action Plan for reducing emissions of GRK (RAD-GRK) in North Sumatra Province concentrated in (1) Identification of areas and activities that have the potential as the source/ absorption of GRK emissions (2) Identification of emissions and projection of GRK period (years 2010-2020) (3) Formulation of the mitigation actions that have the potential to reduce GHG emissions from agriculture; industry; forestry and peatland; energy, transportation, and waste[3].

There are 6 types of gases which are consisted in GHG, namely Carbon Dioxide (CO₂), Dinitro Oxide (N₂O), Methane (CH₄), Sulfurhexaflorida (SF₆), Perflorokarbon (PFCs) and Hidroflorokarbon (HFCs). Any activities which produces any kind of these gases is classified as GHG emissions. activities that contribute to GHG emissions could be energy-based emissions, emissions from the production process and product use, land-based emissions, and emissions from waste[4].

A wide range of industrial and economic activity contributes to GHG emissions for example agriculture. In Karo District, mostly the people are farmers, either horticulture or fruit and produces tremendous organic waste. Typically in Indonesia only small percentage of waste are transported to landfill and mostly occurs in major cities[5].

As mentioned above, RAD GRK concentrates for example in formulation of mitigation actions that have the potential to reduce GHG from agriculture waste. However mitigation in RAD GRK on waste is focused on how the waste to be transported to landfill[3]. As waste from agriculture especially horticulture have a potential to be converted into energy through biogas technology, mitigation policy in RAD GRK should be improved. Biogas reduce CH4 emissions from organic waste while biogas also produced renewable energy [6]. The objective of this study was to analyze energy potential from agricultural waste in Karo District associated with improving RAD GRK policy in North Sumatera Province.

2. Materials and Methods
Organic waste which were cow waste and horticultural waste were used as an input into 5 biogas units. In Karo District, the highest percentage of horticultural vegetation were kinds of cabbage and oranges. In this research, horticultural waste which were used for examples cabbage, china cabbage, broccoli combined with orange waste.

The research method was used Completely Randomized Design (RAL). HRT (Hydraulic Retention Time) 45 days. Treatments were as follows : T1 (100% cow feces), T2 (75% cow feces + 25% horticultural waste), T3 (50% cow feces + 50% horticultural waste), T4 (25% cow feces + 75% horticultural waste) and T5 (100% horticultural waste). Parameter research were gas production, temperature and pH. There were five replications and 5 laboratories scale biogas digesters were used (capacity 500 liters). Gas production was measured by a simple gas meter with 1 atm pressure. Figure 1 shows prototype of gas production measured.
3. Results and Discussion

3.1. Gas Productions
Gas production from this study was presented in table 1. There were differences in gas production between T1 and other treatments. Data analysis was then followed by Duncan Test where T1 and T2 showed gas production were significantly different (5%) from other treatments. Higher gas production should occurred also on other treatments [6], any agricultural waste has a biogas potential. However, accumulation of rotten oranges in T3, T4 and T5 reduced pH of substrates. A pH of 6 to 7 facilitated good environment for microorganisms in growing. Gas production were measured by gas meter with 1 atm pressured. Gas meter prototype was presented in figure 1.

| Treatments | Replication | TOTAL | Mean |
|------------|-------------|-------|------|
|            | 1           | 2     | 3   | 4    | 5    |       |
| T1         | 128,14      | 126,87| 152,58| 153,2| 160,86| 721,65| 144.33a |
| T2         | 96,01       | 98,22 | 107,24| 112,07| 107,24| 520,78| 104,16b |
| T3         | 80,57       | 88,97 | 76,6  | 76,6  | 68,94  | 391,68| 78,33c  |
| T4         | 60,43       | 61,28 | 52,77 | 37,28 | 38,3   | 250,06| 50,01d  |
| T5         | 62,35       | 22,98 | 61,28 | 45,45 | 45,96  | 238,02| 47,6d   |
| Total      |             |       |       |       |       | 2122,19|        |

Table 1. Gas Production (CH\(_4\)) : input cow and horticultural waste

3.2. Temperature
In this research, data of temperature were taken as temperature as part of climate effected gas production[6]. Temperature in this research was about 19°C which was same as temperature of environment. Location of the research was in highland area where ambient temperature was 22 - 23°C in July and August thus temperature of underground where biodigester was set up was below 20°C and automatically effect temperature inside biodigester. Three temperature ranges in the anaerobic
digestion process which were 1) < 20°C; 2) 20 - 45°C; 3) 45 - 60°C[7] and optimal temperature was 35°C [8]. High gas production were occured in July, August and September where temperature were 19 - 21°C [6]. Extreme temperature affected methane bacterium thus cause gas production stopped.

3.3. pH

pH in this research was took from samples in the outlet of biodigesters/slurry, pH were range from 4 to 7. pH is influenced by combination of substrates materials. Lower pH affect microorganisms in growing and pH of 6 to 7 are preferable. Lower pH such 4 may affect microorganisms metabolism thus affect gas production. It was important to measure pH in order to ensure that there was no disturbance on gas production thus gas production could ceased due to acidification or alkaline condition [9]. pH of biogas slurry is a critical point whether slurry could be used as fertilizer. In this research slurry from T1 and T2 only were suggested be used as liquid fertilizer as pH are range from 6 to 7. Standard National Of Indonesia on pH of liquid fertilizer were ranged from 4 to 9 however in order to facilitate habitat for a wider range of good microorganisms, better to apply pH as 6 to 7 which were pH for normal soil. A wider range of good microorganisms in soil will create a good competition with pathogen microorganisms thus create a healthy soil.

3.4. Benefits of Biogas for Local Farmers

There were three major benefits by using bigas technology, e.i. CH₄ as source of renewable energy, slurry as liquid fertilizer and clean environment [10]. Slurry as fertilizer had been proven by research which was conducted by Ginting and Mustamu in 2012. Application of biogas slurry as 250 ml could be an alternative of 2.5 g NPK as early fertilizer on the growth of Spinach Plant (Amaranthus tricolor) [11]. Either livestock manure or agro by-product which are utilized for example through biogas technology is ecologically promoting as cleanliness of the environment is one of biogas technology production [12]. In Malaysia, Biogas technology give benefits such as tremendous renewable energy, fertilizer and could enhancing public health whereas anaerobic digestion reduces the impacts of waste on the environment [13].

This research is followed by dissemination of research result on local farmers in Karo District. 12 biodigesters from PE plastic bag with 0.02 thick were used as biodigester. Kinds of cow waste combined with agricultural waste except orange were used by local farmers. Orange waste which is rotten orange is not used as it is decrease pH thus decrease microorganism metabolism thus decrease gas production. Rotten orange should processed in composting with addition of CaCO₃ to increase pH.

3.5. Benefits of using biogas technology in Karo District on supporting of local action plan for greenhouse gas emission reduction of North Sumatera Province 2010-2020

It was mentioned in the beginning of RAD GRK concentrates on (1) Identification of areas and activities that have the potential as the source/ absorption of GRK emissions. (2) Identification of emissions and projection of GRK period (years 2010-2020) (3) Formulation of the mitigation actions that have the potential to reduce GHG emissions from agriculture; industry; forestry and peatland; energy, transportation, and waste.

In RAD GRK document of North Sumatera Province, from agriculture, it was mentioned that GHG from horticulture was not calculated as the horticulture area was not significant thus GHG emitted also was not significant. There were 6 major emitter activity in agriculture, namely palm oil mill, irrigated rice field, rubber plants, food crops, urea in oil palm plants and livestock. While based on share of agriculture on GRDP (table 2), it was known that horticulture together with crops influenced GRDP from agricultural sector. It concluded from this fact that activities in horticulture were tremendous moreover the highlands in North Sumatera Province were potential for the development of horticulture crops. Associated with RAD GRK where mitigation for waste was to be dumped onto landfill, in case
of horticultural waste it was better to be processed by using biogas technology. Meanwhile in order for biogas technology to be used, it need to be supported by the local government and communities, i.e. farmers.

Table 2. Share of Agriculture, Processing Industries and Others to GRDP at Current Price, 2015 in North Sumatera Province

| Sector/Subsector        | 2015 |
|-------------------------|------|
| Agriculture             | 23.03|
| • Horticulture          | 8.05 |
| • Crops                 | 9.87 |
| • Livestock             | 2.54 |
| • Forestry              | 1.23 |
| • Fishery               | 2.34 |
| Processing Industries   | 23.02|
| Others Sectors          | 52.12|

Table 3. GHG emission from Agricultural Sector (Local Action Plan for Greenhouse Gas Emissions Reduction of North Sumatera Province 2010-2014)

| Emission from Agricultural Sector (Year) | Emission from Agriculture Sector (tCO₂eq) |
|-----------------------------------------|-----------------------------------------|
| 2010                                    | 9.322,588,52                            |
| 2011                                    | 9.412,212,01                            |
| 2012                                    | 9.551,101,32                            |
| 2013                                    | 9.641,232,02                            |
| 2014                                    | 10.521,102,21                           |

From table 3, it could be concluded that the emissions increase significantly from 2006 to 2014. So mitigation should be taken place and based on this research mitigation could be by using biogas technology on waste from horticulture which has not been calculated. By capturing the gas emitted with biogas technology, CH₄ emissions were considerably reduced. Combustion of CH₄ will produce CO₂. As methane was a greenhouse gases with a global warming potential 28 times greater than CO₂ [14], combustion of CH₄ would create benefits such energy and gases with lower global warming potential [15].

Statistic of North Sumatera Provinces 2014, showed that in Karo District there were 256,735 ton horticulture production which cabbage was significantly produced, i.e. 64,305 ton. In general, waste from horticultural product could be as much as 1.5 times than the product itself. So it could be concluded that there were 96,457 ton cabbage waste in Karo District in 2014.

From the research, the best result on biogas production were on T1 and T2 while T1 only contained with cow feces and in T2 contained 75% cow feces and 25% horticultural waste. As it is horticultural waste which would be calculated, so T2 would be used as based of calculation. From 96,457 ton horticultural waste mostly cabbage, it would be produced about 1.415 x 10⁹ CH₄. Capturing methane was equal to cutting emission of methane thus minimizing global warming [6]. Methane had a global warming potential 28 times greater than CO₂ [14]. From this research, it concluded that by capturing methane from horticultural waste mostly cabbage, there were global warming potential as much as 39.62 x 10⁶CO₂ eq.
4. Conclusions
RAD GRK North Sumatera Province should be improved since it was not included waste from agricultural sector, i.e. horticulture. Eventhough land size of horticulture was less significantly than other sector but it produced tremendous product followed by tremendous waste which produced CH₄. From horticultural waste mostly cabbage waste alone, it could be assumption that there were global warming potential as much as 1,415 x 10⁶ CH₄ or 39.62 x 10⁶ CO₂ eq in 2014 which could be cut. By capturing CH₄ through biogas technology, CH₄ emissions are considerably reduced.

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