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The potency of CO_2 and CH_4 emission on various levels of peatland maturity in Rasau Jaya west of Kalimantan Indonesia

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Abstract

Peatland is one of type soil that considered as green gas houses emission especially CO_2 and CH_4, and those gases are the largest contributor on global warming. The goal of research is to evaluate potency of peat land in various level of maturity that release of CO_2 and CH_4 in Rasau Jaya Kuburaya, Kalimantan Barat. This is exploration research and has done by survey and laboratories analysis. Observation point is based on peat land maturity distribution to get soil sample and CO_2, CH_4 emission. The control of this research is Alfisol soil that is taken at Galang. The variables are kind of soil, soil physic and chemical character, and potency of CO_2 and CH_4 emission. The incubation of soil sample is used to get potency of CO_2 and CH_4 production and the gas be analyzed by gas chromatography with flame ionization detector (FID) for determining flux of CO_2 and CH_4, be repeated three times. Peat land has potency of CO_2 and CH_4 larger than mineral soil (Alfisol), and it makes organic material degradation faster than Alfisol. The high level of peat land maturity causes the low level of CO_2 and CH_4 emission. Hemist peat land can release CO_2 and CH_4 higher than Fibrist and Saprist, because metanotrof bacteri decomposed on the optimal condition on Hemist peat land and vice versa with Saprist. Fluvent peat land has the high organic material and in the wet condition produces the high level of CH_4. Inundation condition and high content of organic subtract are the way for formatting optimizing of methane.

Keywords: Peatland, Maturity, Emissions, CO_2, CH_4

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1. Introduction

Global issues in the twenty first century is rate of green house gases emission with the high of CO_2 concentration which is caused by human activities (IPCC, 2006 and Houghton *et al*. 2001). Wide area of peat land has been changed to agriculture and plantation and it causes landscape changing that influence the increasing of green house gases emission, and this condition is the big one of gas emission contribution in Indonesia. From 1994 until 2010 there were many land use change especially from natural forest to another utilization such as big plantation (oil palm) around 64,97% and causes the enhancement of temperature in the last decade that be perceived by people in Kubu Raya regency (Atmojo et al., 2012).

Carbon stock on peat land in Indonesia is around 37 Gyga tons and almost 30% can be found in Kalimantan, and the part of it is in Kubu Raya district. Krisnohadi (2011) in his report indicated totally area of peat land at Kubu Raya is 342,984 ha and about 30% of it (102.934 ha) be developed for oil palm plantation on shallow peat land. The reduction of peat land area will decrease green house gases absorption and in the long period stimulate the increasing of gas emission that causes global warming (WWF, 2008).

Another research reported the connection between peat land reduction and temperature condition. The observation of temperature during 38 years showed the increasing of average daily temperature and temperature maximum as big as 0.023^{o} C and 0.044^{o} C per year respectively (Iswati and Suntoro dan Budiastuti, 2013). In 2011, 50% of oil palm plantation is cultivated on peat land and the soil will release CO_2 to the atmosphere. The continuity of plantation activity on peat land must be stopped to reduce the gas house glasses because activities of plantation contribute 90% of gas on 2020 (Carlson et al., 2012). The important gas that comes from plantation is CO_2 and CH_4 and in the long term causes high level of temperature. The emission of CH_4 comes from decomposition of organic material inorganically (Hairiah, 2005). Beside the activities of plantation, land clearing contributes the increasing of CO_2 in the air.

The conversion of peat land causes the high level of radiation intensity and will enhancement evaporation and reduction water peat content. Furthermore, the application of drainage at oil palm plantation will accelerate reduction of water content in peat land, finally there is not submerged formation and oxidative that caused optimum condition for microorganism development. Enhancement of microorganism activities increases organic material decomposition at peat land and give impact on emission of CO_2. In the natural forest and peat land release 20-40 ton of CO_2 eq ha^{-1} year^{-1} (Ade, 2011).

Land use change produces CO_2, CH_4 and N_2O as much as area of land clearing such as from peat land to agriculture. The changing of peat land to crop cultivation is considered as the big emission contribution, for example, organic fertilizer application at paddy field increases CH_4 and CO_2 (Nieder and Benbi, 2008). Methane has capability for increasing green house gases ten times larger than CO_2 (Boeckx and Cleemput, 1996). Therefore, research of green house gases from the level of peat land maturity should be done to evaluate CO_2 and CH_4 emission.

2. Research method

This research is a kind of exploration and be done by survey and be supported by laboratories analyzes. The location of research is in Rasau Jaya district according to the level of peat land maturity. Observation point is determined by distribution of peat land maturity to take soil sample and gas emission. Alfisol is kind of soil as a control that is taken from Galang. Data be taken from sample point, consist of kind of soil, physic and chemical properties and CO_2, CH_4 emission.

Analyzis and mapping preparation is done at Phedology and Survey Laboratory, Department of Soil Science, Faculty of Agriculture, University of Sebelas Maret Surakarta Indonesia. Analyzes of chemical properties and soil incubation are done at Chemical and Fertility Laboratories in the same Faculty. Gas Chromatography (GC) analyzes be held at Green house Gasses laboratory, Department of Agriculture and Environmental Research, Jakenan, Pati Central of Java Indonesia (Aryani, 2007), and finally CO_2 and CH_4 emission be measured with Soil Incubation Technique method (Susilowati, 2007).

The material are consist of map (land use type, kind of soil and earth), chemical material for soil and GC analyzes. The kind of instrument of research is software Arc View 3.3 GIS (*Geographic Information System*), compass, clinometers, drill of soil and stationery. CO_2 and CH_4 be analyzed with chromatography gas and be completed with Flame Ionization Detector (FID) for determining Flux of Methane and Carbon dioxide (Susilawati and dan Kartikawati, 2008).

3. Result and discussion

3.1. Peat land characteristic

Peat land at Kubu Raya district is a kind of peat land which has decomposed short while (moderate:hemist) and the part of it has decomposed for a long time (saprist) with 1-2 meter of thickness, with 35-65% of organic content. Generally peat land are devided in tree kinds, febrist (mature), hemist (moderate) and saprist (immature), with 35-65% of organic content. The thickness determines soil fertility and the thicker of peat land the lower of soil fertility. It can be explained that the root system can not reach mineral soil that located in the deep of zone. Generally, peat land at Rasau Jaya is cultivated by annual crop, vegetables and oil palm. The level of peat land acidity at location is around 3.3-4.12, this is because of bonding fenolic and carboxil more acidic and easily to release H^+ (Noor, 2006). The analyzed of peat land and mineral soil can be seen in Table 1.

Nitrogen content on peat land is very high but nitrogen availability is very low and just an half of content of nitrogen can be absorbed by plant. That condition can be connected with the high of C/N that causes limitation of nitrogen availability. Majority of nitrogen and phosphor are in the form of organic that need mineralization process to be used by the plant. The content of Potassium is low too and it connects with the level of base saturation on peat land. Along the river there is peaty soil with 40.62% of organic material and belong Fluvent sub ordo (high content of nitrogen), be used for paddy field planting, generally it calls mineral soil.

Table 1. Analyzed of peat land and mineral soil at Kubu Raya

Location	subordo of Soil	Water content	pH of soil	C.Org (%)	N total (%)	P_2O_5 (%)	K_2O (%)
Peat of Galang	Fibrist	73.40	3.283	45.61 (VH)	0.83 (VH)	1.06 (VL)	0.38 (VL)
Peat of Siantan Hulu	Saprist	68.09	4.125	36.03 (VH)	2.06 (VH)	1.15 (VL)	0.42 (VL)
Mineral Soil of Galang	Alfisol	13.10	5.45	2.43 (M)	0.18 (L)	0.17 (VL)	0.63 (VL)
Peaty Mineral soil (Paddy field)	Fluvent	61.21	4.592	23.56 (VH)	0.99 (VH)	0.22 (VL)	0.52 (VL)
Peat land of Rasau J (Upland, Secunder B)	Saprist	88.33	3.666	31.19 (VH)	1.65 (VH)	0.46 (VL)	0.41 (VL)
Peat land of Rasau J (Oil Palm Plantation)	Hamist	76.82	3.346	36.18 (VH)	0.99 (VH)	0.94 (VL)	0.25 (VL)
Peat land of Rasau J (Upland, Secunder C)	Hemist	81.66	3.461	38.93 (VH)	1.08 (VH)	0.53 (VL)	0.21 (VL)

Note : VH= Very High, H = High, M = Moderate, L = Low, and VL = Very Low

3.2. Potency of CO_2 and CH_4 emission

Peat land release CO_2 and CH_4 larger than mineral soil, because of organic decomposition process. In the anaerobic condition, organic material will be decomposed by group of methanogen bacteria and finally produce CO_2 and CH_4. It comes through fermentation process which is produced CO_2 and CH_4 according to this reaction (Nieder and Benbi, 2008).

$$C_6H_{12}O_6 \rightarrow 3\ CO_2 + 3\ CH_4 \qquad (1)$$

The analyzes of CO_2 emission shows that peat land has higher potential for releasing CO_2 than mineral soil (Alfisol) at Galang, as big as 0.08 mg kg^{-1} of soil. For comparison, peaty land (fluvent) from Rasau Jaya has higher potential for releasing CO_2 than peat land, it is about 0.12 mg kg^{-1} of soil, but kind of hamist peat land is the biggest (0.14 mg kg^{-1} of soil).

Hemist peat land has high potential for realising CO_2 because of the high rate of organic decomposition, and fibrist peat land is not the same with hemist because of difference rate of decomposition process, fibrist has not optimum yet. But saprist has decomposed for a long time and finally rate of decomposition will diminish. Anaerob condition will support decomposition process and be produced CO_2, CH_4 periodically (Figure 1) (Nieder and Benbi, 2008).

Tablel 2. Analyzes of CO_2 and CH_4 emmission on peat land

Location	Subordo of Soil	Organic material (%)	C/ N	Production of CO_2 (mg kg^{-1} of soil)	Production of CH_4 (mg kg^{-1} of soil)
Pet land of Galang	Fibrist	78.64	54.66	0.13	0.000421
Peat land of Siantan Hulu	Saprist	62.12	17.50	0.10	0.000372
Mineral soil of Galang	Alfisol	4.18	13.64	0.08	0.000165
Mineral peaty soil (Paddy field)	Fluvent	40.62	23.86	0.12	0.000224
Peat land of Rasau J (Upland, Secunder B)	Saprist	53.78	18.93	0.08	0.000299
Peat land of Rasau J (Oil palm plantation)	Hamist	62.37	36.54	0.14	0.000344
Peat land of Rasau J (Upland, Secunder C)	Hemist	67.13	36.02	0.13	0.000534

Generally, emission of CO_2 comes from organic decomposition in aerobic condition, and then be used by the plant in the process of photosynthesis (Aryani, 2007). In the peat land, emission of CO_2 comes from respiration activities in soil, decaying of organic material, litter and organic material combustion, and organic decomposition in anaerobic way. The amount of CO_2 emission from terestrial ecosystem is calculated from soil and plant respiration. Contribution of root respiration to totally soil respiration is as big as 50%, but some researcher have reported from 10 until 90%.

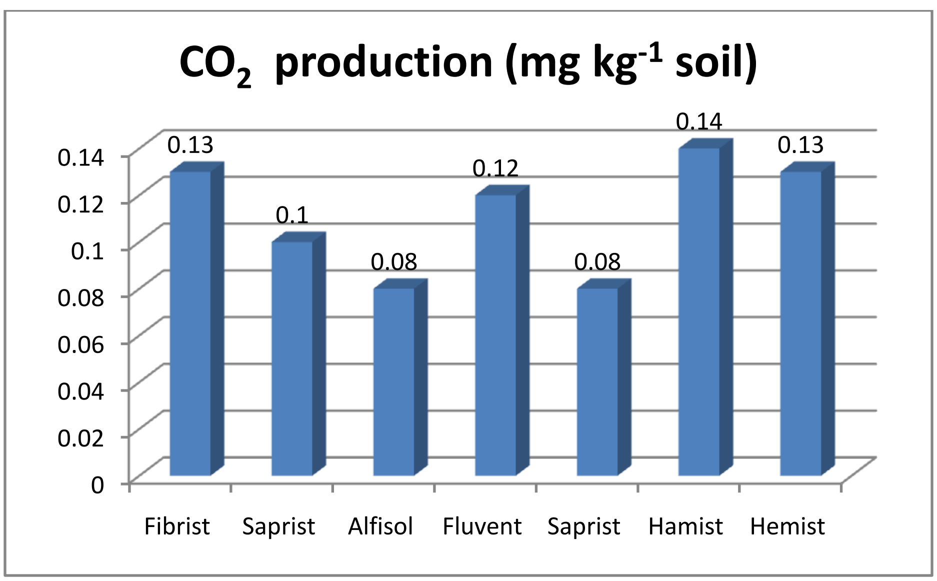

Figure 1. The average of CO_2 potential on peat land (mg kg^{-1} of soil) in the several of maturity levels

The higher of maturity level in peat land (low of C/N) indicates the lower of CO_2 emission. It shows reduction of microorganism activities on organic decomposition process (Figure 2).

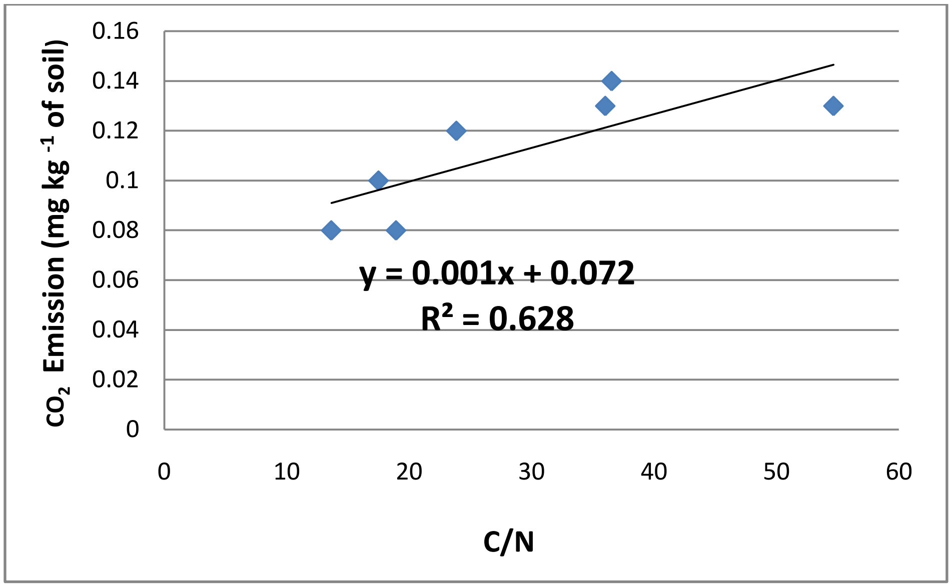

Figure 2. Relationship between maturity level (C/N) with average of CO_2 potential in peat land (mg $kg^{-1}$of soil)

Peat land produce CH_4 emission higher than mineral soil, because of organic material content. Hemist peat land can realese CH_4 more than fibrist and saprist. It proves the high decomposition process which is done by methanotroph bacteria in optimal condition. While on febrist peat land, anaerobic decomposition has not run very well. The decomposition process on saprist peat land indicates to slow and causes the low level of CH_4 emission (Figure 3).

Methane is one of green house gas and has role for absorbing infra red radiation. Global warming potential of methane is ten times larger than CO_2 (Boeckx and Cleemput, 1996). This gas has capability for heating twenty one times larger than CO_2 (Nieder and Benbi, 2008). Methane is call swamp gas that can stay in atmosphere for almost 12 years, and makes ozone depletion. This gas contributes 20% of totally green house gases (Inubushi, *et al*., 2001). Concerning of methane is because of high concentration in atmosphere and the consequences of green house gas contribution.

Peaty Fluvent is mineral soil with high content of organic material. This type of soil is saturated and gives impact on emission of CO_2, CH_4. The impact of saturation is anaerobic condition on decomposition process. The low of potential redox and availability of organic compound are precondition for performing of methane. There is positive relationship between saturation and methane production; it means that saturation can increase production of methane (Suntoro, 2013). Field paddy can produce methane more than peanut and vegetables cultivation.

The relationship between peat maturity level (reflected by C/N) with potency of CH_4 emission indicates level of CH_4 emission is influenced by level of C/N. Higher of C/N causes higher of CH_4 emission (Figure 4). In another word, reduction of C/N is the important condition, because it means enhancement of peat maturity can give positive impact to the environment, as a result of CH_4 reduction. Underdone peat land in anaerobic condition is favorable condition for performing methane (Couwenberg, 2009). So it is not recommended if peat land is under waterlogged condition.

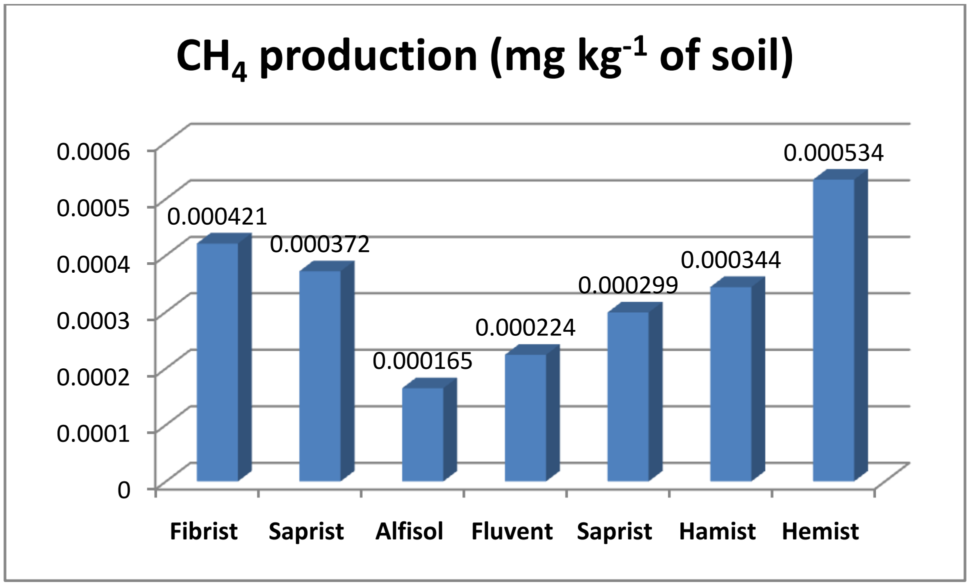

Figure 3. The average of CH_4 potential on peat land and mineral soil (mg kg^{-1} of soil)

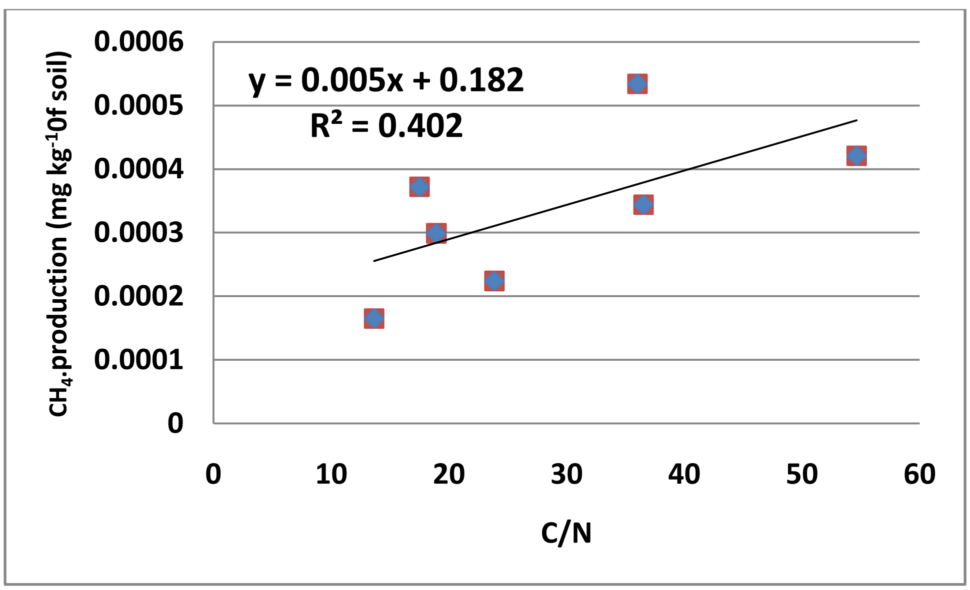

Figure 4. Relationship between level of maturity (C/N) with average of CH_4 potential on peat land (mg $kg^{-1}$of soil)

It can be concluded that peat land has the higher potential for releasing CO_2 and CH_4 than mineral soil. The increasing of maturity level causes the less releasing of CO_2 and CH_4. The sequence of peat land releases gas emission from high to low, Hemist > Fibrist > Saprist > peaty Fluvent > Alfisol.

4. Conclusion

- Peat land has a higher potential for releasing CO_2 and CH_4 emission than mineral soil (Alfisol), high of organic subtract contributes high of organic decomposition
- The high level of peat maturity give positive impact because of CO_2 and CH_4 reduction. Hemist has capability for releasing potential bigger than Fibrist and Saprist. The optimum condition on Hemist makes a good condition to methanotroph bacteria for decomposition process.
- Peaty fluvent is like mineral soil, it has a high of organic material content. In the paddy field condition, this soil produces high level of CH_4 emission. Water logging be supported with organic subtract is the precondition for performing methane

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