Effect of Temperature Soil and Water Table of Methane Emission on Transfer Function Peatlands Into the Garden of Palm

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Abstract

This study aims to determine the effect of soil temperature and water table to the emission of CHgas4 in the conversion of peatland forests into oil palm plantations in City of East waringin, Central Kalimantan, Indonesia. The study was conducted using a randomized block design consisting of two factors; the first factor is the location of peat land of oil palm plantations (L_s) and peatland forests (L_h);the second factor is the depth of 0-35 cm soil layer (D1),35-70 cm (D2),70-105 cm (D3) and 105-140 cm (D4). Measurement of soil temperature and water table is done simultaneously with the measurement of CH_4 emission gas. The method used is Wireless Sensor Network (WSNs) comes Graph Sensitive MQ-4 for 6 months (dry-wet rainy season), with the tool chamber. The results showed emissions CH_4 in peatlands for oil palm plantation 0:44 to 3:06 mg m^{-2} j^{-1},in the peatland forests at 0:42 - 3.92 mg m^{-2} j^{-1}. CH_4 emissions significantly correlated with the water table and soil temperature at a depth of 105-140 cm, with a correlation coefficient (r) and 0.020 -0.630 ($p <0.05$). The surface temperature of the soil around the chamber (10 cm) and the water table significantly influence CH_4 emissions, with a p-value respectively 0.028 and 0.0001 ($p <0.05$), with the regression coefficient (b) respectively and 0.603 (-0.026). The coefficient of determination (R^2) produced 0.6390 and water table give the largest contribution to the emission of CH4 (43.97%) of the total value of the effective contribution of 63.90%.

Keywords: *Emissions of methane, the temperature of the soil, water table, peatland conversion, oil palm plantations*

I. INTRODUCTION

Peatlands are biological resources potential and serve as a reducer of flooding, climate control, life support and biodiversity (Cassel, 1997; Maltby, 1997; Noor, 2001; Galbrait et al.,2005; Rieley et al.,2008).

Indonesia as a country that has fairly extensive tropical peatlands. One spread on Borneo island, with an area of 5,769,246 ha. Central Kalimantan province has the widest peat 3.01054 million ha (Wetland, 2005), largely converted into oil palm plantations, until the year 2010 has reached 307 515 ha (Sabiham and Sukarman, 2012).

Peat forest conversion into oil palm plantations in Indonesia is greenhouse gas emissions (GHG), the largest. As one of the dominant factors causing environmental problems of climate change and global warming become a "time bomb" for the environment (Reijntjes et al., 1992; Riwandi, 2003; Jauhiainen et al.,2004; DNPI 2010; Nurida et al.,2011). Study Intergovernmental Panel on Climate Change (IPPC) (2007) to ensure that global climate change occurs because the Earth's atmosphere is filled by GHG, such as CO_2, CH_4, $N2^O$ which forwards short-wave radiation is not hot but retains long-wave radiation is the heat, consequently, the Earth's atmosphere got hotter.

The Intergovernmental Panel on Climate Change (IPCC) (2007) reported that the contribution of CH_4 on global warming ranks second only to CO_2. AbilityCH_4 to increase the earth's temperature is very high, due to the absorption of infrared light by the molecules 25 times greater than CO2. The presence of CH_4 in the atmosphere is 1.3 ppm increase in global temperature of 1.3 °C (Lelieveld et al., 1993; Hanson and Hanson, 1996; Pearce, 2003). Concentration ofCH_4 in the atmosphere in 1990 amounted to 1.75 ppm at a rate of increase of 1% per year and CO_2 at 354 ppm with an increase of 0.5% per year, effect on global climate change and critical to the anticipated (Sudadi, 2009). Along the strengthening of the issue of climate change and global warming, peat this time needs serious attention and management in order to remain sustainable (Noor, 2001; Noorginayuwati et al.,2008; Melling and Goh, 2008).

The opening of oil palm plantations by removing natural vegetation and manufacture of drainage channels lead to changes in the water table.Changes in the water table are very influential in the process of oxidation-reduction, ultimately affecting temperatures (soil and water). CH_4emissionsoccur quite significant because of the drainage and temperature (Minkkinen et al.,1997; Roulet, 2000).

Gas emissionsCH_4 on peatland conversion to oil palm plantations varies greatly depending on the characteristics of peat soil, such as soil temperature and water table. EmissionsCH_4data, the temperature of the soil and water table in peatlands palm plantations are relatively limited. Therefore it is necessary to measure the gas emissions of $CH_4$the temperature of the soil and water table in peatlands palm plantations and peatland forest as a comparison. This study is an attempt to support the mitigation of greenhouse gas emissions (GHG) emissions, in particular, methane (CH_4)on conversion of peatland forests into oil palm plantations, in order to minimize gas emissions of CH_4.

The purpose of this study to determine the effects of soil temperature and water table to the emission of methane gas on peatland conversion of forests into oil palm plantations.

II. MATERIALS AND METHODS

The experiment was conducted in peatland oil palm plantations and peatland forest District Besi City, East waringin, Central Kalimantan. The study area is located between 02°21' 00"-02° 31' 00" S and 112° 46 '00 "- 112o 57' 03" E. The geographical condition of the flat ramps, slopes of 0-8%, a height of 3-17 m.

The sampling method variable measurement is done observations in-situ at two locations (peatland palm plantations (Ls) and peatland forests (Lh)), on the 4th depth of the soil layer (layer I (0-35), II (35-70), III (70-105), and IV (105-140) cm) as a treatment, repeated 3 times. Based on observations on peat blocks of oil palm plantations, research representative location specified in peatlands oil palm plantations produce TM-3 age 6 years and peatland forests. This provision is based on the age of 6 years old is the oldest palm trees in the garden peat, roots are in(± 60 cm) and a canopy cover is quite high (closer to the condition of peatland forests as a comparison). Depth measurement of temperature in the soil profile is determined based on the results of the survey, that the water table in the rainy season in some peatland (palm, bush and forest) between 30.5 to 32.6 cm and a dry season between 102.6 to 104.5 cm.

Variables measured include gas emissions CH_4, soil temperature of the soil at four depths, namely: I (0-35 cm); II (35-70 cm); III (70-105 cm); IV (105-140 cm), the temperature of the soil surface around the chamber (10 cm), and the water table.Measurement of the water table because its existence is affecting the soil temperature in the soil profile, the temperature at ground level, as well as CHgas4emissions.Measurements were made during the nine months (dry-wet rainy season), beginning in December 2015 - August 2016, menyesesuaikan weather.

Gas emission CH_4 measurements in situ using wireless sensor networks (WSNs), equipped with MDA300 type sensor, a 2.4 GHz radio frequency transmitter freeway communication radius of 500 m^2 and a monopole antenna. The server side includes data base station (Newbridge), to collect all information and data on the installed sensors complete with MQ-4 Sensitive Graph dedicated readers methane (Eugster, 2012). Gas emissionCH_4 measurements performed with the tool chamber (diameter 20.5 cm; height 9.7 cm).

Measurements Water table performed in situ using soil water table meter equipped with sensors, with tools PVC pipe diameters of 1¼ inches. Measurement is done by inserting soil water table in PVC pipe from the ground until the sensor touches the surface of the water in the soil profile. Measurement of soil temperature of the soil at four depths and land surface temperatures around the chamber (10 cm) are performed in situ using a soil thermometer. Per depth of soil sampling for soil temperature measurements with peat drill tools.

The results of the measurement of gas emission CH_4 in ppm then converted in units of mg m^{-2} h^{-1}.Values obtained from the reduction of the water table with high measurement results in PVC pipes that are at ground level.Data were analyzed statistically using ANOVA to determine the effects of treatments. Correlation analyses were conducted to determine the relationship between variables. Statistical analyses were performed using SPSSpackage Version 20.

III. RESULTS AND DISCUSSION

Effect of conversion of peatland forests into oil palm plantations on gas emissions CH4, the temperature of the soil and water table.

A. Gas Emissions CH_4.

Emissions data CH_4 are presented in Figure 1 shows that the distribution of gas emissions CH4 in peatland palm grove tend to be higher than in the peatland forests, except in August (wet dry season). CHemissions4 in peatland palm grove of 0.44 to 3.06 mg m-2 h-1 and in the peatland forests of 0.42 to 3.92 mg m^{-2} h^{-1}.

Results of analysis of variance showed that the conversion of peatland forests into oil palm plantations significant effect on the increase in emissions of gas emissions CH_4.Gas emissionsCH_4 lows in December (0.42 mg m^{-2} h^{-1})and the highest in August (3.92 mg m^{-2} h^{-1})on peatland forests, but common peatland emissions higher oil palm plantation , with temporary distribution patterns tend to be linear. Distribution pattern of CH_4 emission in two locations (period: 2015-2016) Figure 1.

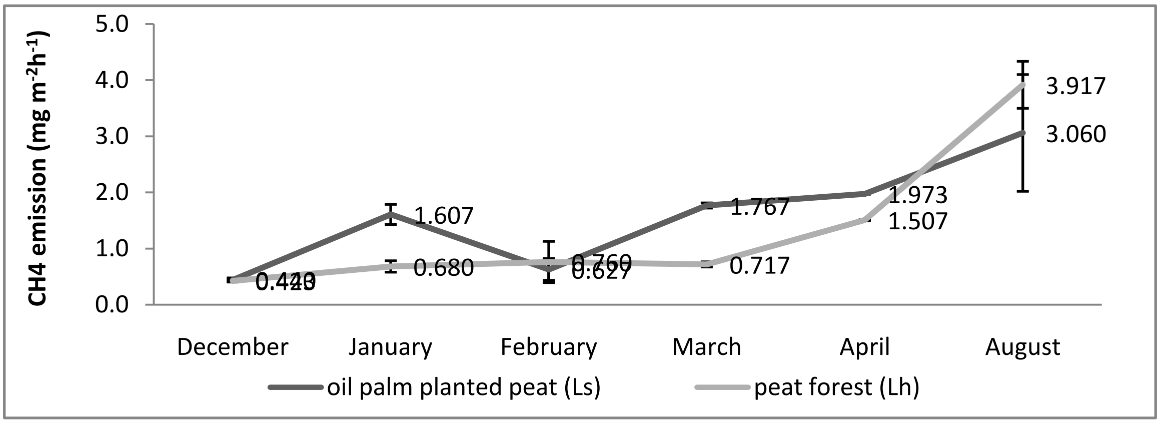

Figure 1. Distribution Pattern of CH_4 Emission in Two Locations (Period: 2015-2016)

High gas emissions of CH_4 in oil fields due to drainage greatly affect the water table changes, while the forest land there is no drainage channel. Changes in the water table affecting oxidation-reduction processes in the soil profile. If the soil under reducing conditions, the air spaces in the soil a bit so that the gas CH_4 released into the atmosphere more slowly and emitted is very small. If the soil under oxidative conditions, the air spaces in the soil more so that the gas CH_4 released into the atmosphere more quickly, more and emitted enormous. The presence of peatland drainage channels in palm groves, causing more oxidative conditions than peatland forests.

Drainage and clearing of peat can cause changes in the ecosystem of the sink into a source carbon(Hirano et al.,2007). EmissionsCH_4 to the atmosphere as much as 43% comes from the wetlands and rice fields, respectively estimated around 20% (Bouwman and Sombroek, 1990; Wild, 1995).

In the opinion of Nurida et al., (2011) that carbon emissions come from the peat forest plant root respiration(autotrophic respiration)and from methanogenic activity which results in CH_4.The increase in GHG emissions from peatlands occurs due to the decomposition of peat(heterotropic respiration).Decomposition of the peat surface increased with increasing aeration in peat profiles due to declining water table. This condition can significantly alter GHG fluxes from the peat surface, there may be a reduction or cessation of emissions of CH_4.

B. Soil temperature in the Soil Profile

Soil temperature data presented in Figure 2 shows that the average soil temperature at 4 layers of peat soil in the palm grove is higher than peatland forests. Soil temperatures profiles peatlands for oil palm plantations from 28.23 to 30.83 ^oC and peatland forests of 28.00 to 30.10 ^oC.Distribution pattern of soil temperature in two locations (Period: 2015-2016)Figure 2.

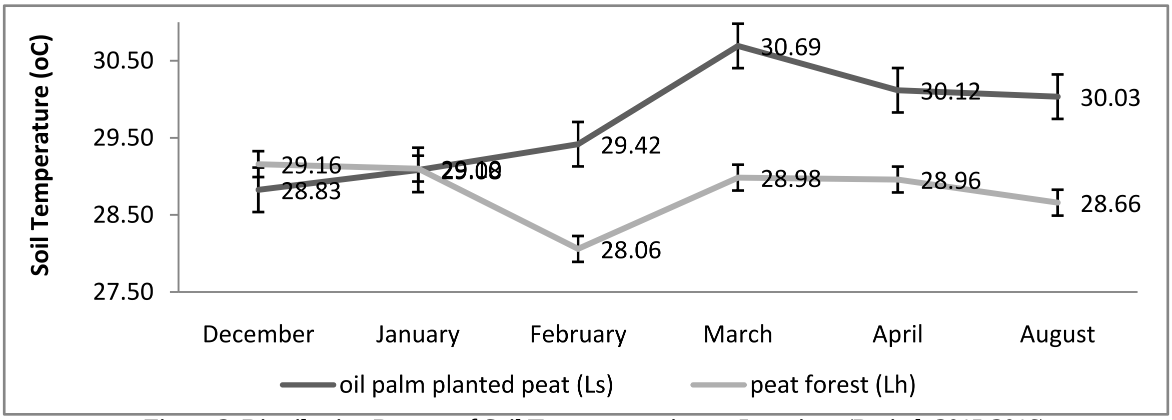

Figure 2. Distribution Pattern of Soil Temperature in two Locations (Period: 2015-2016)

Results of analysis of variance showed that the conversion of peatland forests into oil palm plantations significant effect on the increase in ground temperature in the soil profile. In general the temperature of the soil in the soil profile palm plantations in peatlands higher than peatland forests. The high temperature of the soil in the profile peatland palm groves, due to plant species with homogeneous low density, whereas in plants the forest is quite heterogeneous, solid, high density, a lot of litter.

C. The Surface Temperature of the Soil Around the Chamber (10 Cm)

Of land surface temperature data presented in Figure 3 shows that the temperature of the soil surface around the chamber (10 cm) of oil palm plantations in peatlands tends to be lower than in peatland forests. The surface temperature of the soil around the chamber (10 cm) of oil palm plantations in peatlands of 26.74 - 27.89 °C and peatland forests of 27.71 - 28.92 °C. The temperature range between 26-29 °C, including room temperature criteria.

Results of analysis of variance showed that the conversion of peatland forests into oil palm plantations significant effect on land surface temperature reduction around the chamber (10 cm). In general, temperatures around the chamber The oil field is lower than the forest land, but the temperature difference between the palm forest land and land is relatively small and still in the temperature range between 26-29 oC (room temperature criteria).Distribution pattern of soil temperature around the chamber in two locations (Period: 2015-2016)Figure 3.

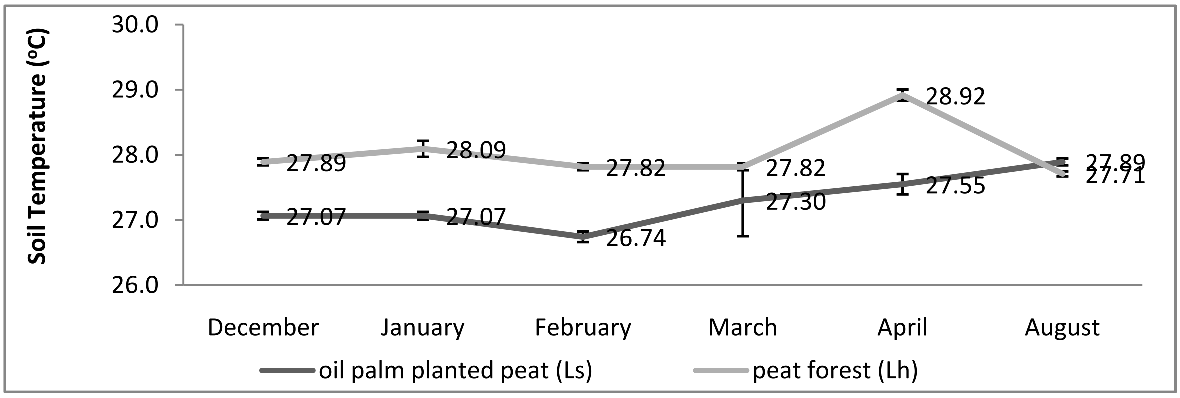

Figure 3. Distribution Pattern of Soil Temperature Around the Chamber in two Locations (Period: 2015-2016).

D. Water Table

Data water table presented in Figure 4 show that the water table The palm garden peatlands to be lower than in peatland forests. Water table The oil palm land between (-78.98 - (-33.95) cm and forest land between (-69.48 - (+22.40) cm, with the distribution pattern of tend to be irregular. Value Water table position forest lands in January and March portrait waterlogged soil conditions.

Results of analysis of variance showed that the conversion of peatland forests into oil palm plantations significant effect on the decline in the water table. The water table in the oil fields deeper than forest land. Water table deepest in the palm plantation and forest land located in the month of August with the value of each -78.98% and -69.48%. The water table in the forest has a positive value in January and March respectively to the value of 22.40% and 6.00% of the land surface (Figure 4).

These conditions indicate the area in case of flooding. The level of ground water level is closely related to weather conditions, particularly the amount of rainfall and rainy days when measurements in the field. Picture of the climatic conditions in the study area when measurements showed that the average rainfall per month from December to August between 126.0 to 398.0 mm and the average number of rainy days between 6-18 days. The highest amount of rainfall in January (398.0 mm) and the lowest amount of rainfall in August (126.0 mm). The depth of the water table in the oil fields disebebkan their drainage channels to accelerate the reduction of water in the plantation area, while forest land no channels, so the existing water remains stagnant. The existence of drainage is very influential in both the soil temperature in the soil profile and on the ground.Distribution pattern of water table in two locations (Period: 2015-2016)Figure 4.

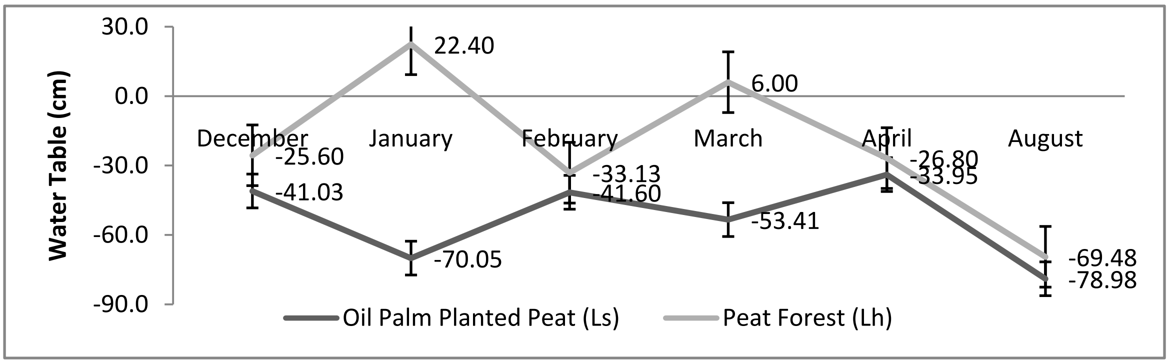

Figure 4. Distribution Pattern of Water Table in Two Locations (Period: 2015-2016)

Relationship between soil temperature in the soil profile, land surface temperature around the chamber (10 cm) and Water table with gas emissionCH_4

Test results correlation between emissions CH_4 the temperature of the soil within the soil profile (depth I (0-35 cm); II (35-70 cm); III (70-105 cm); IV (105-140 cm)), the temperature of the soil surface around the chamber (10 cm) and water table, showing that emissionsCH_4 significantly correlated with the water table and soil temperature at a depth of IV (105-140 cm), with a correlation coefficient (r) -0.630 and 0.02 (p-value <0.05). Based on the regression test results indicate that the land surface temperature around the chamber (10 cm) and the water table significantly influenceemissionsCH_4, with a p-value respectively 0.028 and 0.0001 (p <0.05), with regression coefficient (b) respectively 0.603 and (-0.026). The coefficient of determination (R^2)produced 0.6390 and water table give the largest contribution to the emission of CH_4 (43.97%) of the total value of the effective contribution of 63.90%. This is in line with the results of research conducted by the Rule and Clymo (1998), Hargreaves and Fowler (1998), Jungkunst et al.(2008), Berglund and Berglund(2011).

The liberation of gasCH_4 from the soil to the atmosphere can occur with the role of the water table (how bubbling) and soil temperature (diffusion method). How bubbling, the water table in making land contains more air space and together with the air bubbles out of the ground,gas CH_4 is released into the atmosphere. Diffusion occurs because of the role of soil temperature in the soil profile and soil surface temperature is high, causing differences in concentration in the atmosphere is higher than in the soil. With the air space in the soil that much, then the gasCH_4 in the ground faster and more move into the atmosphere. This is in line with the results of research conducted by Jauhiainen et al., (2001) the process flow of emissionsCH_4 of peatlands occur through bubbling, diffusion, and transport of vascular plants.

The research result Husin (1994), said that the presence of ground water in tropical peat swamp forests have an important role as an abiotic control the flow of gasses into the atmosphere. Daily variation of methane emission in paddy fields affected by the type of water management and soil temperature, wherein at noon methane emissions greater than the dawn. Old and patterns of flooding, saturation is an important criterion for the formation of CH_4 (Neue and Roger, 1993). The optimum temperature ranges the formation of CH_4 (25-30^{0}C). On condition that there is enough substrate, an increase in temperature from 17^{0}C to 30^{0}C causes an increase in production of 2.5 - 3.5 times (Nieder and Benbi, 2008).

Given the land surface temperature around the chamber (10 cm) and the water table significantly influenceemissions CH_4, it is necessary strategies of these two variables manipulation technology to minimize emissions of gasCH_4 oil palm plantations on peatland. Manipulation is done so that the ground surface temperature around the chamber (10 cm) are at the lowest temperature (26.65 ^{0}C) and the water table is less than 80 cm.

Recommendations can be given to manipulate the land surface temperatures around the chamber (10 cm), to be maintained under these conditions, ie by planting ground cover plants (roots shallow) or give mulch from the midrib of palm and palm empty fruit bunches of oil to reduce evaporation. The type of ground cover plants (roots shallow) are frequently used and can be recommended is Centrosome sp. Colopogoniummuconiodes, Puerarianjavanica, Mucunabracteata.To maintain the water table conditions is not more than 80 cm, it needs to be made so that the surface water drainage channel in the main channel is maintained at a depth of 60-70 cm below the soil surface and the groundwater in the planting of oil ranges between 40-60 cm.

IV. CONCLUSION

The transformation of peatland forests into oil palm plantations significant effect on the increase in gasemissions of CH_4, the temperature of the soil within the soil profile and significant effect on land surface temperature reduction around the chamber (10 cm) and the water table.

Gas emissionsCH_4 in the oil fields higher than forest land. EmissionsCH_4 significantly correlated with the water table and soil temperature at a depth of IV (105-140 cm), with a correlation coefficient (r) and 0.020 -0.630 (p <0.05).

The surface temperature of the soil around the chamber (10 cm) and the water table significantly influenceemissions CH_4, with a p-value 0.028 and 0.0001 (p <0.05), the regression coefficient (b) respectively, and 0.603 (-0.026). The coefficient of determination (R^2)produced 0.6390 and water table give the largest contribution to the emission of CH_4 (43.97%) of the total value of the effective contribution of 63.90%.

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