DYNAMIC OF METHANE AND CO\textsubscript{2} FLUXES FROM SAGO PALM (METROXYLON SAGU ROTTB.) PLANTATION IN PAPUA PEATLAND, INDONESIA

DINAMIKA FLUKS METANA DAN CO\textsubscript{2} DARI PERKEBUNAN SAGU (METROXYLON SAGU ROTTB.) DI LAHAN GAMBUT PAPUA, INDONESIA

Anggri Hervania\textsuperscript{1}, Randy Sanjaya\textsuperscript{1}, A. Wihardjaka\textsuperscript{1}, Prihasto Setyanto\textsuperscript{1}, Maswar\textsuperscript{2}

\textsuperscript{1}Indonesian Agricultural Environment Research Institute. Jl. Jakenan-Jaken Km 5 Jakenan Pati 59182
\textsuperscript{2}Indonesian Soil Research Institute. Jl. Tentara Pelajar, No.12, Bogor 16114

Abstract. Peatland use for sago palm plantation can emit greenhouse gases (CH\textsubscript{4}, CO\textsubscript{2}, N\textsubscript{2}O) to the atmosphere. The aims of the study was to determine the flux dynamics of CH\textsubscript{4} and CO\textsubscript{2} in sago palm. The study on the dynamic of methane (CH\textsubscript{4}) and carbon dioxide (CO\textsubscript{2}) fluxes from sago palm plantation in Papua peat land was conducted using a closed chamber technique. Fluxes of CH\textsubscript{4} and CO\textsubscript{2} were measured every three months, beginning on April 2013 until March 2014. Results, showed annual CO\textsubscript{2} emissions at 34,88 t CO\textsubscript{2}-e ha\textsuperscript{-1} yr\textsuperscript{-1} and CH\textsubscript{4} emissions at 9,96 t CO\textsubscript{2}-e ha\textsuperscript{-1} yr\textsuperscript{-1}. Temporal variation of the measured CO\textsubscript{2} was very high suggesting the need for a higher frequency measurement. CO\textsubscript{2} and CH\textsubscript{4} fluxes were neither influenced by carbon stock nor peat thickness.

Keywords: Closed chamber, sago, emission, methane, carbon dioxide, peat land.

INTRODUCTION

Peat land as a hydrology and ecology function has the particularity that is as biodiversity habitats and important carbon stock. Peat land can store carbon in the form of organic matter accumulated over thousands of years. Indonesia peat land tangible in mixed forest, secondary forest, scrub, and grassland marsh (Istomo, 2005). Extensive peat in Indonesia reached 21 million hectares representing 10,8% Indonesia's land area, 35% were in Sumatra, Kalimantan 32%, 30% and 3% in Papua and Sulawesi (Agus and Subiksa, 2008). On the entire peat land area, 7,97 million hectares in Papua (Wahyunto et al., 2006). The peat area approximately 33,07% considered feasible for cultivation of agricultural crops (Agus and Subiksa, 2008).

Sago palm for several years assimilated carbon dioxide from on a rainforest system, this makes an important effect and good for environmental remediation. Sago forests as carbon stocks are potentially to carbon sequestration so that greenhouse gas mitigation should be done to reduce the effects of global warming (Flores, 2009). Carbon dioxide be
used sago palm for photosynthesis and be stored in sago log as carbon biomass was estimated at about 250 kg per log (Craun cit Sulaiman et al., 2008). Emissions from different ecosystems are very dynamic, differences on peat land ecosystem, different significantly on flux. Cumulative greenhouse gas flux for forest, sago, and oil palm ecosystem are 18.34 mg C m$^{-2}$ yr$^{-1}$; 179.54 mg C m$^{-2}$ yr$^{-1}$; -15.14 mg C m$^{-2}$ yr$^{-1}$, respectively (Melling et al., 2005).

The aims of the study was to determine the dynamics flux of methane and carbon dioxide in sago palm on peat lands and its correlation with carbon stocks and peat thickness as well as compare emissions from sago palm.

**MATERIALS AND METHODS**

Monitoring of the dynamics of fluxes on sago palm plantations carried out in peat land in Mimika of Papua Province during 2013-2014. Greenhouse gas flux monitoring was done four times, namely April 2013, July 2013, October 2013, and March 2014. Gas samples were taken from six sites with a distance of 20 meters between sites (Figure 1.). Coordinated site of gas sampling was represented in Table 1.

Gas samples were taken twice using a closed cylindrical chamber technique with 21 cm in diameter 30 cm in height, in the morning (07.00-09.00 am) and afternoon (12.00-14.00 pm). Gas sample were taken every 3 minutes intervals at minute of 3$^{rd}$, 6$^{th}$, 9$^{th}$, 12$^{th}$, 15$^{th}$, 18$^{th}$, and 21$^{th}$ after closing rubber septum. Gas samples were taken using syringe vol. 10 mL and immediately stored in vials. At the firts time sampling, the area have been disturbed for first time. No water management at this area, growth of sago palm is natural existing.

![Figure 1. Scheme of sampling site on Timika Papua.](image)
Table 1. Coordinate site of gas sampling, stock carbon, and thickness peat land.

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>S</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>4° 34',084'</td>
<td>136° 43,752'</td>
</tr>
<tr>
<td>II</td>
<td>4° 34,086'</td>
<td>136° 43,737'</td>
</tr>
<tr>
<td>III</td>
<td>4° 34,075'</td>
<td>136° 43,725'</td>
</tr>
<tr>
<td>IV</td>
<td>4° 34,078'</td>
<td>136° 43,700'</td>
</tr>
<tr>
<td>V</td>
<td>4° 34,072'</td>
<td>136° 43,687'</td>
</tr>
<tr>
<td>VI</td>
<td>4° 34,067'</td>
<td>136° 43,663'</td>
</tr>
</tbody>
</table>

Gas samples were analyzed in Greenhouse Gases Laboratory of Indonesian Agricultural Environment Research Institute in Central Java. The concentration of CH₄ and CO₂ was determined by a micro gas cromathography of GC CP 4900. Calculation of CO₂ and CH₄ fluxes was adapted using equation from IAEA (1993):

\[
E = \frac{Bm \times \delta Csp}{Vm} \times \frac{V}{A} \times \frac{x 273.2}{T + 273.2}
\]

\[\text{.........................(1)}\]

Information:

\(E\) = emissions CO₂/CH₄ (mg m⁻² day⁻¹)

\(V\) = volume of chamber (m³)

\(A\) = board base lid (m²)

\(T\) = average temperature in chamber (°C)

\(\delta \text{Csp}/\delta t\) = the change rate concentration of CH₄ dan CO₂ (ppm/minute)

\(Bm\) = gas molecular weight CH₄ dan CO₂

\(Vm\) = gas volume in stp (standard temperature of 25 °C and pressure of 1 atm): 22,41 L

Peat thickness and carbon stock were measured at the same site with gas sampling. Site of peat thickness observation was presented in Figure 2.
RESULTS AND DISCUSSIONS

Papua Province has approximately 2,644,438 hectares of peat land dominated shallow peat (50-100 cm) is about 1,506,913 hectares (56,98%) and peat medium (100-200 cm) covering an area of 817,651 hectares (30,92%) and peat in (> 200 cm) covering an area of 319,874 hectares (12,10%) (Ritung et al., 2013). Based on the peat land map in Papua (Fig.2), sago palm in sampling area were on shallow until medium peat land thickness.

Dynamic of Methane Flux

The methane (CH₄) flux on April 2013 in sampling site at point 2 showed the highest one (Fig.3) due to high methanogenic activity. Activity of methanogens in peat lands can easily be detected because methanogenic metabolic activity is directly related to the amount of CH₄ produced in peat. The quantities of CH₄ emitted from peat lands are, however, not always proportional to the activity of methanogens, since emission rates represent the quantity of CH₄ produced in anoxic layers minus the amount of CH₄ oxidized by methanotrophs in aerobic layers. Methanogen activity is more precisely correlated to potential methane production (Galand, 2004).

Average daily CH₄ flux on sago land in Timika is equal to 328,56 mg CH₄ m² d⁻¹ in April 2013, increasing to 67,28 mg CH₄ m² d⁻¹ in July 2013, 77,72 mg CH₄ m² d⁻¹ in the October 2013, and 46,07 mg CH₄ m² d⁻¹ in March 2014. The first sampling on April 2013 showed the highest flux, early GHG flux measurement must disturb the turf conditions, thus promoting the release of CO₂ and CH₄ is higher than when the next GHG flux measurements. The deviation on first measuring CH₄ fluxes on April 2013 is highest (Fig.3.)
Dynamic of Methane and CO₂ Fluxes from Sago Palm

Dynamic of Carbondioxide Flux

The carbondioxide (CO₂) flux on first sampling, showed the highest one (Fig.4). Early GHG flux measurement must disturb the turf conditions, thus promoting the release of CO₂ is higher than when the next GHG flux measurements. Purwanto et al., (2005) suggested that the organic matter accumulated was more aromatic in tropical peats than in boreal peats, which may be derived from the differences in vegetation and rate of decomposition of labile organic compounds and a cause of the small and less-varied CO₂ flux.

Average daily CO₂ fluxes on sago land in Timika is 21.100 mg of CO₂ m² d⁻¹ in April 2013, declined to 5.240 mg CO₂ m² d⁻¹ in July 2013, 7.503 mg CO₂ m² d⁻¹ in October 2013, and 4.380 mg CO₂ m² d⁻¹ in March 2014. The deviation on first measuring CO₂ fluxes on April 2013 is highest (Fig.4.)
Emissions CO₂ and CH₄

Emissions at the first time sampling showed the high emissions compared with the other time sampling (Table 2). Disturbed the location at the first time sampling have been released CO₂ and CH₄ to the atmosphere.

Table 2. Emissions CO₂ dan CH₄ in Timika Papua.

<table>
<thead>
<tr>
<th>Date</th>
<th>CO₂</th>
<th>CH₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-Apr 2013</td>
<td>77,02</td>
<td>25,18</td>
</tr>
<tr>
<td>17-Jul 2013</td>
<td>19,13</td>
<td>5,16</td>
</tr>
<tr>
<td>22-Okt 2013</td>
<td>27,39</td>
<td>5,96</td>
</tr>
<tr>
<td>05-Mar 2014</td>
<td>15,99</td>
<td>3,53</td>
</tr>
<tr>
<td>Mean</td>
<td>34,88</td>
<td>9,96</td>
</tr>
</tbody>
</table>

The annual CO₂ emissions from sago palm plantation in Papua showed 34,88 t ha⁻¹ yr⁻¹ and CH₄ emissions is 9,96 t ha⁻¹ yr⁻¹. Total emissions from sago peat land in Papua is 44,84 t CO₂-e ha⁻¹ yr⁻¹. The natural sago palm showed the high emissions, not significant compared with oil palm emissions 46 ± 30 t ha⁻¹ yr⁻¹ in Jambi Province (Setiari and Agus, 2013) as well as Melling et al., (2007), found a peat emission rate of 41 t ha⁻¹ yr⁻¹ under a five-year-old oil palm plantation in Sarawak, Malaysia. Water management need on contributing natural ecosystem such as sago palm in Papua to reduce greenhouse gas emissionis, Akira et al., (2009) said that maintained ground water level at < -45 cm impact on small CH₄ fluxs.

No significant correlation between CO₂ flux and peat land thickness as well as stock carbon based on correlation person test, 0,018 and -0,018 respectively. CO₂ was positively correlated with the water table, in the ground water level higher CO₂ emissions, whereas for methane valid otherwise, the difference due to the depth of water table drainage effect on CO₂ flux (Batubara 2009), (Handayani 2009), Moore and Dalva (1993). According to research by Handayani (2009), the depth of ground water level due to drainage determine the oxidation and reduction which is strongly associated with the rate of decomposition and determine the value of the CO₂ flux. The deeper of water table correlate with that decomposition of organic matter and CO₂ flux high because CO₂ is the end product of the decomposition process. Detailed information is required to evaluate the contribution of peat lands thickness and stock carbon to CO₂ emission from sago palm.
Dynamic of Methane and CO$_2$ Fluxes from Sago Palm

No significant correlation between CH$_4$ flux and peat land thickness as well as stock carbon based on correlation person test, -0.334 and 0.334, respectively. Melling et al., (2005) suggested that in sago ecosystem, the seasonal variation in CH$_4$ flux was positively correlated with rainfall due to the necessary retention of high water table for the crop which increased its susceptibility to flooding (and anaerobic conditions). CH$_4$ produced by biologically in anaerobic sites, methanogen activity and CH$_4$ oxidixer, such as temperature, reduction-oxidation potential, and the amount of easily decomposable organic matter, as well as the type of vegetation are potential factor affecting temporal and spatial variations in CH$_4$ emissions from peat land (Blodau, 2002; Treat et al., 2007).

CONCLUSIONS

In Papua peat land used for sago palm cultivation, the annual CO$_2$ emissions was 34.9 t CO$_2$e ha$^{-1}$ yr$^{-1}$ and CH$_4$ emissions was 10.0 t CO$_2$e ha$^{-1}$ yr$^{-1}$. CO$_2$ and CH$_4$ fluxes were not influenced by stock carbon and thickness peat land. The possibilities that CO$_2$ and CH$_4$ fluxes from sago palm plantation were influenced by groundwater and biological activities.

ACKNOWLEDEMENT

This research was supported by ICCTF (Indonesian Climate Change Trust Fund). We thank to Prof Fahmudin Agus for the assistance. We thank to Ali Pramono, Miranti Ariani, Titi Sopiawati, Sri Wahyuni for excellent assistance in the laboratory, and also thank to Jumari, Randy Sanjaya, Susanto for assistance in field. We also wish to thank Dr Maswar Bahar on their assistance in stock carbon and thickness petland.

REFERENCE


Galand, P.E. 2004. Methanogenic Archaea in boreal peat lands. Academic Dissertation in General Microbiology. General Microbiology Department of Biological and Environmental Sciences Faculty of Biosciences University of Helsinki Academic.


