



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.*



## Horizontal and vertical emissions of methane from peat soils

A.V. Jeffary<sup>1</sup>, O.H. Ahmed<sup>1,2,3</sup>✉, R.K.J. Heng<sup>4</sup>, L.N.L.K. Choo<sup>5</sup><sup>1</sup>Department of Crop Science, Universiti Putra Malaysia (UPM), Bintulu Campus, Bintulu, Sarawak, Malaysia<sup>2</sup>Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia, Serdang, Selangor Darul Ehsan, Malaysia<sup>3</sup>Center of Excellence in Borneo Ecosystem Science Research (Borneo Ekosains), Universiti Putra Malaysia (UPM), Bintulu Campus, Bintulu, Sarawak, Malaysia<sup>4</sup>Department of Forestry Science, Universiti Putra Malaysia (UPM), Bintulu Campus, Bintulu, Sarawak, Malaysia<sup>5</sup>Soil and Water Management Programme, Strategic Resource Centre, Malaysian Agricultural Research and Development Institute (MARDI), Roban, Saratok, Sarawak, Malaysia

### ARTICLE INFO

#### Article history:

Received: 01 June 2019

Accepted: 31 August 2019

Published: 30 September 2019

#### Keywords:

Emission, Methane flux,

Tropical peatlands,

Greenhouse gas

#### Correspondence:

O.H. Ahmed

✉: [osumanuharuna@gmail.com](mailto:osumanuharuna@gmail.com)

### ABSTRACT

Methane emission depends on the rates of methane production, consumption and ability of soil and plants to transport the gas to the soil surface and also within soil particles. The objective of this study was to determine CH<sub>4</sub> fluxes horizontally and vertically from the floor and wall of the pit of a tropical peat soil. The horizontal emissions in the dry and wet seasons were 2.96 t CH<sub>4</sub> ha<sup>-1</sup>yr<sup>-1</sup> and 4.27 t CH<sub>4</sub> ha<sup>-1</sup>yr<sup>-1</sup>, respectively and the vertical emissions were 0.36 t CH<sub>4</sub> ha<sup>-1</sup>yr<sup>-1</sup> and 0.51 t CH<sub>4</sub> ha<sup>-1</sup>yr<sup>-1</sup>, respectively. The total amount of the horizontal and vertical emissions in the dry and wet seasons were 3.32 t CH<sub>4</sub> ha<sup>-1</sup>yr<sup>-1</sup> and 4.78 t CH<sub>4</sub> ha<sup>-1</sup>yr<sup>-1</sup>, respectively. Horizontal emission was higher in the wet season due to an increase in the water table which resulted in an increase of CH<sub>4</sub> emission. Thus, there is a need for direct CH<sub>4</sub> measurement from cultivated peat soils to ensure that CH<sub>4</sub> emission is neither underestimated nor overestimated.

Copyright ©2019 by authors and BAURES. This work is licensed under the Creative Commons Attribution International License (CC By 4.0).

### Introduction

Peat soils are important natural resources. Peat soils have been cleared, developed, and cultivated for large scale plantations due to their positive contribution to Malaysia's economic growth in agricultural sector. Globally, agriculture is considered to be responsible for about two-thirds of the anthropogenic sources of greenhouse gas emissions (Melling *et al.*, 2005). Agriculture, forestry, and peat extraction for fuel and horticultural purposes are major causes of peatland disturbance because when peats are disturbed, the alteration in their hydrology results in the peat's oxidation which alters the greenhouse gases balance (Maria, 2008). Concerns on the role of peatlands as a main carbon sequester started because greenhouse gases (GHGs) emission contributes to global warming (Daud, 2009). Cultivation of different crops has varying impacts on the environment (Azqueta and Sotelsek, 2007). Cultivation of

pineapples on peat soils has now become profitable and popular in Malaysia. Malaysia is known to be the only country in the world that uniquely and largely cultivates pineapples on peat soils. This practice has been in existence for nearly a century. However, concerns by NGOs has been expressed that increasing cultivation of pineapples on peat soils lead to increase in the emissions of harmful greenhouse gas such as methane (CH<sub>4</sub>). Previous study on drained peat soil cultivated with pineapple done by Ahmed and Liza (2014) showed that 0.35% CH<sub>4</sub> were emitted. Currently, there is lack of information on soil CH<sub>4</sub> emissions horizontally and vertically from pineapple cultivation on drained tropical peatlands.

The objective of this study was to quantify horizontal and vertical CH<sub>4</sub> emissions on a drained tropical peatlands cultivated with pineapple.

### Cite this article

Jeffary, A.V., Ahmed, O.H., Heng, R.K.J. and Choo, L.N.L.K. 2019. Horizontal and vertical emissions of methane from peat soils. *Journal of Bangladesh Agricultural University*, 17(3): 359–362. <https://doi.org/10.3329/jbau.v17i3.43212>

## Materials and Methods

### Site description

The study was carried out at Malaysia Agricultural Research and Development Institute (MARDI) Peat Research Station Saratok, Sarawak, Malaysia. MARDI, Saratok has a total area of 387 hectares and located on a logged-over forest with flat topography of 5 m to 6 m above mean sea level (Ahmed and Liza, 2015). Based on the von Post Scale, the peat soils is classified under H7 to H9; well decomposed sapric peat with a strong smell and thickness ranges 0.5 m to 3.0 m (Ahmed and Liza, 2015). The mean temperature of the peat area ranges from 22.1 to 31.7 °C with relative humidity ranging from 61 to 98% (Ahmed and Liza, 2015). The annual mean rainfall of the area is 3749 mm; where in the wet season, the monthly rainfall is more than 400 mm whereas in the dry season is 200.7 mm (Ahmed and Liza, 2015).

### Greenhouse gases emission measurements

Methane emission measurements were carried out at 0-5 cm and 5-10 cm peat soil depths, respectively. Measurements of the CH<sub>4</sub> emission were carried out in 10 m x 10 m drained peat soil plots cultivated with pineapple. Methane flux sampling was carried out for 24 hours at every 6 hours interval (between 0600 hr to 0600 hr) and were monitored once throughout the dry (July 2015) and wet (December 2015) period.

### Soil CH<sub>4</sub> horizontal emission measurements

The horizontal movement of CH<sub>4</sub> emissions from the peat soil surface was measured using the closed chamber method (Norman *et al.*, 1997; Crill *et al.*, 1988). The fabricated I-shaped chamber was gently pressed vertically on the surface of the soil pit at of 3-5 cm depth. The chamber was equilibrated for 30 minutes. The headspace samples of 20 mL were extracted from the chamber every minute for 6 minutes starting at 1 minute using a 50 mL syringe. The extracted gas was then transferred to 20 mL vacuum headspace vials using a disposable syringe needle. Methane concentration was measured using a Gas Chromatography (GC- Agilent 7890A) equipped with a thermal conductivity detector (TCD) (Ahmed and Liza, 2015).

### Soil CH<sub>4</sub> vertical emission measurements

The vertical CH<sub>4</sub> movement was measured at 5 cm depth interval (0-5 cm, 5-10 cm), from the surface to 10 cm above water table (saturated zone). The L-shaped chamber was installed horizontally to the wall of the peat soil at 20 cm. The end of the chamber was covered and sealed with steel cap and parafilm, respectively. For each depth, peat soil was manually removed to a suitable working size pit. The open cylinder was left standing for approximately 30 minutes to establish an equilibrium state.

### Methane flux calculation

The CH<sub>4</sub> sampling and measurement was carried out for 24 hours at every 6 hours (between 0600 hr to 0600 hr). The gas flux was measured in early morning I (0600-0700), afternoon (1200-1300), evening (1800-1900), midnight (2400-0100), and early morning II (0600-0700) to obtain a 24 hours GHG emission. The gas sampling was carried out once a month from July 2015 to August 2015 for dry season; September and December 2015 for wet season. Thus, the total numbers of gas sampling are 4 times in 4 months. The results were based on the measurement of CH<sub>4</sub> from the five durations using two methods (I-chamber and L-chamber) in the dry and wet seasons. The values of CH<sub>4</sub> emitted were averaged and converted into units of t ha<sup>-1</sup> yr<sup>-1</sup>. The CH<sub>4</sub> fluxes were then calculated using the following equation (Zulkefli *et al.*, 2010; Widen and Lindroth, 2003; IAEA, 1992).

$$\text{Flux} = [(\text{CO}_2/\text{CH}_4) \text{ dt}] \times \text{PV} \text{ ART}'$$

where (CO<sub>2</sub>/CH<sub>4</sub>)/(dt) is the evolution rate of CO<sub>2</sub>/CH<sub>4</sub> within the chamber headspace at a given time after which the chamber were placed into the soil, P is the atmospheric pressure, V is the volume headspace gas within the chamber, A is the area of soil enclosed by the chamber, R is the gas constant, and T is the air temperature.

### Statistical analysis

Analysis of variance (ANOVA) was used to detect treatment effects whereas treatments means were compared using Duncan's New Multiple Range Test (DNMRT) at P ≤ 0.05. The statistical software used for this analysis was Statistical Analysis System (SAS) version 9.3.

## Results and Discussion

Methane emission was significantly affected by season (Figure 1). The seasonal variation in CH<sub>4</sub> flux was higher in the wet seasons due to rainfall which might have increased the water table of the peat soil. According to Farmer *et al.* (2011), during wet season, CH<sub>4</sub> is emitted in the form of bubbles which are transported by molecular diffusion through the aerobic layer of the peat. Soil CH<sub>4</sub> emission was not significantly different regardless of sampling period (Figure 1). Methane emission in the morning (1.02 t ha<sup>-1</sup> yr<sup>-1</sup>) was the highest during the wet season followed by early morning (0.99 t ha<sup>-1</sup> yr<sup>-1</sup>). The lowest CH<sub>4</sub> emission occurred at noon (0.72 t ha<sup>-1</sup> yr<sup>-1</sup>). However, in the dry season, CH<sub>4</sub> emission in the early morning (0.68 t ha<sup>-1</sup> yr<sup>-1</sup>) was highest in the dry season followed by at noon (0.64 t ha<sup>-1</sup> yr<sup>-1</sup>). The lowest CH<sub>4</sub> emissions occurred in the morning (0.51 t ha<sup>-1</sup> yr<sup>-1</sup>). The differences in the day and night temperature of the experimental site in the dry and wet seasons might have also inhibited the photosynthetic activity of the *Ananas comosus* (L.) Merr. plants.

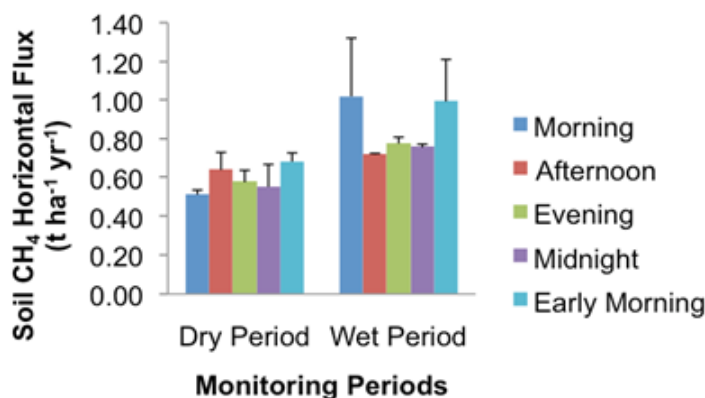


Fig. 1 Horizontal emission of methane from peat soil cultivated with pineapple at different sampling periods (Error bars represent standard error).

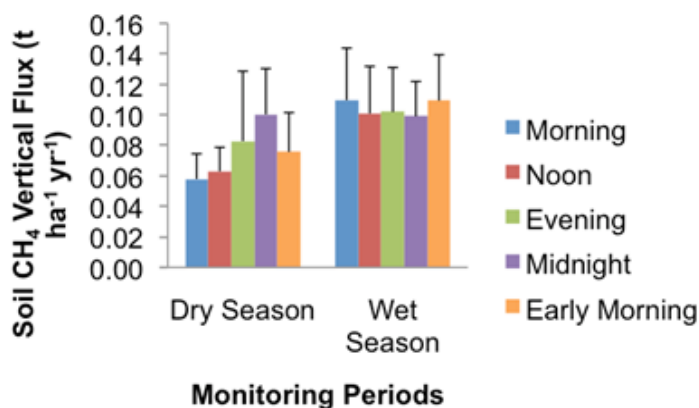


Fig. 2 Vertical emission of methane from peat soil cultivated with pineapple at different sampling periods (Error bars represent standard error).

Furthermore, the root respiration and decomposition of the pineapple plants might have contributed to the emission of CH<sub>4</sub> in the wet season (Ahmed and Liza, 2015). In the dry and wet seasons, there was distinct seasonal variation in the vertical emission of CH<sub>4</sub> (Figure 2). Vertical emission of CH<sub>4</sub> was higher in the wet season due to the water table level of the peat soil. In the wet season, higher CH<sub>4</sub> emission occurred because of favourable conditions essential for methanogenesis which increases oxidation of CH<sub>4</sub> (Melling et al., 2005). The CH<sub>4</sub> emission is also related to the microbial population and the availability of adequate substrate for microbial metabolism, but not for plant root activities (Kechavarzi et al., 2010; Kuzyakov, 2006). According to Melling et al., (2005), a thick aerobic layer with higher temperature increases CH<sub>4</sub> oxidation thus, resulting in higher CH<sub>4</sub> uptake as shown in CH<sub>4</sub> emission during the wet season (Figure 2). The CH<sub>4</sub> emissions were statistically similar across all the five sampling periods however, there was higher CH<sub>4</sub> emission in the early morning (2.73 t ha<sup>-1</sup>yr<sup>-1</sup>) during wet season followed by at noon (2.59 t ha<sup>-1</sup>yr<sup>-1</sup>) and morning (2.06 t ha<sup>-1</sup>yr<sup>-1</sup>) in that order. The CH<sub>4</sub>

emitted regardless of time of sampling was not significantly different (Figure 2).

## Conclusion

In tropical peat soils cultivated with pineapples, horizontal emission of CH<sub>4</sub> is higher than vertical emission. However, to avoid underestimation of CH<sub>4</sub> emission from pineapples cultivation on tropical peats, both horizontal and vertical emissions of this gas must be considered regardless of season.

## Acknowledgements

Sincere appreciation goes to Ministry of Higher Education, Malaysia, and Universiti Putra Malaysia for the financial support provided through Putra Grant and Fundamental Research Grant Scheme (Project FRGS/1/2015/WAB01/MOA/02/2). We would like to thank Malaysia Agricultural Research and Development Institute (MARDI) Saratok, Sarawak, Malaysia for the collaborative research.

## References

- Ahmed, O.H. and Liza Nuriati, L.K.C. 2015. Greenhouse Gas Emission & Carbon Leaching in Pineapple Cultivation on Tropical Peat Soil. Serdang: Universiti Putra Malaysia Press.
- Azqueta, D., Sotelsek, D. 2007. Valuing Nature: from environmental impacts to natural capital. *Ecological Economics* 63, 22–30.
- Crill, P.M., Bartlett, K.B., Harris, R.C., Gorham, E., Verry, E.S., Sebacher, D.L., Madzar, I., Sanner, W. 1988. Methane flux from Minnesota peatlands. *Global Biogeochemical Cycles*, 2: 371–384. <https://doi.org/10.1029/GB002i004p00371>
- Crill, P., K. Bartlett, R. Harriss, E. Gorham, E. Verry, D. Sebacher, L. Madzar, and W. Sanner. 1988. Methane flux from Minnesota peatlands. *Global Biogeochemical Cycles*, 2: 371–384.
- Daud, A. 2009. Economic Valuation of Pineapple Cultivation on Peat Soil at the Integrated Agricultural Development Area, Samarahan, Sarawak. Ph.D. dissertation, Universiti Putra Malaysia, 2009.
- Farmer, J., Matthews, R., Smith, J.U., Smith, P. and Singh, B.K. 2011. Assessing existing peatland models for their applicability for modelling greenhouse gas emissions from tropical peat soils. *Current Opinion in Environmental Sustainability*, 3: 339–349. <https://doi.org/10.1016/j.cosust.2011.08.010>
- IAEA. 1992. *Manual on Measurement of Methane and Nitrous Oxide Emissions from Agriculture*. In Sampling techniques and sample handling, pp. 45–67 IAEA-TECDOC-674. Vienna, Austria: IAEA.
- Kechavarzi, C., Dawson, Q., Bartlett, M. and Leeds-Harrison, P.B. (2010). The Role of Soil Moisture, Temperature and Nutrient Amendment on CO<sub>2</sub> Efflux from Agricultural Peat Soil Microcosms. *Geoderma*, 154: 203–210. <https://doi.org/10.1016/j.geoderma.2009.02.018>
- Kuzyakov, Y. (2006). Sources of CO<sub>2</sub> Efflux from Soil and Review of Partitioning Methods. *Soil Biology & Biochemistry*, 38: 425–448. <https://doi.org/10.1016/j.soilbio.2005.08.020>
- Kuzyakov, Y. and Larionova, A.A. (2006). Contribution of Rhizomicrobial and Root Respiration to the CO<sub>2</sub> Emission from Soil (A Review). *Eurasian Soil Science*, 39(7): 753–764.
- Maria, S. 2008. *Peatland and Climate Change*. Finland: International Peat Society. <https://doi.org/10.1134/S106422930607009X>
- Melling, L., Hatano, R., Goh, K.J. 2005. Soil CO<sub>2</sub> flux from three ecosystems in tropical peatland of Sarawak, Malaysia. *Tellus B* 57: 1–11. <https://doi.org/10.1111/j.1600-0889.2005.00129.x>
- Norman, J.M., Kucharik, C.J., Gower, S.T., Baldocchi, D.D., Crill, P.M., Rayment, M., Savage, K., Striegl, R.G., 1997. A comparison of six methods for measuring soil-surface carbon dioxide fluxes. *Journal of Geophysical Research*, 102: 28771–28777. <https://doi.org/10.1029/97JD01440>
- Wid'en, B. and Lindroth, A. 2003. A calibration system for soil carbon dioxide-efflux measurement chambers. *Soil Science Society of America Journal*, 67: 327–334. <https://doi.org/10.2136/sssaj2003.3270>
- Zulkefli, M., Liza Nuriati, L.K.C., and Ismail, A.B. 2010. Soil CO<sub>2</sub> flux from tropical peatland under different land clearing techniques. *Journal of Tropical Agriculture and Food Science*, 38 (1): 131–137.