Abstract No: A-115

CHANGES IN THE PHYSICOCHEMICAL PROPERTIES OF TROPICAL PEAT DURING ITS EARLY DECOMPOSITION UNDER OIL PALM PLANTATION ENVIRONMENTS

Masahiro Maeda[1], Nagamitsu Maie[1], Lulie Melling[2], Hajime Tanji[1], Zulhilmy Abdullah Mohd[2] and Akira Watanabe[3]

[1]School of Veterinary Medicine, Kitasato University, Aomori, Japan
[2]Tropical Peat Research Laboratory Unit, Chief Minister's Department, Sarawak, Malaysia
[3]Graduate School of Bioagricultural Sciences, Nagoya University, Nagoya, Japan

**Corresponding author: maie@vmas.kitasato-u.ac.jp*

SUMMARY

Peatland environment, such as groundwater level and nutrient status, determines the vegetation type of tropical peat swamp forest (TPSF). As such, tropical peat (TP) with different vegetation may have different physico-chemical properties and thus exhibit different vulnerability to environmental changes. In Sarawak, oil palm plantation (OPP) has extended into tropical peatlands, due to limited acreage of arable dry field. Therefore, it is crucial to understand the changes in the biogeochemical processes of tropical peatland under OPP environments for the sustainable management. In this study, we aim to evaluate the diversity in the decomposition rate and process of TP under OPP environments. To achieve that purpose, a mesocosm incubation experiment was conducted. Peat samples were collected from three major types of TPSF in Sarawak, namely, mixed peat swamp (*MPS*), *Alan Batu* (*A. Batu*), and *Alan Bunga* (*A. Bunga*) forests. Peat samples were packed in a PVC column (10cm ID x 80 cm L), and buried in an OPP. The mesocosms were recovered after 1-year of incubation, and changes in the mass and the physicochemical properties of TP were investigated for particle size distribution (wet sieving) and C composition (^{13}C CPMAS NMR). Physico-chemical analyses of intact TP (before incubation) revealed that *MPS* had undergone microbial decomposition to a greater extent than *A. Batu* and *A. Bunga*. C composition of TP was relatively similar among different particle size fractions for each forest type. After 1-year incubation, total C (TC) decreased by 14±4% for *A. Batu* but significant decrease was not observed for other two types. TC of <63 µm size fraction increased and/or > 4 mm size fraction decreased significantly for all forest types, suggesting a rapid downsizing of TP at an early stage of decomposition under OPP environments.

Keywords: *decomposition process, physicochemical properties, Tropical peat, vegetation*

INTRODUCTION

Tropical peatland area is estimated to contribute to 11% (44.1x10^4 km^2) of global peatland area, of which 56% is located in Southeast Asia (Page *et al.,* 2011). A large amount of wood peat is accumulated under tropical peat swamp forest (TPSF). Carbon stock of tropical peatland in Southeast Asia is estimated to be 68.5 PgC, of which Indonesia and Malaysia account for 65% and 10% respectively (Page *et al.,* 2011).

Since 1960s, countries such as Indonesia and Malaysia in Southeast Asia, began to develop tropical peatland to OPP due to limited acreage of arable dry field. Once tropical peatland is developed to OPP, the environment changes considerably and may accelerate the decomposition of peat. Therefore, it is important to better understand the changes in the physico-chemical properties of peat accompanied by the changes in peat environment or land utilization to contribute to the sustainable development of TP.

Groundwater level and nutrient status are reported to change with the distance from river. For examples, total phosphorous, total nitrogen, and total potassium decrease as the distance from the river increases (Sjogersten *et al.,* 2011). As such, zones of different vegetation develop along with the distance from the river. Specifically, major species of TPSF successes from *MPS*, *A. Batu*, *A. Bunga*, and *Padan Alan* from the margin to the center of peat dome in Borneo, Malaysia (Melling *et al.,* 2007). Since groundwater level, microbial activity, and the quantity and quality of organic matter supplied are different among different vegetation, physico-chemical properties and vulnerability of peat may also vary between them. As such, it will be desirable to develop tropical peatland considering the variety of the decomposition characteristics. However, little is known on the variation in the decomposition rate and process of TP.

Therefore, we aim to evaluate the variation in the decomposition rate and process of TP converted to OPP environments. To achieve that purpose, we conducted a mesocosm incubation experiment. Peat samples were

Figure 1: A picture of mesocosm incubation experiment conducted in Naman OPP. A mesocosm was 80cm long and 10cm in diameter. A 20 cm extension pipe and a fringe was attached to measure greenhouse gas emission rate (Faustina *et al*.). Each mesocosm contains either *MPS*, *A. Batu*, or *A. Bunga* peat. Incubation experiment was conducted in 4 replicates.

collected from 3 types of primary forests (namely, *MPS*, *A. Batu*, and *A. Bunga*) in Maludam National Park, Sarawak, Malaysia, and incubated in an OPP by using mesocosm (Figure 1). After 1-year incubation, mesocosms were recovered, and changes in the physical and chemical properties of peat were investigated by size fractionation and ^{13}C CPMAS NMR-based C composition.

METHODS

Sample Collection

Peat samples were collected between 20 and 40 cm from *MPS* (1.2 km from Batang Lupar River), *A. Batu* (5.0 km), and *A. Bunga* forests (5.9km) at Maludam National Park, Sarawak, Malaysia.

Preparation of mesocosm

Peat samples were transported to Naman OPP, Sibu, Sarawak, where incubation experiment was conducted. TP samples were mixed thoroughly by hand and large plant debris were removed. TP sample amounting to ca. 800 g was packed into a PVC pipe (9 cm ID Ｘ 20 cm L), to which a piece of polyester air filter (1 cm thickness) was inserted beforehand. A mesocosm was prepared by connecting 4 pipes in series using couplers and the bottom was covered with polyethylene net with 7 mm mesh. The mesocosms were buried into peat so that the top surfaces of the peat in the mesocosm and OPP were leveled (Fig. 1). The experiment was conducted in 4 replicates in an OPP.

Particle size fractionation

TP was sieved in wet condition successively into 8 different size fractions of 2mm, 1mm, 0.5mm, 0.25mm, 0.125mm, and 0.063mm. Fractionated samples were freeze-dried and weighed. The <0.063mm size fraction was collected by the combination of centrifugation and filtration.

Chemical Analyses

Total C and N contents were measured using a NC analyzer (Sumigraph NC-22). Solid state ^{13}C NMR spectra were measured at a ^{13}C resonance frequency of 100.7 MHz on a Jeol ECX-400 NMR spectrometer equipped with a commercial 4-mm CPMAS probe using a standard RAMP-CP pulse sequence. Analytical conditions used were as follow; i) rotation frequency of 10.0 kHz; ii) recycle delay0.7-1s; iii) Gaussian line broadening, 50-100Hz.

RESULTS AND DISCUSSION

Variety in the physicochemical properties of TP under different vegetation

A. Batu and *A. Bunga* peats contained large percentages of the finest (< 63 µm) and coarsest (>4.0 mm) size fractions (Fig. 2). *MPS* contained a lower percentage of finest size fraction than other two peats. However, C composition analysis revealed that *MPS* contained higher percentage of alkyl C than *A. Batu* and *A. Bunga* peats, suggesting higher degree of microbial decomposition for the former (Fig. 3). These apparent discrepancies can be explained the types of peat fragmentation processes. One is physical fragmentation by external forces such as root growth, and the other is microbial decomposition accompanied by fragmentation. Changes in the amount of respective size fraction is determined by a balance between supply and consumption. For *MPS* peat, consumption rate of the finest size fraction was probably faster than the supply rate. On the other hand, physical fragmentation was probably more dominant than microbial decomposition for *A. Bunga* peat. Lower percentage of O-alkyl C for *MPS* peat further suggests that *MPS* peat contains less amount of easily decomposable organic matter than other two types.

Decomposition rate and decomposition process

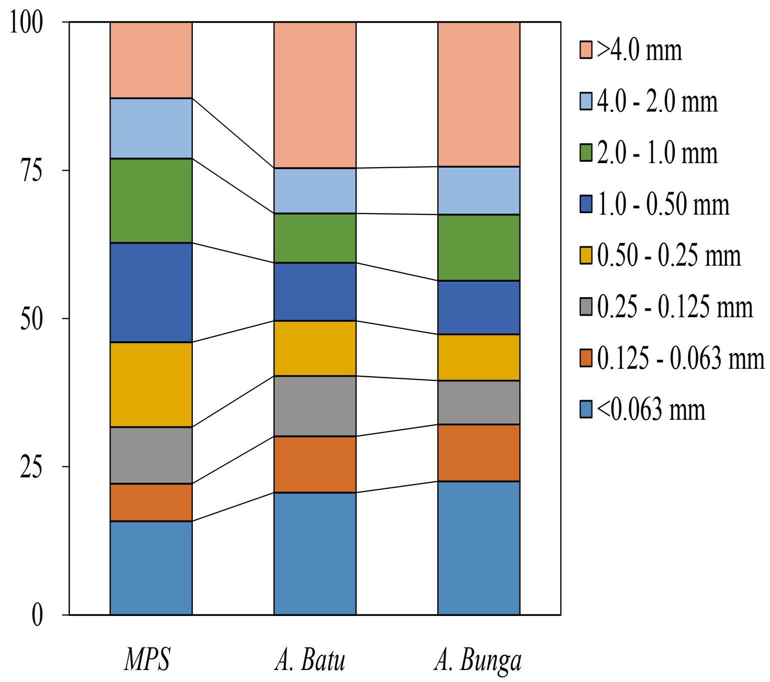

Figure 2: Particle size distribution patterns of tropical peat before incubation.

After 1-year incubation, C amount did not decrease significantly for *MPS* (residual C after incubation; 102±3%) and *A. Batu* (101±3%) peat. However, a significant decrease was observed for *A. Bunga* peat (86±4%; Student's-T test, $p < 0.05$). Faustina *et al.,* (unpublished data) found that mineralization rates of *MPS*, *A. Batu*, and *A. Bunga* peats during 1-year were 2.7%, 3.8%, and 6.6%, respectively. Therefore, a few percentages of mineralization did not seem to be detectable from the mass decrease of mesocosm. However, since mass decrease of *A. Bunga* was about two times of the mineralization rate, leaching of dissolved organic matter (DOM) from mesocosm is considered to be also an important decomposition process for *A. Bunga* peat. Particle size distribution (PSD) showed an increase of the finest particle size fraction (<63 µm) for *MPS* and *A. Batu* peats, and a decrease of the coarsest (> 4 mm) particle size fraction for *A. Bunga* peat, both of which suggested a rapid decrease of particle size of peat during 1-year of incubation.

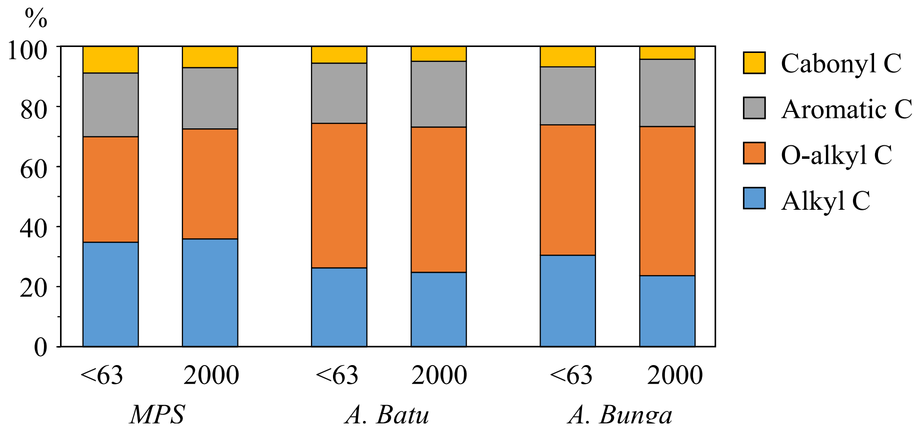

Figure. 3: Carbon composition of peat with different particle size and different vegetation (before incubation). <63 and 2000 refer to <63µm and 1.0-2.0 mm fraction, respectively.

The percentage of O-alkyl C decreased while alkyl-C increased in the finest size fraction for *MPS* and *A. Batu*. Considering the increase of the finest size fraction, selective decomposition probably proceeded accompanied by the decrease of particle size. For *A. Bunga* peat, percentage of alkyl C of the finest size fraction lowered, but O-alkyl C increased. This could be due to a rapid non-selective decomposition of *A. Bunga* peat. This is supported by a resemblance of C composition between the finest size fraction and 2.0-1.0 mm size fraction for *A. Bunga* peat.

The results in this study suggested that decomposition rate can be different among TP with different vegetation. Specifically, *A. Bunga* peat decomposed faster than *A. Batu* and *MPS* peats. Particle size of peat will decrease during a relatively short time (during 1 year) after development to OPP, which can be accompanied by the changes in C composition.

CONCLUSION

Vegetation of tropical peat successes along with the distance from the river, reflecting a gradient in the groundwater level and nutrient status. Peat accumulated under *A. Bunga*, or in the center of peat dome, where low level of nutrients are available, is less decomposed by microorganisms and thus contains more labile organic matter. As such, *A. Bunga* peat will be more vulnerable to development than *MPS* peat. Thus, it is important to consider the variability in the vulnerability when develop TPSF for sustainable use, for which vegetation can be a useful index. Decrease in the particle size of peat changes the physical properties of peat, which may affect air and water status of peat. This change might affect positively or negatively to the decomposition rate, which remains a problem yet to be solved.

ACKNOWLEDGEMENTS

This work was supported by JSPS KAKENHI Grant Number 24405029. We thank to the staff members of tropical peat research laboratory unit (TPRL), Sarawak, for their dedicated cooperation in conducing this research.

REFERENCES

1. Page, S.E., Rieley, J.O., and Banks, C.T.J. 2011. Global and regional importance of the tropical peatland carbon pool. *Global Change Biology* 17, 798–818.
2. Sjögersten, S., Cheesman, A.W., Lopez, O., Turner, B.L. 2011. Biogeochemical processes along a nutrient gradient in a tropical ombrotrophic peatland. *Biogeochemistry* 104, 147–163.
3. Melling, L., Goh, K.J., Uyo, L.J., Sayok, A., Hatano, R.. 2007. Biophysical characteristics of tropical peatland. In: Proceedings of the Soil Science Conference of Malaysia, (Ed. By J. Hamdan et al.), pp. 110-119, Malaysian Society of Soil Science, Serdang, Selangor.