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DIVERSITY IN THE PHYSICOCHEMICAL PROPERTIES OF TROPICAL PEAT IN SARAWAK, MALAYSIA

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SUMMARY

Tropical peat swamp forests (TPSFs) in Sarawak, Malaysia, consist of three major types of vegetation, namely *mixed peat swamp* (*MPS*), *Alan Batu* (*A. Batu*), and *Alan Bunga* (*A. Bunga*) forests, reflecting the variance in the groundwater-level and nutrient concentrations. Tropical peats developed under different vegetation are expected to have different physicochemical properties, which may lead to the different vulnerability to environmental change. However, TPSFs have been developed for oil palm plantation (OPP) irrespective of vegetation types. Sustainable management of OPP depends on the understanding of the variability in the physicochemical properties (or decomposition processes) of TP. Therefore, a variety of peat samples was collected from sapric, hemic, and fibric layers at *MPS*, *A. Batu*, and *A. Bunga* forests in Maludam National Park in Sarawak, and their physicochemical properties were investigated in terms of particle size distribution (PSD) (wet sieving), C composition (^{13}C CPMAS NMR), and humus composition (alkaline extraction). PSD patterns were different among different layers and different forest types with finest PS (< 63μm) fraction was dominant for all the samples. The percentage increased from fibric to hemic layers for *MPS*, but the changes were subtle for the other two types. Both *Alkyl C/O-alkyl C* ratio and the amount of alkaline-extractable humic acids as indicator of decomposition were higher for sapric layer than other layers and for *MPS* and *A. Batu* than *A. Bunga*. These results suggested *MPS* peat had undergone a higher extent of microbial decomposition than other types. In conclusion, the physicochemical properties of TP under different vegetation can vary, reflecting different microbial activities and decomposition processes which are important in determining the best approaches on development and management of peat swamps for oil palm production.

Keywords: *diversity, physicochemical properties, tropical peat, vegetation*

INTRODUCTION

Tropical peatland area, of which 77% is found in coastal region of Southeast Asia, is estimated to cover 11% of global peatland area (Page *et al.*, 2011). Tropical peatland is usually ombrotrophic, and the pH is low (2.9-4.5) due to organic acids formed during decomposition process. Different from many temporal and boreal peatlands of which major vegetation is bryophytes, herbaceous plants, and shrubs, whereas tropical peatlands is covered with trees (tropical peat swamp forests).

Groundwater level and nutrient concentrations of tropical peatland show gradient with the distance from the river: For examples, contents of total phosphorous, total nitrogen, and total potassium decrease as the distance from the river increases (Sjogersten *et al.*, 2011). As such, zones of different forest type are formed with the distance from the river. TPSF in Sarawak successes from mixed peat swamp forest (MPS), *Alan Batu* forest (*A. Batu*), and *Alan Bunga* forest (*A. Bunga*) from the margin to the center of a peat dome. Physicochemical characteristics of peat may vary among these forest types, reflecting the differences in groundwater and nutrient environments, and thus microbial activities. Therefore, it is important to understand the characteristics of tropical peat, considering the forest types.

However, there is still little knowledge on the physicochemical characteristics of tropical peat considering its variety. Therefore, our purpose in this research is to unveil the variability in the physicochemical characteristics of TP under major vegetation of TPSF in Sarawak. Physical properties of peat is investigated in terms of particle size distribution pattern (wet sieving), and chemical properties were investigated by humus composition (alkaline extraction), and carbon composition (^{13}C CPMAS NMR) of TP.

METHODS

Sample Collection

Soil samples were collected from sapric, hemic, and fibric layers at MPS, *A. Batu*, and *A. Bunga* forests in Maludam National Park, Sarawak, Malaysia (Figs. 1 and 2). *A. Batu* and *A. Bunga* belong to Dipterocarpaceae, and have the identical scientific name, *Shorea albida,* but they are different in phenotype. Seasonal variation of groundwater level at three sampling sites is shown in Figure 3. The groundwater level was low in the order of *MPS, A. Batu*, and *A. Bunga*, which corresponded to the distance to the river.

Size fractionation

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

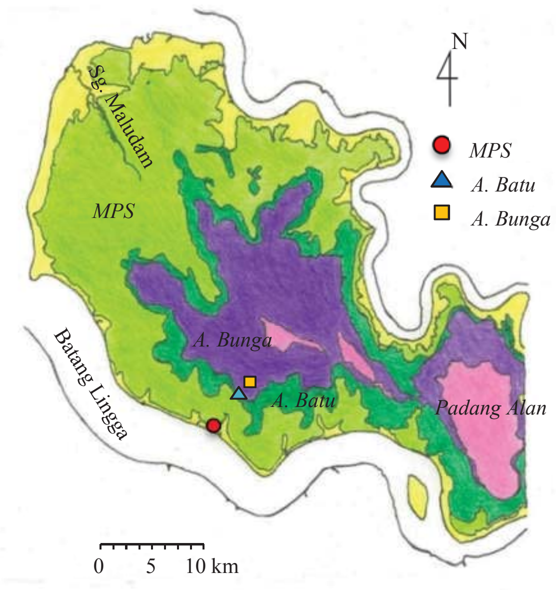

Figure 1: Vegetation map of Maludam National Park and sampling sites. Map is provided from Tropical peat research laboratory, Sarawak (TPRL).

Chemical Analyses

Total C and N contents were measured on a NC analyzer (Sumigraph NC-22). C composition of the <63µm, 125-250, 500-1000 µm fractions were measured by solid state ^{13}C NMR spectra 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 were as follows; rotation frequency, 10.0 kHz; recycle delay, 0.7-1s; Gaussian line broadening, 50-100Hz. Humus composition was analyzed by alkaline extraction method described as follows. Humus was extracted from peat with 0.1 M NaOH for 24h on an oscillating shaker. Alkaline extractable humus was recovered by centrifugation, and it was acidified to separate into fulvic acid (FA, supernatant) and humic acid (HA, precipitate) fractions. HA and FA contents were determined by a wet-digestion method using $K_2Cr_2O_7$ as an oxidant.

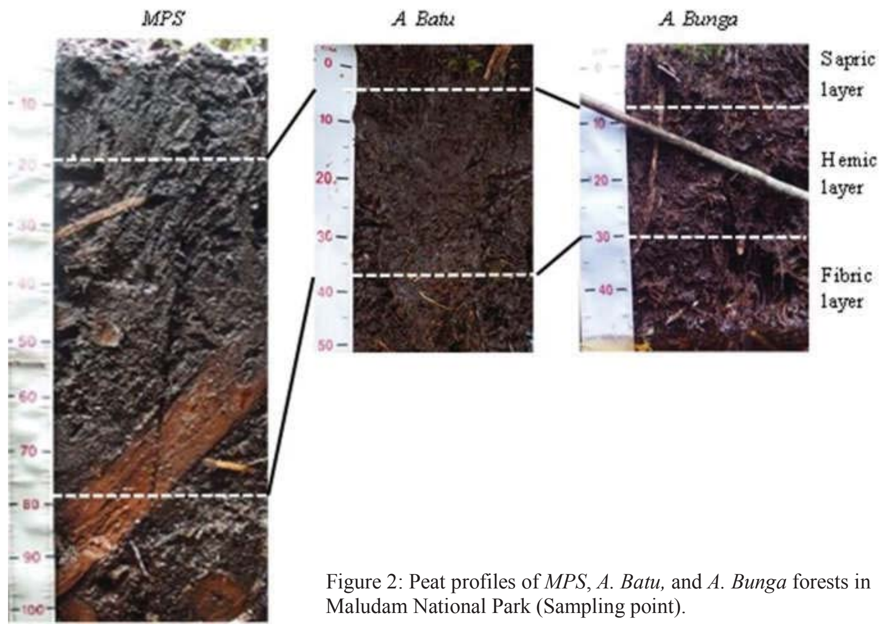

Figure 2: Peat profiles of *MPS*, *A. Batu,* and *A. Bunga* forests in Maludam National Park (Sampling point).

RESULTS

Particle size distribution

The <63µm fraction was dominant for all types of peat and contributed to 30-60%. Sapric layer, which is considered to have undergone highest degree of decomposition, did not necessary contained high proportion of <63µm fraction compared with other layers. Fragmentation proceeded apparently from fibric to hemic layer for *MPS* and *A. Bunga* forests, while such a trend was not observed for *A. Batu* forest.

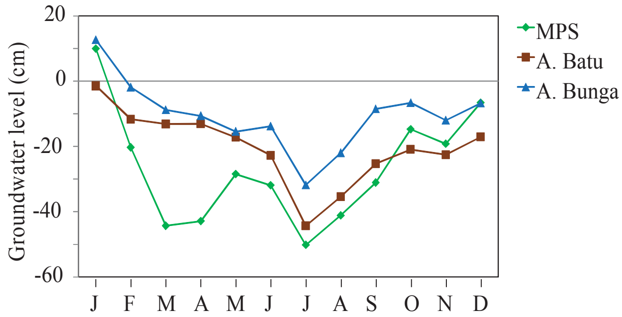

Figure 3: Temporal variations in the groundwater level at *MPS*, *A. Batu*, and *A. Bunga* sites in 2014. Provided from TPRL

Humus composition

Percentages of humic acids (%HAs) extracted from sapric and hemic layers were higher for *MPS* (28-29%, and 33-40%, respectively) than other two types (17-21% and 10-24%, respectively). It is interesting to note that %HAs did not appreciably different among different particulate size fractions for sapric layers, but increased with decrease of particle size for hemic and fibric layers.

C composition

% *O*-alkyl C in the <63µm fraction was higher in the order of *A. Bunga* > *A. Batu* > *MPS*. On the other hand, % alkyl C increased as the particle size decreases, showing the highest variations. Alkyl C/O-alkyl C ratio, which is often used as an index of decomposition of plant residue (Baldock *et al.*, 1992, 1997), was higher for *MPS* and *A. Batu* forests than *A. Bunga* forest. In accordance with humus composition, this value increased as the size decreased for hemic and fibric layers.

DISCUSSION

Physicochemical characteristics of tropical peat are different among different forest types, which were formed in a band-shape reflecting a distance to a river. *MPS*, which forms the nearest to the river, is more microbially decomposed than others. Content of humic acids, which was formed by oxidative decomposition of plant residue, and alkyl C/O-alkyl C values were both high for *MPS* compared with other two types. Furthermore, particle size distribution pattern of MPS in sapric and hemic layers were finer than other two types. The reason may include a lower groundwater level and higher nutrient concentration of *MPS* than other types, which enhanced microbial activity. The *A. Bunga* peat, which is dominated near the center of peat dome was considered to have experienced less extent of microbial decomposition. This was obvious from generally low humic acid content and Alkyl C/O-alkyl C ratio for *A. Bunga* peat. *Alan Batu* showed an intermediate characteristics between *MPS* and *A. Bunga*.

Chemical characteristics of "<63µm" fraction between three types of forests were significantly different. The reason may be explained as follows: different fragmentation processes were proceeded between *MPS* and *A. Bunga*, i.e. microbial decomposition was the dominant process for *MPS* while physical fragmentation by external force associated with root growth was dominant for *A. Bunga*.

CONCLUSION

Vegetation of tropical peat successes with the distance from the river, reflecting the gradation of groundwater level and nutrient concentrations. Physicochemical properties of tropical peat under different vegetation is also different, which is, if not all, partly attributable to the difference in the microbial activity. *A. Bunga* peat is considered to have undergone less microbial decomposition than *MPS* peat. However, *A. Bunga* peat still contains a higher amount of easily decomposable organic matter than *MPS* peat. Therefore, it is possible that *A. Bunga* peat is more vulnerable to development, and as such it would be better to avoid development of *A. Bunga* forest.

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