HEAT CONTENT AND BURNING TIME OF TROPICAL PEAT

Dayang Nur Sakinah Musa*, Rebecca Mishallyne Afat, Melissa Sharmah Gilbert, Kamlisa Uni Kamlun

Forestry Complex, Faculty of Science and Natural Resources,
Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia.

*Corresponding author : dns.m@ums.edu.my

ABSTRACT. Peat composes of organic matter and easily drying out during the dry season. This situation will result in a smouldering fire in peat swamp forest especially with the help of El-Nino phenomenon and eventually will destroy home for endangered species such as Orangutan. It is important in order to study the effect of forest fire on peat thermal properties. The study was conducted in Binsuluk Forest Reserve, Sabah, Malaysia, The aims of this study were to measure the heat of content and burning time of peat at a different level and to find the relationship of the heat of content in Binsuluk Forest Reserve. Samples of burnt peat were taken using an auger at 1.5 m, 2.0 m, 2.5 m and 3.0 m depths. The peat samples were tested for heat of content (MJ Kg^{-1}) and burning time (minutes). Results shown that peat has a higher heat of content at a depth of 3.0 m with 51.65±2.07 MJ Kg^{-1} and lower heat of content at 2.5 m depth with 49.60±0.46 MJ Kg^{-1}. Burnt peat takes longer time recorded at 3.0 m peat depth with mean value of 127.20±1.88 minutes and the shorter time recorded at the depth of 1.5 m with mean 101.40±0.51 minutes. Thus, these data suggest that increases in the heat of content of the peat can increase the time for the peat to completely burnt. The heat content and burning time were perhaps influenced by the moisture content of the peat in Binsuluk Forest Reserve with range of moisture content between 209.88±0.18 % to 1013.51±1.39 % . The information on thermal properties of peat in Sabah is important for the forest managers and researchers to get an idea of the impact of forest fire on peat and can create better management on the peat swamp forest area.

KEYNOTES: Peat swamp forest, Peat fire, Burning time, Heat of Content

INTRODUCTION

Peat swamp forest stored carbon and known as a unique ecosystem. Endangered species such as *Pongo pygmaeus* (Orangutan) were endemic in this area. In Sabah, Malaysia the total area of the peat swamp forest is 116,965 ha which cover mostly the west-coast of Sabah. In South East Asia, the peat was recorded from 1m to 9m deep in Thailand, Indonesia and up to 20.7m deep in Loagan Bunut National Park Sarawak, Malaysia (Yoshino at al., 2002; Comas at al., 2015; Melling at al., 2006). In Sabah, the Lumadan peat in Beaufort which located nearby Klias was recorded to have 1.5 to 3.0 m depth of peat thickness and can be classified as medium to massive peat depth (Zainorabidin & Mohamad, 2016).

However, 4.7% of total peatland in Malaysia are actually threatened by forest fire especially during the dry season with the help of El Niño phenomenon. In Sabah, El Niño phenomenon contribute to severe fire event in Beaufort, Keningau, Sook and Tongod districts which destroyed 20,000 ha (13,000 ha alienated and state lands; 7,000 ha forest reserves) and is estimated RM48 million are needed to rehabilitate the 7,000 ha forest reserves (SFD, 2016). Human activities such as fishing and open burning are the main reason for this catastrophic event. The fire event has disturbed peat swamp forest for decades and become more frequent recently which increased number of anthropogenic activities around the area will contribute to fire event if the peat and fire management is not improved (Cattau at al., 2016). Peat swamp forest is estimated to store 89 Pg of carbon globally and carbon loss

can happen such in 1997 where the aboveground forest biomass carbon loss is estimated to be 0.038 Gt C, meanwhile, carbon loss from peat fire was estimated to be higher which is in range of 0.218 to 0.491 Gt C (Page at al., 2011; Boehm at al., 2011). Thus, peat contributed to larger carbon emission to the atmosphere compare to other forest biomass especially during dry season when dried peat is more vulnerable to fire. However, the losses cannot compare to the loss of biodiversity, water and carbon (SFD,2016).

Previously, not many data on thermal properties on different level of peat depths recorded due to the difficulties to measure the peat depths. Moreover, the heat of content and the burning time of the peat in Binsuluk Forest Reserve is unknown. In this research, the project aims to measure the heat of content and burning time of peat at a different level in Binsuluk Forest Reserve. The information of these findings is expected to help forest managers and other researchers on how to control the peat fire as it is hard to extinguish and predict the amount of heat released at different peat level.

MATERIALS AND METHOD

Study site

The site location for this project in the burnt area of 2016 in Binsuluk Forest Reserve that located near Klias Peninsula with a total area of 12,106 ha (Figure 1). The soil type of the Binsuluk Forest Reserve is mixed peat swamp forest (Zainorabidin & Mohammad, 2016). The forest reserve undergoes forest fire because of the El Niño event in 2016 and was severely damage to approximately 1000 ha (SFD,2016). Then, five (5) plots are constructed at the burnt area of 2016 as shown in Figure 2 and samples of burnt peat are taken by using an auger. Four (4) samples of burnt peat; 1.5m, 2.0m, 2.5m and 3.0m depths were collected (Figure 3), then, stored and taken back to the laboratory.

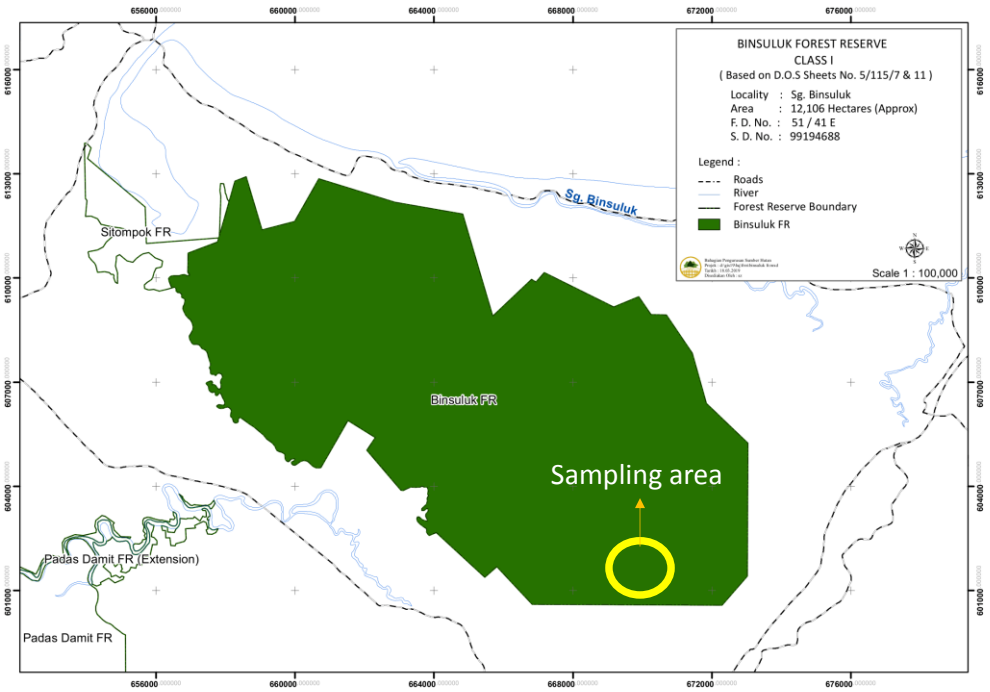

Figure 1: Binsuluk Forest Reserve (SFD, 2019)

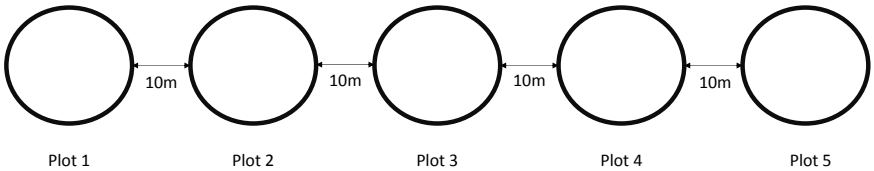

Figure 2: Plot established in the burnt area of BFR for samples collections.

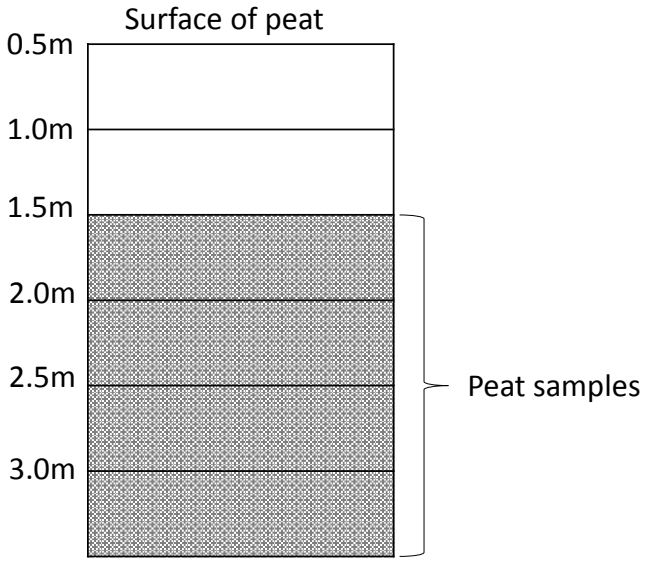

Figure 3: Samples collected at different level of peat depths.

Preparation of materials

The burnt peat samples of 1.5 m, 2.0 m, 2.5 m, and 3.0 m depths were oven dried at 105°C until constant weight. After that, the peat samples were grinded and sieved at 2.0 mm for heat of content and burning time analysis. The samples were divided into 1.2 mg of each level for heat of content analysis and 30 ml of each sample for burning time analysis.

Heat of content determination

The samples of peat are weight 1.2 mg and placed inside the Adiabatic Bomb Calorimeter IKA-C5000 machine and combusted under 3000 kPa pressure for the measurement of the heat of content (MJ Kg^{-1}) (IKA, 1998; Musa & Nuruddin, 2015)

Burning time determination

To imitate the smoldering fire in peat, the samples of the 30 ml volume of burnt peat from the four levels of peat depth were burnt at a constant temperature in a closed dark area to prevent winds for burning time (minutes) analysis. The burning time (minutes) was recorded using a timer and will stop timing when the burnt peat samples show no presence of smoke and ember.

Data analysis

Data of the burnt peat at 1.5 m, 2.0 m, 2.5 m and 3.0 m depths were analysed by using one-way-ANOVA (Tukey's test) to compare the level of peat depths. An independent-samples-T-test was run to determine if there were differences between different peat depth.

RESULTS AND DISCUSSION

The mean of heat of content and burning time of the burnt peat at 4 different levels of peat depth (1.5 m, 2.0 m, 2.5 m and 3.0 m) were shown in Table 1. The heat of content measures the heat released from the combustion process of peat as the quantity for the heat released per unit of combustible mass. It was found out that the different levels of peat depths in the forest reserve; 1.5 m, 2.0 m, 2.5 m and 3.0 m contain no significant different of heat of content within the peat levels ($p=0.686$). According to Usup at al. (2004), tropical peat is formed by woods and makes the heat content higher with a range of 19 to 23 MJ Kg^{-1} and more flammable compare to boreal peat that is ranged from 8 to 18 MJ Kg^{-1} or other fuel types such as grass especially during dry season. The result of this study shows that the

burnt peat of Binsuluk Forest Reserve has higher heat of content range from 49.60±0.46 MJ Kg^{-1} at 2.5 m depth, followed by 50.30±2.07 MJ Kg^{-1} (1.5 m); 50.56±0.71 MJ Kg^{-1} (2.0 m) and the highest at peat level of 3.0 m depth, 51.65±0.87 MJ Kg^{-1}. The result was the same as mentioned in previous study where topical peat has higher heat content and more flammable. As the peat getting deeper in-depth, more biomass such as roots and organic matter compared to the surface area, which has more decompose organic matter; also the moisture content typically higher. The heat of content is normally impacted by the moisture content where the peat will absorb the heat during evaporation process (Rein at al., 2008).

Table 1: Mean ± standard error of Heat of Content (MJ Kg^{-1}) and Burning Time (minutes) of burnt peat at 1.5m, 2.0m, 2.5m and 3.0m depth level in Binsuluk Forest Reserve.

Depth (m)	Heat of content (MJ Kg^{-1})	Burning Time (minutes)
1.5	50.30±2.07 [a]	101.40±0.51 [a]
2.0	50.56±0.71 [a]	106.40±0.24 [b]
2.5	49.60±0.46 [a]	109.60±0.24 [c]
3.0	51.65±0.87 [a]	127.20±1.88 [d]

**Note: same alphabet in the same column indicates no significant different (p>0.05)*

Significant value: Heat of content (p=0.686); Burning time (p=0.000)

The burning time shows statistically high significant difference between four (4) levels of peat depth (p=0.000) with volume 30 ml. From the Table 1, the heat of content was the highest at level 3.0 m depth of peat with mean 127.20±1.88 minutes. 2.5 m shows burning time of 109.60±0.24 minutes and at 2.0 m depth it indicates shorter time at 106.40±0.24 minutes. The most rapid time taken for the peat to completely burnt is peat at 1.5 m depth with mean of 101.40±0.51 minutes. From the results, lower the depth of the peat, the quicker the time needed for the burnt peat to completely turn into ashes with no sign of ember and smokes. The idea of the burning method was adapted from previous study by Frandsen (1997), Huang at al. (2016) and Syaufina at al. (2004). According to Huang at al. (2016), the burning duration will increases when the moisture content around 100-130%. This is similar to this study where the moisture content of the peat could possibly influence the ignition process of heat of content as the peatland is waterlogged area and usually high in moisture content and lower depth of the peat area.

The study has found that the moisture will increase by depth which might be the reason why the heat content and burning time of the peat was the highest and longer at 3.0m depth in Binsuluk Forest Reserve. Moisture content in Binsuluk Forest Reserve at level of 1.5m and 2.0m depths was 332.46±0.18% and is 1013.51±1.39 % respectively (Musa & Ramli, 2017). The burning took shorter time with 5% of moisture content because of the low density of the peat (Huang at al., 2016). Musa & Ramli (2017) stated that higher bulk density contribute to lower moisture content in peat where the density were the lowest at lower depth of 2.0m depth with 0.09 ±0.09 gcm^{-3}; peat at higher level of peat i.e. 0.5m, 1.0m and 1.5m depth has a mean density of 0.28±0.17 gcm^{-3}, 0.25±0.09 gcm^{-3} and 0.19±0.01 gcm^{-3} in that order where they have significant difference (α=0.05) with the 2.0m depth. Figure 4 shows a burning time and heat of content of the peat. It clearly shows that the burning time were increasing by depth, however, the heat content was about the same as it has no significant difference (p>0.05).

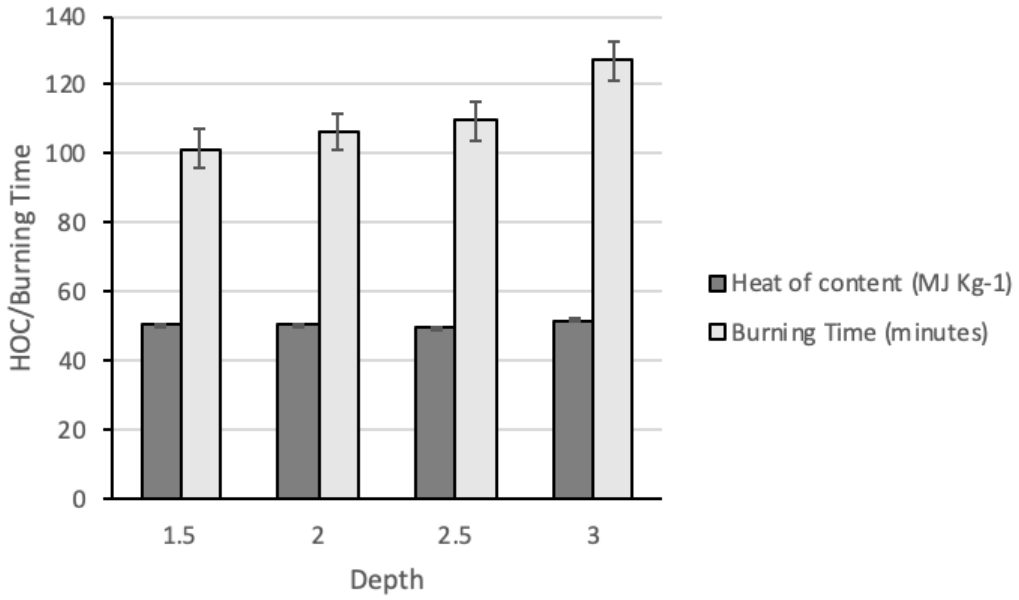

Figure 4: Heat of Content and Burning time of peat in burnt area of 2016 in Binsuluk Forest Reserve.

This experiment attempts to understand the smouldering fires in tropical peat swamp forest. In this way, it shows that smouldering fire in peat can occur at 3.0m depth and can linger on for some period of time. When this situation happened, it indicates that peat can be ignited at deeper than 1.5m. Smouldering fire in peatlands is the largest combustion event on the planet which is hard to detect and can last for month and years, and will eventually cause haze disaster that causes serious problem to humans and the environment (Huang & Rein, 2019; Putra at al., 2019).

CONCLUSION

The study indicates that the deeper the peat depth, the lower the compaction of the peat and increase its moisture content. Thus the physical properties of peat such as moisture content and bulk density will influence the burning time of the peat. Heat of content was high in tropical peat and it shows that the tropical burnt peat in Binsuluk Forest Reserve has high heat content from 1.5 m until 3.0 m levels of peat depth and range from 49.60±0.46 MJ Kg-1 to 51.65±0.87 MJ Kg^{-1}. Burning time of the burnt peat to completely turn into ashes shows that the peat took longer time to completely burnt and this will increase the tendency of smoldering fire in peat swamp area to last longer especially during dry season. From the research, the burning time increased when the depth level of peat increased. High statistically significant difference between the four levels of peat depth ($p<0.05$). Peat swamp forest play an important role in the ecosystem. Important actions must be taken to reduce the impact of peat fire on the biodiversity and awareness program should be enhanced to educate citizen regarding this matter. It is recommended that the scope of the research area should be expanded to cover the aspect of flammability of the tree parts and regrow tree parts in the study area.

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