The Characteristics of Peats and Co₂ Emission Due to Fire in Industrial Plant Forests

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Abstract: Riau Province has a high threat to forest fire in peat soils, especially in industrial forest areas. The impact of fires will produce carbon (CO₂) emissions in the atmosphere. The magnitude of carbon losses from the burning of peatlands can be estimated by knowing the characteristics of the fire peat and estimating CO₂ emissions produced. The objectives of the study are to find out the characteristics of fire-burning peat, and to estimate carbon storage and CO₂ emissions. The location of the research is in the area of industrial forest plantations located in Bengkalis Regency, Riau Province. The method used to measure peat carbon is the method of lost in ignition. The results showed that the research location has a peat depth of 600-800 cm which is considered very deep. The Peat fiber content ranges from 38 to 75, classified as hemic peat. The average bulk density was 0.253 gram cm⁻³ (0.087-0.896 gram cm⁻³). The soil ash content is 2.24% and the stored peat carbon stock with 8 meter peat thickness is 10723.69 ton ha⁻¹. Forest fire was predicted to burn peat to a depth of 100 cm and produced CO₂ emissions of 6,355,809 tons ha⁻¹.

Keywords: peat, forest fire, carbon, bulk density

1. Introduction
The area of peatland in Indonesia is more than 20 millions ha, 6.29 million ha is in Sumatra, while 4.044 millions ha are in Riau Province. Riau Province contributes 45% peatland in Indonesia where most of it is for Industrial Timber Plantation (HTI), in which at present its condition is threatened. The hot spot data from the last 5 years shows the source of forest and land fires in Riau has shifted from mineral land to peatland. Most of the fires occurring in peat forests are classified serious due to the characteristics of peat which is composed of litters of organic materials with vegetation above and are potential for fuel. The forest fires that occur in peatlands will increase the amount of CO₂ in the atmosphere so that the availability of carbon in peat declines.

Peatlands store carbon in plant biomass, litters beneath peat forests, peat layers and mineral soil under the peat substratum. The range of peat carbon content is about 30-70 tons m⁻³. This amount is equivalent to 300-700 tons ha⁻¹ m⁻¹ carbon stock. If peat has a thickness of 10 m, then the carbon stored in it is about 3000-7000 tons ha⁻¹ [1]. Peat soils store C much higher than mineral soils. Each one gram of dry peat stores about 180-600 mg of carbon, whereas every one gram of mineral soils contains only 5-80 grams of carbon. In the tropics, the carbon stored by soil and plants on peatlands can be 10 times the carbon stored by soil and soil in mineral soils (Agus and Subiksa, 2008).
Peat with a depth of 1 m has a carbon content of 600 tons ha$^{-1}$ [2], while peat forest biomass contains only about 200 carbon tons ha$^{-1}$.

This study aims to determine the characteristics and reserves of peat carbon and CO$_2$ emissions from fires in industrial plantations. The benefits of this research can provide information on the characteristics and reservation of peat carbon and CO2 emissions generated during the fire in industrial plantations so as to facilitate the management of peatland forests in climate.

2. Method

The research was conducted on peatlands of industrial plantation of PT. Sekato Pratama Makmur, Bengkalis Regency, Riau Province. It is conducted in April to July 2016. Measurement of peat carbon reserves at the research sites is done by several stages, namely 1) Measurement of depth of peat soil and soil sampling, 2) Analysis of sample in laboratory and 3) Data processing. Determination of observation point is done by using transect system that is terrain technique. In each transect, soil observation and sampling were taken. Peat soil samples were taken with a half-cylindrical peat drill. Sampling is at every 50 cm interval of the depth of the peat layer. The depth of soil drilling is carried out from the surface of the peat until alluvial soils are found. At every 50 cm interval, soil sampling is taken to measure peat maturity, bulk density, ash content and carbon content. To know the level of organic material in peat material it is done by method of lost on Ignition (LOI). To calculate CO$_2$ emissions that are emitted due to peat decomposition process, this formula is used $\text{CO}_2 = C \times 3.67$ $\text{CO}_2$ = The amount of CO$_2$ gas from peat decomposition, $C$ = the weight or amount of carbon lost during the decomposition process, 3.67 = constant to convert carbon to CO$_2$.

3. Result and Discussion

The carbon stored in peat soils is determined by the thickness of the peat. The result of peat drilling at the study sites shows that the peat depth ranges from 600 to 800 cm. The process of peat soil formation lasted for a very long time. This correlates to the depth of peat soil that can reach tens of meters. The result of peat age measurement in Bengkalis Regency of Riau Province shows that peat age in Bengkalis Regency is 4,740-5,730 BC (Neuzil [3]). According to Widjaya Adhi [4], peat depth 600 to 800 cm is grouped deep into very deep peats. (Harjowiegeno, [5]). The degree of organic soil decomposition is indicated by the fiber content. Based on laboratory results, the peat fiber content in each peat depth varies. The peat fiber content in the fire area ranged from 38-75%, grouped into hemic peat (half-baked) according to Agus et al. [1]. Peat on the surface (top layer) is generally relatively more mature due to faster decomposition rate. The development of canals and forest fires will lead to soil compaction as well as decreased moisture content that impact on high bulk density values. The average bulk density in the fire area is 0.253 gram cm$^{-3}$ with the value of 0.087-0.896 gram cm$^{-3}$. The value of bulk density in some depth of peat in fire area can be seen in figure 1.

![Figure 1. Bulk density on some depths of Peat](image-url)
Figure 1 shows that the bulk density value on the peat surface is higher than the inside part. The differences in bulk density values are due to differences in peat maturity in each soil profile. Peat maturity is found on the surface of the peat. This occurs because the surface layers of peats both naturally and also due to human activities are able to accelerate the maturity of the peat.

The distribution of bulk density value is higher than Yulianti’s research result [6] which ranges from 0.07-1.73 gram cm$^{-3}$. According to Regulation Number. 4 of 2001, the standard criteria for damage to the physical properties of peat causes the compaction of the soil and decrease the water content that affects the high value of the density. Soil with low bulk density values generally have high porosity, so the potential to absorb and channel the water becomes high, but if the bulk density is too low, the soil has a low bearing capacity (Nugroho et al. [7]; Widjaja-Adhi [4]). Bulk density value is influenced by moisture content. According to Hanafi [8] the higher the moisture content the lower the bulk density.

The level of ash in peat soil shows the amount of mineral content in the peat. In some locations generally the ash content in peat soils increases with the proximity of the peat layer to the substrate layer (Dariah, [9]. The average value of ash content on each peat in the study area was 2.24%. Ash content at each depth of peat layer can be seen in figure 2.

![Peat ash content in some depth](image)

Figure 2. Peat ash content in some depth

The ash content on the peat surface layer is higher than the lower layer. The weight or ash content from the surface layer of peat soil to the bottom layer at forest fire location is 0.0057 grams cm$^{-3}$. The increasing of ash levels in forest fires is assumed to come from minerals stored in peat and burning biomass. Peat fires and plant biomass that grow on it cause the material to oxidize into gaseous form, especially CO$_2$ which is emitted into the atmosphere. The minerals contained in peat and plant biomass accumulate on the burning surface layer of the peat, thus increasing the ash or mineral content of the surface of the peat. The amount of carbon stored in peat soils is strongly influenced by the thickness of the peat. The distribution of carbon content per hectare in thickness / into peat can be seen in Figure 3.
The storage of peat carbon at study site with 8 meters peat thickness of 10723.69 tons/ha is equivalent to 1341.14 ton ha\(^{-1}\) m\(^{-1}\). The value of carbon stocks is higher than Prayitno et al. [10] of 1675,361 -9055,922 tons ha\(^{-1}\). Peat with a depth of 1 meter at the study site has a peat content of about 1739.95 tons ha\(^{-1}\). According to Page et al. [2] peat with a depth of 1 meter has a carbon content of about 600 tons ha\(^{-1}\).

The carbon storage of peatlands is relatively high which causes these ecosystems to contribute greenhouse gas emissions, if carbon materials stored in peat form decompose or fire. The forest fire that occurred in 2014 has resulted in CO\(_2\) emissions. Fires in peatlands can reach an average depth of 22 cm (between 0-42 cm), even in certain places it can reach a depth of 100 cm (Limin et al., [11]). It is estimated that the burning peat reaches a depth of 1 meter. In spite of the fact there was never equally even fire. Based on the calculation of the fire emission amount of 0-50 cm layer is 19.850.484 tCO\(_2\) and at layer 50-100 cm is 18.284.371 tCO\(_2\). So total emission of the depth of peat layer 0-100 cm with fire area 6000 hectares is estimated 38,134,855 tCO\(_2\).

4. Conclusion
The research location has a peat depth of 600-800 cm which is considered very deep peat. The peat fiber content ranges from 38 to 75, classified as hemic peat. The average bulk density is 0.253 gram cm\(^{-3}\) (0.087-0.896 gram cm\(^{-3}\)). The soil ash content is 2.24% and the stored peat carbon stock with 8 meter peat thickness is 10723.69 ton ha\(^{-1}\). Forest fires are predicted to burn peat to a depth of 100 cm and produce CO\(_2\) emissions of 6,355,809 tons ha\(^{-1}\). The peat depth characteristics is the major factor in estimating carbon stocks in peatlands.

5. Acknowledgement
The researchers would like to thank KemenristekDikti who has assisted in financing the research, PT. Sekato Pratama Makmur which has provided facilities for researchers to conduct research in Hampar working area, Bengkalis Regency. The researchers also thank Research and Community Service and Forestry Department, Lancang Kuning University.

6. References
[1] Agus F, K. Hairiah dan A. Mulyani. 2011. *Pengukuran Cadangan Karbon Tanah Gambut*. Petunjuk Praktis. World
Agroforestry Centre-ICRAF, SEA Regional Office dan Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Basah (BBSDLBP), Bogor, Indonesia, 58 p.

[2] Page, S. E., Siegert, F., Rieley, J.O., Boehm., H.V., Jayak, A. and Limin, S. 2002. *The amount of carbon released from peat and forest fires in Indonesia during 1997*. Nature, vol 420, 2002.

[3] Neuzil, S.G. 1997. *Onset and Rate of Peat and Carbon Accumulation in Four Domed Ombrogenous Peat Deposits, Indonesia*, in: Biodiversity and Sustainability in Peatlands- Proceedings of International Symposium of Tropical Peatlands, Palangkaraya, Indonesia, Edited by: rieley, J.o and page, S.e., Samara Publishing, Cardigan.

[4] Hardjowigeno, S. 1993. *Klasifikasi Tanah dan Pedogenesis*. Akademika Pressindo. Jakarta.

[5] Yulianti, N. 2009. *Cadangan Karbon Lahan Gambut dari Agroekosistem Kelapa Sawit PTPN IV Ajamu Kabupaten Labuhan Batu Sumatera Utara*. Thesis. Sekolah Pascasarjana. Institut Pertanian Bogor.