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PEAT MATURITY AND THICKNESS FOR CARBON STOCK ESTIMATION

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SUMMARY

A simple, but accurate approach is needed for monitoring below ground peat carbon stock. Based on over 2200 peat samples from Sumatra and Kalimantan, we determined peat maturity and bulk carbon content (C_v) relationships. Weight based carbon content, C_{org}, has relatively little variation between 0.52±0.17; 0.51±0.08 to 0.049±0.08 Mg Mg^{-1} while peat bulk density varies widely between 0.10±0.06; 0.12±0.07 and 0.18±0.10 Mg m^{-3} leading to C_v of 0.048±0.024; 0.060±0.028 and 0.082±0.032 for fibric, hemic and sapric peats, respectively. This peat maturity and C_v information can be used to speed up the otherwise very expensive, laborious and tedious peat sampling and monitoring of peat carbon stock.

KEY WORDS: peat maturity, bulk carbon content, sapric, hemic, fibric

INTRODUCTION

Ritung *et al*. (2011) revision of the Indonesian peatland map of Wetland International (2002, 2003, and 2006) using ground truth data, estimated Indonesia's peatland area to be around 14.9 million ha, distributed mainly in Sumatra, Kalimantan and Papua islands. This land becomes important for development as the availability of non peatland becomes more limited. When peat swamp forest is cleared and/or drained, it becomes a carbon source (Hooijer et al. 2010; Murdiyarso *et al*., 2010). Therefore, measurement of C stock in peat is one of the most important aspects of the national greenhouse gas (GHG) inventories in countries where peatland is a large land resource. GHG emissions from peat can be assessed from the change in carbon stock times the activity data (IPCC, 2006) based on the measurements of peat bulk density (BD) and weight based carbon content (C_{org}) (Agus *et al*. 2011). However, complete and destructive measurements of BD and C_{org} are very expensive and time consuming. For tropical peat, Page *et al*. (2002) suggested the use of bulk carbon content (C_v) of 0.057 Mg m^{-3}. However, using this value may result in an overestimate of carbon stock and GHG emissions from immature (fibric) peat and underestimate carbon stock and GHG emissions from mature (sapric) peat. Data on peat maturity and C_v relationship can be used to improve the estimate of peat carbon stock and peat emission. This research evaluated the variation of C_v in different degrees of peat maturity based on BD and organic matter content measurements.

MATERIAL AND METHODS

Peat samples were collected from the Provinces of Riau, Jambi and Nangroe Aceh Darussalam in Sumatra island and the Provinces of West Kalimantan, Central Kalimantan and South Kalimantan in Kalimantan island of Indonesia in 2008 to 2011. Peat maturity from each auger was evaluated on site manually based on its colour and structure. Fibric peat is brown in colour and when pressed by hand, more than 60% of the fibre remains in the palm. It also shows the structure of the plants from which it originated. Hemic peat is brown to dark brown in colour and when pressed by hand, about 30 to 60% of the material remains in the hand. Sapric peat is dark brown to black in colour and pressing it by hand, will cause most of the material to slip out between fingers and less than 30% remains in the palm (Agus *et al.*, 2011).

Peat samples were collected using a peat auger (Eijkelkamp model) at 50 cm soil depth increments from the surface to the peat-mineral soil interface. This auger removes 500 cm^3 peat samples when the full 50 cm length is filled. Where the change in peat structure (maturity) is observed within each auger, then the sample is cut to separate those of different maturity. Each sample was analysed for BD by drying at 105^oC for 4 x 24 hours until constant weight is reached. Soil organic matter content is measured semi quantitatively by the loss on ignition (LOI) method in a furnace at 550^oC for 8 hours. Using 149 pairs of samples from 0-20 cm and 20-50 cm depths, the relationship between C_{org} using C and N Autoanalyser and organic matter content (LOI method) is shown in Figure 1. Since we used the LOI technique for most of our samples, C_{org} is calculated as,

C_{org} = 0.568 * Organic matter content [1], and

Bulk carbon content, C_v = BD x C_{org} [2]

More than 2200 samples were collected and the data of peat maturity, C_{org}, BD and C_v compiled into a spreadsheet for mean and standard deviation calculation.

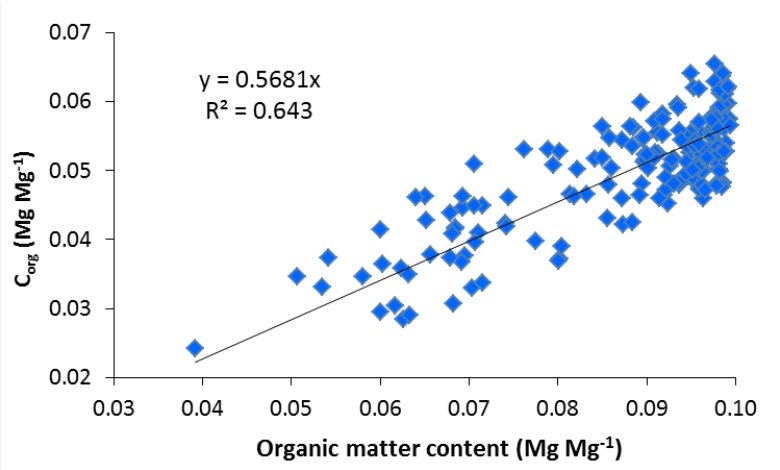

Figure 1. Organic matter content (C_{org}) measured by C and N auto-analyser as a function of organic matter content measured by the loss on ignition method.

RESULTS

Organic carbon content (C_{org}) is relatively similar across peat maturity classes ranging narrowly from 0.49±0.08 Mg Mg^{-1} to 0.52±0.07. However, BD varies very widely ranging from 0.18±0.10 Mg m^{-3} in sapric peat to 0.10±0.06 Mg m^{-3} in fibric peat. C_v also varies with BD (Table 1). The Standard deviation of BD is more than half of its mean value indicating a high variation. The C_v values of sapric, hemic and fibric peat as shown in Table 1 translate to carbon stock of 820±320, 600±280 and 480±240 Mg C ha^{-1} for every m peat layer, respectively. As for the combined Sumatra and Kalimantan data, the C_{org} for Sumatra and Kalimantan for each of the maturity class did not vary very widely, while the data of bulk density, and hence C_v, had high variation (Table 2).

Table 1. Weight based organic matter content (C_{org}) bulk density (BD), and volume based carbon content (C_v) of peat of different maturity average for Sumatra and Kalimantan.

Properties	Peat maturity		
	Sapric (n = 404)	Hemic (n=1019)	Fibric (n = 789)
		Mean±SD	
C_{org} (Mg Mg^{-1})	0.49±0.08	0.51±0.08	0.52±0.07
BD (Mg m^{-3})	0.18±0.10	0.12±0.07	0.10±0.06
C_v (Mg m^{-3})	0.082±0.032	0.060±0.028	0.048±0.024

n = number of samples. SD = Standard deviation.

Table 2. Weight based organic matter content (C_{org}) bulk density (BD), and volume based carbon content (C_v) of peat from Sumatra and Kalimantan of different maturity.

Properties	Peat maturity		
	Sapric (n = 404)	Hemic (n=1019)	Fibric (n = 789)
		Mean±SD	
Sumatra			
C_{org} (Mg Mg^{-1})	0.48±0.09	0.53±0.07	0.53±0.06
BD (Mg m^{-3})	0.18±0.10	0.12±0.07	0.10±0.06
C_v (Mg m^{-3})	0.082±0.029	0.058±0.028	0.050±0.025

n = number of samples. SD = Standard deviation.

Table 3 shows some variation across provinces that may be related to the site specificity. The sapric peat in Jambi, with a large number of samples, has a C_v value closest to that of the Sumatra and Kalimantan average (Tables 1 and 2). The hemic and fibric peats have somewhat higher C_v than the Sumatra and Kalimantan average. This may be related to the dominance of mature peat in Jambi. Our sampling site in Central Kalimantan is Jabireun Subdistrict with clay accumulation at 150 cm to 300 cm depth and may not be very representative for the whole central Kalimantan.

Peat with maturity of sapric, hemic or fibric can be found in all types of land uses (Table 4). The initial maturity before land use change takes place seems to be the dominant factor in determining peat maturity. By knowing the thickness (m) of different layers of peat maturity, carbon stock (Mg ha^{-1}) of each layer can be determined by multiplying the thickness and bulk carbon content of the respective maturity.

Table 3. Bulk carbon content, C_v (Mg m^{-3}), and bulk density, BD (Mg m^{-3}), expressed as Mean±Standard deviation (SD) of peat from different locations (provinces) of Indonesia.

Location	Sapric			Hemic			Fibric		
	BD (Mg m^{-3})	C_v (Mg m^{-3})	n	BD (Mg m^{-3})	C_v (Mg m^{-3})	n	BD (Mg m^{-3})	C_v (Mg m^{-3})	n
W. Kalimantan	0.147±0.049	0.073±0.024	22	0.102±0.019	0.056±0.009	25	0.074±0.020	0.042±0.011	80
C. Kalimantan	0.170±0.029	0.092±0.018	41	0.162±0.035	0.071±0.014	143	0.117±0.029	0.055±0.010	133
S. Kalimantan	0.161±0.127	0.074±0.066	24	0.124±0.091	0.057±0.047	57	0.081±0.080	0.038±0.034	103
Jambi	0.179±0.098	0.081±0.030	269	0.159±0.088	0.075±0.031	271	0.126±0.052	0.064±0.024	221
Riau	0.170±0.049	0.084±0.023	48	0.118±0.044	0.063±0.019	159	0.088±0.032	0.047±0.016	100
Aceh	n.a.	n.a.	n.a	0.076±0.036	0.042±0.020	364	0.053±0.034	0.031±0.019	152

n = number of samples. SD = Standard deviation. n.a. = data is not available

Table 4. Distribution of peat maturity under different land use types.

Peat Maturity	Land use types							
	Forest	Shrub	Timber plantation	Rubber plantation	Oil palm plantation	Paddy rice	Pine apple and others	Total
Fibric	117	82	12	159	240	101	78	789
Hemic	150	97	14	199	479	56	24	1019
Sapric	82	13	58	54	153	26	18	404
Total	349	192	84	412	872	183	120	2212

CONCLUSION

The bulk carbon content of 0.082±0.032; 0.060±0.028 and 0.048±0.024 Mg m^{-3} represents Sumatra and Kalimantan peats of sapric, hemic and fibric maturities. Utilization of these values can improve the estimate of peat carbon stock and carbon stock changes rather than using single value, for instance 0.060 Mg m^{-3} (Wösten *et al.* 1997) or 0.057 Mg m^{-3} (Page *et al*. 2002), without adding too much additional work.

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