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LAND-USE CHANGES TROPICAL PEAT CHARACTERISTICS

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SUMMARY

Tropical peatlands are vast carbon stores and subjects of quickly advancing man made deforestation and drainage. In this study we clarified the impacts of land use change on the physical and chemical properties of tropical peat in Central-Kalimantan, Indonesia. For physical characteristics we determined peat bulk density and fractioned particle size distribution, and for chemical characteristics we analyzed extractives, holocellulose (cellulose and hemicelluloses), acid soluble lignin, Klason's lignin, ash and total carbon and nitrogen content. The study showed that the bulk density and content of decomposition resistant lignin like compounds increased after land use change.

INTRODUCTION

Tropical peatlands are vast carbon stores but due to current deforestation and drainage they are largely converted to net carbon sources (Hooijer *et al.*, 2010; Miettinen and Liew, 2011; Page *et al.*, 2011). The effects of water level drawdown on tropical peat carbon dynamics has been studied mainly through changes in greenhouse gas emissions and peat subsidence (Wösten *et al.*, 1997; Jauhiainen *et al.* 2008; Hooijer *et al.*, 2012; Jauhiainen *et al.*, 2012). Relatively little work has been done on the effects of land use change on the physical and chemical characteristics of tropical peat. The aim of this study is to increase understanding of tropical peat characteristics and major impacts of deforestation and drainage on these peat characteristics.

MATERIAL AND METHODS

Study sites

Peat sampling was carried out in the basin of the Sabangau River in Central-Kalimantan, Indonesia. The sampling plots were established on three different land uses, which form a range from undrained forest growing area to peatland subject to previous drainage, deforestation and/or fire. Two plots were in undrained peat swamp forest, one in drained forest, and two plots in deforested, drained peatland (Table 1).

Table 1. Detailed information of the sampling plots.

Land use type	**Location**	**Land use history**	**Peat thickness, m**	**Sampling depths**	**Long term upper and lower quartile**
Undrained forest	2°19’16.96’’S 113°53’54.29’’E	original forest cover, selective loggings (1990) and illegal loggings (2000)	~2–3 m	10–15, 40–45, 80–85	2,7 cm -30,8 cm
Undrained forest	2°18’18,30’’S 114°4’30.0’’E	original forest cover, but selective logging (1990) and illegal loggings (2000)	~2–3 m	10–15, 40–45, 80–85	6.0 cm -23.0 cm
Drained forest	2°20’43.24’’S 114°2’7.02’’E	original forest cover, drained (1996→), selective logging (1996-1998)	~4 m	10–15, 40–45, 80–85, 110–115	-27,1 cm -58,5 cm
Deforested, burned peatland	2°20’0.43’’S 114°1’12.99’’E	drained and clear cut (1996→), burned several times	~4m	10–15, 40–45, 80–85, 110–115	-8,3 cm -31,0 cm
Deforested, agricultural peat soil	2°17’38.22’’S 114°1’4.69’’E	drained and clear cut (1987→), agricultural use	~4m	10–15, 40–45, 80–85, 110–115	-16.5 cm -30.3 cm

Sampling and sample treatments

According to Pitkänen *et al.* (2011) peat coring may selectively exclude some of the roots and wood from the peat sample. For our study we attempted to get sufficiently large, undisturbed, volume extract samples. Instead of coring with an auger we dug a pit for peat sampling. Samples were cut out from one wall of the pit using a volume exact frame (10*10*5 cm^{-3}) and a sharp knife. Six replicate samples were taken from three or four depths in the peat profile at each site (Table 1).

Samples were divided to two subsample sets. The first sample set (3 samples) was dried at 60°C to constant weight and bulk density (BD) was calculated from it. The second sample set (3 samples) was passed through two sieves (ø 1.5 mm and ø 0.15 mm) using running water to provide three substrate fractions. The fractions were dried at 60°C to constant weight. The results from these two sub sample sets are called from now on as non-fractioned sample (BD samples), woody fraction (ø >1.5mm) and fibric fraction (1.5< ø <0.15 mm). For each layer in the peat profile the portion of smallest particles (so called ‘sapric’ fraction) was calculated by subtracting the average share (g^{-1} cm^{-3}) of woody and fibric fractions from the average BD of the non-fractioned sample.

The content of extractives, holocellulose (cellulose and hemicellulose), acid soluble lignin and Klason's lignin were analyzed from the non-fractioned samples. Total carbon and -nitrogen content were analyzed with Leco CHN 600-analyzater. Ash content was determined from the ignition loss.

RESULTS

Peat characteristics in both deforested peatland sites, and both undrained peat swamp forest sites were found to be similar, and therefore data from the respective sites were aggregated into one group for analysis. The main differences in peat characteristics between the land uses were in the topmost peat close to the peat surface. At the deforested sites the BD and proportion (% of the BD of non-fractioned sample) of sapric particles was higher than in the forested sites (Fig. 1, Table 2). In forests the proportion of woody and fibric (% of the BD of non-fractioned sample) material was higher than in deforested sites. Also BD and proportion of fibric (% of the BD of non-fractioned sample) material was greater in drained forest than in the undrained forest (Fig. 1, Table 2).

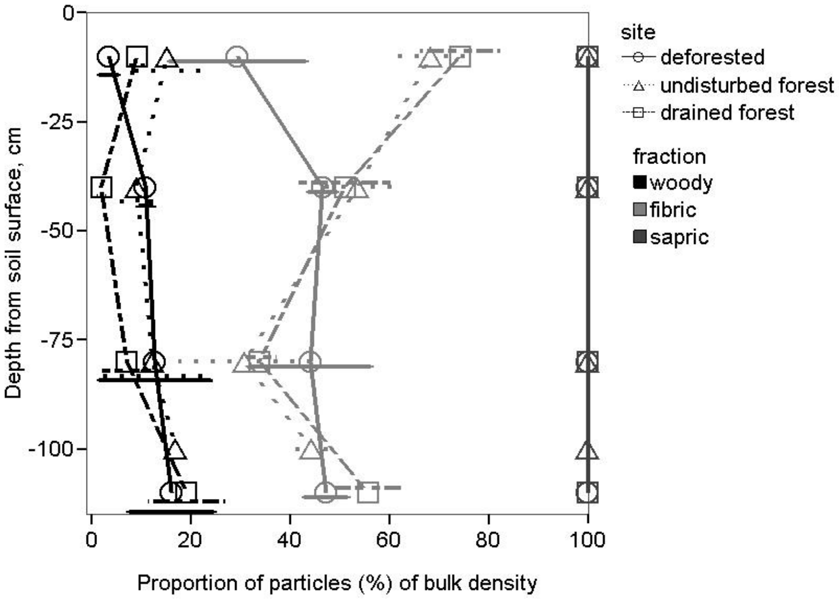

Fig. 1. Cumulative proportions of woody, fibric and sapric particle fractions of the BD at various depths in surface peat.

The average peat carbon content of non-fractioned samples was from 57% to 59% in different land use types and the differences were not significant between the sites (Table 2). The total peat nitrogen content was 0.8-1.3%, and it was at the highest in forest sites. The content of Klason's lignin was higher in the surface peat on deforested sites in comparison to forest sites. The topmost peat contents of extractives and holocellulose were greater in forests than in deforested peatlands. In the deeper sampling depths, variation of the peat extractives and holocellulose remained low between the sites (Fig. 2).

Table 2. BD and fraction distribution and total nitrogen and carbon content of the non-fractioned bulk density samples (average ±SD)

Value	**Undrained forest**	**Drained forest**	**Deforested peatland**
Number of samples	21	12	24
BD, g^{-1} cm^{-3}	0.13±0.02	0.16±0.04	0.15±0.03
woody fraction, %	12.9±8.1	9.4±7.7	10.9±8.2
fibric fraction, %	37.±15.7	44.4±16.2	31.0±8.2
Number of samples	14	8	16
total C, %	57±2.7	59±3.4	57±3.2
total N, %	1.2±0.37	1.3±0.49	0.8±0.08
C:N	52±17	64±23	73±8

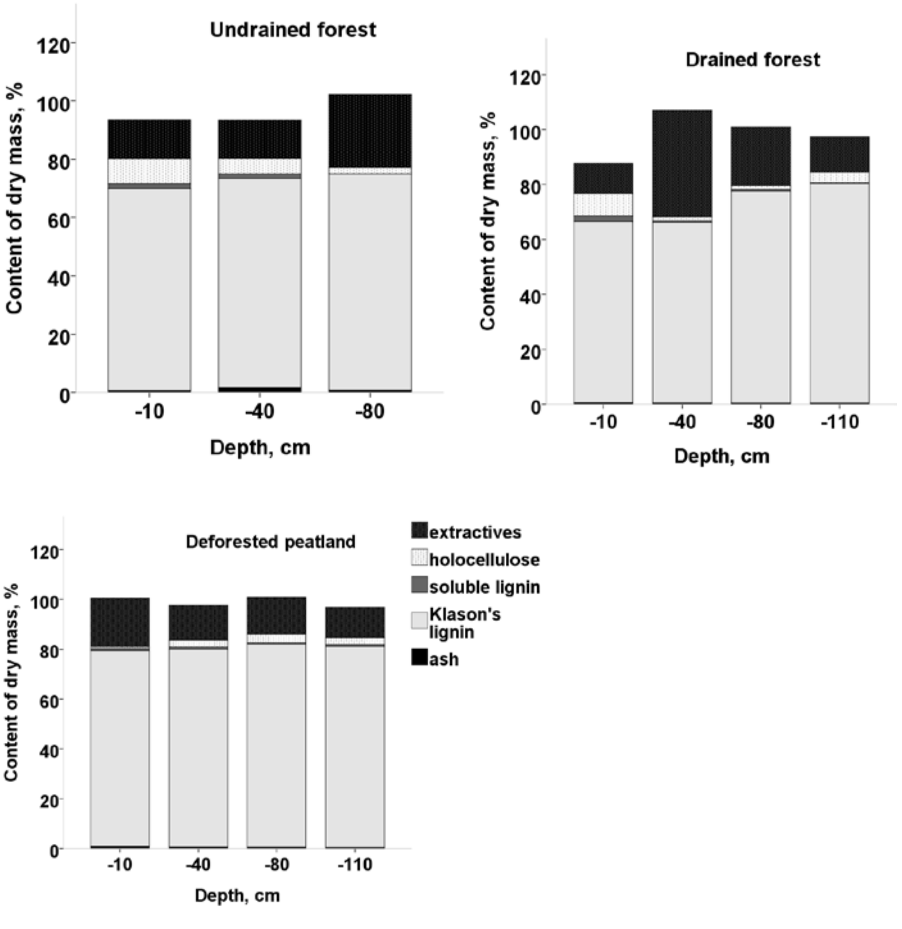

Fig. 2. Chemical composition of surface peat at various depths at various land use types, i.e. undrained peat swamp forest (top left), drained forest (top right), and deforested, drained peatland (down).

DISCUSSION AND CONCLUSION

This study shows that deforestation and drainage change both physical and chemical characteristics of tropical peat. The differences were greatest in the topmost peat between the three land uses studied. This is probably caused by the increased aerobic conditions in the surface peat after drainage. The change in peat characteristics from undrained forest was notably greater after extreme land uses, i.e. in deforested and drained peat. However, differences in peat characteristics were smaller between undrained and drained forests. The effects of land use change can be seen as an increase in bulk density and relative increase in decomposition resistant lignins, while the proportion of more easily decomposing compounds becomes smaller. Research on the processes leading to these observed effects at various land use patterns will be continued.

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