American Journal of Environmental Sciences 6 (4): 402-405, 2010
ISSN 1553-345X


# Effect of Converting Secondary Tropical Peat Swamp Forest into Oil Palm Plantation on Selected Peat Soil Physical Properties

[1]Mohd Suffian Firdaus, [1]Seca Gandaseca,
[2]Osumanu Haruna Ahmed and [1]Nik Muhamad Ab. Majid
[1]Department of Forestry Science, Faculty of Agriculture and Food Sciences,
[2]Department of Crop Science, Faculty of Agriculture and Food Sciences,
University Putra Malaysia Bintulu Campus, Sarawak, 97008 Bintulu, Sarawak, Malaysia

**Abstract: Problem statement:** The conversion of forest land into oil palm plantation is considered to be one of the causes of soil degradation and loss of tropical land forest in Southeast Asia. The objective of this study was to compare selected peat soil physical properties of secondary tropical peat swamp forest and oil palm plantation to determine the effect of forest conversion. **Approach:** Peat soil samples were collected from secondary tropical peat swamp forest and oil palm plantation at Batang Igan, Sibu, Sarawak, Malaysia. Experimental plots of 300 $m^3$ were set up in both sites and thirty peat soil samples were collected randomly in both sites at 0-15 cm depth using a peat auger. Undisturbed cores and bulk samples were collected for analysis of bulk density and moisture content. Fiber content of the total mass of organic materials was determined by wet sieving method. Soil bulk density, moisture content, organic matter, mineral content, soil porosity and particle density were determined by standard procedures. Hydraulic conductivity was measured in the field using Model 2800K1 Guelph Permeameter and soil strength was determined using Hand Operated Cone Penetrometer Eijkelkemp. Unpaired T-test was used to compare the variables of the two sites. **Results:** Both sites had similar degree of decomposition classified as hemic peat. No significant differences in fiber content, moisture content and particle density. Bulk density, mineral content and soil strength were significantly higher in the oil palm plantation while organic matter content, porosity and saturated hydraulic conductivity were significantly higher in the secondary tropical peat swamp forest. **Conclusion:** Conversion of secondary tropical peat swamp forest to oil palm plantation has significantly increased soil bulk density, mineral content and soil strength but significantly decreased organic matter content, porosity and saturated hydraulic conductivity. However, degree of decomposition, fiber content, moisture content and particle density were not affected by the conversion.

**Key words:** Secondary tropical peat swamp forest, oil palm plantation, soil physical properties

## INTRODUCTION

Peat has composition at least 65% of organic matter or less than 35% of mineral content (Tie and Kueh, 1979) but it could exceed of 75% (Huat, 2004). Peat soil has been recognized as one of the major group of soils found in Malaysia. An estimated 2-2.5 million hectares of peat swamp forests are still remaining in Malaysia and estimated of 1.5 million hectares are in Borneo with major areas in Sarawak (Parish, 2002)

Peat swamp forests are water-logged inland formed when rivers drain to the areas and begin to develop with peat deposits usually are at least 50 cm thick but can extend up to 20 m (McGinley, 2008).

The study site has been logged since 2005 and it over the years becomes a secondary tropical peat swamp forest.

Malaysia is one of the most important countries in the production of oil palm since the last four decades (Nasrin *et al*., 2008). However, the conversion of forest land into plantation for agriculture such as oil palm plantation has caused degradation and loss of tropical rain forest in Sarawak (Nakashizuka, 2007).

Nevertheless, converting the forest into oil palm plantation may change the soil physical properties. The knowledge on the physical properties of the peat soils as affected by oil palm cultivation is necessary to develop useful resources management plan for peat land areas.

**Corresponding Author:** Seca Gandaseca, Department of Forestry Science, Faculty of Agriculture and Food Sciences, University Putra Malaysia Bintulu Campus, Sarawak, 97008 Bintulu, Sarawak, Malaysia

The objective of this study was to compare selected peat soil physical properties of secondary tropical peat swamp forest and oil palm plantation to determine the effect of forest conversion.

## MATERIALS AND METHODS

Peat soil samples were collected from a secondary tropical peat swamp forest and oil palm plantation at Batang Igan, Sibu, Sarawak, Malaysia. Experimental plots were set up in each site with the size of 300 $m^3$. Thirty peat samples were collected in both sites randomly by using peat auger at 0-15 cm depth.

The samples were dried and sieved to pass 2 mm sieve. Undisturbed cores and bulk samples were also collected for laboratory analysis for bulk density and moisture content (McLay *et al*., 1992; Carter, 1993). The samples were not allowed to dry and were stored at approximately 5°C to discourage any bio-chemical activity.

Fiber content of the total mass of organic material was determined by wet sieving method (Jarret, 1983). The loss on ignition method was used to determine the organic matter and mineral content (Murtedza *et al*., 2002). Soil porosity and particle density were determined by standard procedures (Carter, 1993; Bashour and Sayegh, 2007).

Hydraulic conductivity was measured in the field using Model 2800K1 Guelph Permeameter by applying constant head well permeameter method (Quinton *et al*., 2008). Hand Operated cone Penetrometer Eijkelkemp was used to determine the soil strength (Brady and Weil, 2007).

Unpaired t-test was used to compare variables between the both sites by using The Statistical Analysis System (SAS) version 9.1.

## RESULTS

The results in Table 1 indicate that both sites had similar degree of decomposition as there was no significant difference of the percentage of fiber content between the secondary tropical peat swamp forest and the oil palm plantation.

Additionally, physical properties such as percentage of moisture content and particle density also showed no significant difference between the both sites.

The bulk density, mineral content and soil strength were significantly greater in the oil palm plantation than in secondary tropical peat swamp forest.

However, physical properties such as percentage of soil organic matter content, porosity and saturated hydraulic conductivity were significantly higher in the secondary tropical peat swamp forest.

Table 1: Mean comparison of selected soil physical properties between Secondary Tropical Peat Swamp Forest (STPSF) and Oil Palm Plantation (OPP)

| | Mean | |
|---|---|---|
| Variables | STPSF | OPP |
| Fiber content (%) | 41.485±3.208[a] | 41.156±3.381[a] |
| Bulk density ($gcm^{-3}$) | 0.112±0.004[b] | 0.168±0.007[a] |
| Moisture content (%) | 352.7±25.533[a] | 348.7±15.902[a] |
| Organic matter content (%) | 97.296±0.348[a] | 96.269±0.188[b] |
| Mineral content (%) | 2.704±0.348[b] | 3.730±0.188[a] |
| Particle density ($gcm^{-3}$) | 1.312±0.005[a] | 1.270±0.039[a] |
| Total porosity (%) | 91.466±1.821[a] | 86.406±3.888[b] |
| Soil strength ($Ncm^{-2}$) | 34.542±1.108[b] | 38.458±1.039[a] |
| Saturated hydraulic conductivity ($cm^{-1}$) | 0.032±0.008[a] | 0.003±0.0007[b] |

**Note:** Means with the same letter are not significantly different at $p \leq 0.05$ using unpaired t-test

## DISCUSSION

The insignificant difference values of fiber content indicate that the secondary tropical peat swamp forest and oil palm plantation had similar degree of decomposition and classified as hemic peat type which is intermediate in degree of decomposition. The low rate of decomposition was due to the waterlog condition that prevents it from rapid decomposition by microbes (Yule and Gomez, 2009).

Both sites had bulk density values in the range of 0.1-0.2 g $cm^{-3}$ and were similar with the previous research (Satrio *et al*., 2009a). This indicates that the peats were not well decomposed hemic materials (Richardson and Vepraskas, 2000). Soil with low bulk density is better compare to the soil with high bulk density (Yahya *et al*., 2009). The significantly higher bulk density values in the oil palm plantation indicate the effect of the forest conversion in terms of tillage (e.g., soil compaction due to usage of heavy duty machinery) which depletes soil organic matter and weakens the soil structure (Brady and Weil, 2007).

Supposedly, moisture content of oil palm plantation soil was expected to be lower than peat swamp forest due to evaporation from the soil surface and the lower percentage of organic matter (McLay *et al*., 1992). However, both sites had similar moisture content probably because of the drainage system in the peat swamp forest and the high proximity of water table to the surface in oil palm plantation.

The effects of soil organic matter on soil function are profound and influences soil physical, chemical and biological properties (Salimin *et al*., 2010). The low organic matter content in oil palm plantation could be due to tillage which is associated with depletion of soil organic matter in the oil palm plantation (Brady and Weil, 2007). Additionally, the greater soil aeration during and after opening the peat swamp forest might have caused breakdown of organic residues and hence encouraged decomposition of organic material by microbes (Brady and Weil, 2007).

Ash content or mineral content in peat soils can be as low as 2% or may be as high as 50% (Bell, 2007). The high mineral content in the oil palm plantation is consistent with low organic material determined in the site. Besides, fertilizer application carried out by the plantation might have increased the mineral content of the soil.

The low porosity of the oil palm plantation was due to cultivation as porosity often decreasing after several years of planting (Yahya *et al*., 2009). Cultivation increases soil bulk density and the pore space proportionately decreases (Brady and Weil, 2007).

Soil strength was significantly higher in oil palm plantation because of its lower water content and higher bulk density (Brady and Weil, 2007). Additionally, the usage of heavy machinery may have compacted the soil below its working depth (Satrio *et al*., 2009b).

Drainage system can reduce hydraulic conductivity of peat swamp (Gandaseca *et al*., 2009). The significant differences in the saturated hydraulic conductivity of the two sites were consistent with the differences in their bulk densities and total porosities. The higher saturated hydraulic conductivity of the peat swamp forest compared to that of the oil palm plantation could be due to the lower bulk density and higher percentage of total porosity.

## CONCLUSION

Conversion of secondary tropical peat swamp forest to oil palm plantation has significantly increased soil bulk density, mineral content and soil strength but significantly decreased organic matter content, porosity and saturated hydraulic conductivity. However, degree of decomposition, fibre content, moisture content and particle density were not affected by the conversion.

## ACKNOWLEDGEMENT

Fund for this research was provided by the Ministry of Higher Education Malaysia. The authors also thank Forest Department of Sarawak, Sarawak Forestry Corporation and New Time Resources Sdn. Bhd. for the permission and cooperation during the research.

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