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Peat Moisture and Water Level Relationship in a Tropical Peat Swamp Forest

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Abstract: Forest fire occurring in the tropical peat swamp forest has been a major concern and has been on the increase at an alarming rate during the past decades. This problem is further compounded by the fact that some of the affected areas have burned twice or more. If left unabated, peat areas that will be at risk to frequent fires will be on the increase. Peat soils when dry, posed a high risk of combustibility. It is therefore essential to understand the moisture characteristic of the peat soil in order to devlop forest fire management programme. The objective of this study was to monitor peat moisture and water level relationship. A study has been conducted to investigate the temporal characteristics of the peat water level and to understand the relationship between water table and peat moisture. The study was conducted at Compartment 101, Raja Musa Forest Reserve, Selangor, Malaysia. This area was on fire in 1998, early June 1999 and 9 March 2000. A 180 m long transect starting from the edge of the canal into the forest was established. Twenty peizometers of 2 m length each, were installed along the established transect. Water table and peat samples were taken weekly beginning at 24 October to 20 December 2000. Peat soils were analyzed for soil moisture on oven-dry basis. The result showed that there was a systematic rise and fall of the water table. The maximum and minimum water table recorded were at 22.6 cm above ground and 31.5 cm below ground, respectively. In the forested area, results showed that the changes in water level had a smaller range (16.9 cm) compared to the open area (25.1 cm). Mean peat moisture sample at depths 0 cm (surface), 50 and 100 cm were 577, 891 and 1070%, respectively. ANOVA analysis showed that lower depth has significantly higher moisture (at 95% confidence level) compared to higher layers. The study shows the temporal variations of water level in peat swamp forest. This variations can be used as a basis for early warning indicator of peat forest fire.

Key words: Tropical peat forest, forest fire, peat moisture

INTRODUCTION

Tropical peat is determined as all organic soils in the wetlands of the tropics and subtropics lying within latitudes 35 degrees North and South including those at high altitudes (Andriesse, 1988). Formed under anaerobic conditions (Carlson, 1985) through the action of bacteria, fungi and chemical compounds on plant remains, peat is an organic material which develops as a result of the incomplete breakdown of wetland vegetation (Shier, 1985), may occur as a sedimentary deposit anywhere the natural drainage of rainwater is permanently reduced or impeded.

Frequency of fire occurrence in the peat area, whether under forest or agriculture land has been on the increase at an alarming rate. This will lead to degradation of peat and increasing susceptible to the recurrent fires. Many of the areas affected have burnt more than once and if this situation is not monitored, fire may be a periodic event.

Most of the fires in peat areas are classified as ground fire. This type of fire occurs in subsurface organic fuels such as duff layers under forest stands, arctic tundra and organic soils of bogs, swamp and peat (Brown and Davis, 1973). Peat fire is dominated by smouldering combustion under the soil surface, penetrating into deeper horizons of the soil, burning out funnel shaped pits and then spreads in a horizontal manner (Artsbashev, 1983). This also causes injury to the tree roots causing extensive damage especially toppling of the trees. A study conducted by Ainuddin *et al.* (2001) shows that fire caused considerable changes in the vegetation composition and structure of the burned forest. It also changed the chemical and physical characteristics of the peat soil (Lailan and Ainuddin, 2000; Lailan *et al.*, 2004).

Water is one of the important components in peat forest ecosytem and water level is one of the indicators of hydrological conditions which can lead to the increase

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in susceptibility of forest fire. The objective of this study was to monitor peat moisture and water level relationship. Specifically the objectives of the study presented in this paper were to investigate the temporal and spatial characteristics of water table in peat swamp forest and to understand the relationship between water table and peat moisture in peat swamp forest.

MATERIALS AND METHODS

This study was conducted at Compartment 101, Raja Musa Forest Reserve; a site (3°27'01"N and 101°25'27"E) that was on fire during *El-Nino* season in 1998, early June 1999 and 9 March 2000. The area is now covered with weed. This site was selected based on several considerations such as near the canal since this study needs to know the effect of canal to peat water table level and peat moisture. This site consists of two major vegetation types; weed (in burnt areas) and forest (in unburned areas).

Water table levels in peat swamp forest were measured using peizometers made of PVC pipe, which has the length of 2 m and with the diameter of 5 cm, installed into 1.5 m depths. To specifically address the hydrological effects posed by canal and differences between open area and under canopy, peizometers were installed 10 m apart with the exception of second (5 m) in a single transect, consisting of 20 peizometer arranged from the edge of the canal to 180 m inside the forest. Measurements were taken weekly using measuring tape and a torchlight.

Peat soils in peat swamp forest were sampled up beside the line of the peizometers at the distance of 0, 5, 10, 20, 40, 60 and 80 m from the canal and so on at 3 depths of 0 cm (surface), 50 and 100 cm. Peat samples were taken weekly and were measured for moisture using gravimetric method. Moisture is calculated on the basis of loss in weight between original and dried sample. The water table level and peat moisture data were used to determine the relationship to the peat swamp forest. The data were analysed using ANOVA and Duncan Multiple Range Test (DMRT) from Statistical Package of Social Science (SPSS) software.

RESULTS AND DISCUSSION

Variations in the water table for 20 peizometers between 24/10/2000 to 20/12/2000 are shown in Table 1 and Fig. 1. Result shows that during the study period, there was systematic rise and fall of the water table. The lowest water table occurred in 8/11/2000 which showed reading of 31.5 cm below ground, while the highest water

Table 1: Peat water table at Raja Musa Forest Reserve, Selangor during the study period

Distance from canal (m)	Water table (cm) Mean	Range
0	-17.7	28.0
5	-13.8	34.0
10	-14.2	32.9
20	-12.6	27.5
30	-9.1	24.5
40	-7.2	24.2
50	-1.2	21.2
60	6.8	21.5
70	-2.1	20.6
80	-5.8	23.4
90	3.0	21.4
100	7.4	19.1
110	10.4	23.2
120	0.8	21.0
130	-1.9	24.5
140	4.2	28.0
150	0.2	24.6
160	11.0	27.1
170	3.4	25.5
180	-5.5	24.0

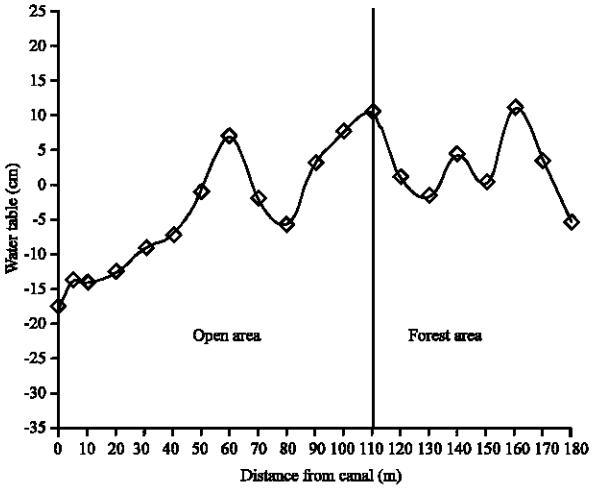

Fig. 1: Mean water table at the study site during the study period

table occurred on 29/11/200 which gave a reading of 22.6 cm above ground (flooding). This was due to heavy raining season during the measurement period. There was a significant drop of water table from the distance of 60 m to the edge of canal, which was from 6.8 to -17.7 cm. However, after 60 m from the canal, the water table showed a decrease and an increasing trend as it moved towards the forest area from the canal. Meanwhile, in the forest area there was only little fluctuation of the water table, from 10.4 cm at the distance of 110 m decreasing to -1.9 cm, then increasing again to 11.0 cm at 160 m from the canal before it decreases to -5.5 cm at 180 m.

This study also showed that as the peizometer goes toward the forest area the reading was higher compared to those near the canal. Water level in open area which

Table 2: Mean surface, 50 and 100 cm depth peat moisture

Distance from canal (m)	Soil moisture (%) Surface	50 cm	100 cm
0	491	774	1045
5	474	937	1103
10	454	994	1102
20	401	796	1036
40	620	974	1138
60	600	947	1113
80	646	1010	1133
100	658	840	1050
120	661	871	1047
140	663	873	1031
160	781	952	1134
180	472	723	915
Mean	577	891	1070

ranged from 7.4 to -17.7 cm were larger than the forest area (distance from 110 m onward) which has the ranged of 11.4 to -5.5 cm. The drop in water table toward the canal suggests that the canal might facilitate the outflow of water from the forest.

Mean peat moisture during the study period at depth 0 cm (surface), 50 and 100 cm were 577, 891 and 1070%, respectively (Table 2). In the surface soil, the minimum and the maximum were 189 and 1304% respectively, while at depth 50 cm minimum and maximum peat moisture were 401 and 1578%, respectively. However, at 100 cm depth, minimum peat moisture was 661%, while the maximum was 1695%. We can see that the minimum soil moisture occurred at the open area, while the maximum soil moisture occurred in the forest area. The results also showed that the lower soil moisture at open area may be caused by the outflow of water from the canal. Result also showed that peat moisture increased with the depth of the soils, mainly due to the evaporation process at the surface.

In terms of peat moisture range, surface level has the highest range of 380%, followed by 50 cm depth which has a range of 287% and 100 cm depth which has a range of 223%. This showed that the soil moisture of the deepest depth of soil (100 cm) fluctuated less compared to the surface soil.

CONCLUSIONS

The water table level in peat swamp forest showed a systematic temporal characteristic of rising and falling. The maximum water table occurred was 22.6 cm above ground while the minimum was 31.5 cm below ground. The canal has some effect to the water table as the result showed that the water table decreased as it moved toward the canal. Other than that, there was a difference in water table between forest area and open area, where the range of the forested area was smaller than the open area.

There was significant result of peat moisture within depth of the soils. For the surface soil, the moisture ranged from 401 to 781%, while at 50 cm, it ranged from 723 to 1010%. Moisture of the 100 cm depth has the highest value, which ranged from 915 to 1138%.

From the results shown, we can conclude that there was an effect of the canal on the peat water table. An effect was also noticed between open area and forest area. The lower layers of peat have higher moisture contents. We hope to develop relationships between water level depths and peat moisture that can be used as an indicator for the early warning system in the peat forest fire management.

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