FUEL CHARACTERISTICS OF SELECTED PLANT SPECIES REGROW ON BURNT AREA IN RAJA MUSA FOREST RESERVE, SELANGOR, MALAYSIA

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Tropical peat swamp forest is an important ecosystem that functions to restore balance in the hydrological process, habitat for flora and fauna as well as cater the needs for human livelihood. The forest however is threatened by many factors which lead to forest fire. There are many studies conducted to understand better the ecological balance, economic benefits, and impact of peat degradation of the forest but little is known on the species flammability which eventually provides information for forest fire risk management in tropical peat swamp forest. The aim of the study was to estimate the flammability index (FI) o the dominant plant species that were found in burnt area in Raja Musa Forest Reserve based on the its characteristics and flammability of species. The study site was located in Raja Musa Forest Reserve, Selangor, Malaysia where the forest suffered severe wildfire few years back and currently progressively rehabilitated. The fuel characteristics analyzed were moisture content, calorific value, chemical composition and thermal stability. 8 species were commonly found in the study plot and they were pioneer species of the burned area which were *Scleria sumatrensis, Imperata cylindrica, Melicope latifolia, Melastoma malabathricum, Macaranga pruinosa, Lyodium flexuosum, Nephrolepis biserrata,* and *Uncaria tomentosa*. The result shows that *I.cylindica* has highest ranking rate of spread and ash content. *S.sumatrensis* is high in coverage percentage and cellulose content while *L.flexuosum* is identified as goof fuel for combustion due to its low moisture content, ignition time and ignition temperature. *U.tomentosa* had the highest calorific value and extractive percentage amongst the analyzed species. The study found that the species flammability varies differently on its fuel characteristics basis. The flammability index exhibits that *S.sumatrensis* and *L.flexuosum were* indicated to be highly flammable and serve as good for combustion. The findings of this study provide insights of identifying the species which were highly combustible and resists fire. The fuel

characteristics and flammability information were essential to recognize the significant fire threats from the species present in the area aside from peat, climatic and human causes. The evaluation, however, do not portrayed the whole Raja Musa Forest Reserve but only the affected burnt area

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KAREKTER BAHAN BAKAR BAGI SPESIS TUMBUHAN TERPILIH YANG TUMBUH SEMULA DI KAWASAN TERBAKAR HUTAN SIMPAN RAJA MUSA, SELANGOR, MALAYSIA

Oleh

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Hutan paya gambut tropika adalah satu ekosistem yang berfungsi untuk mengimbang kembali proses hidrologikal, habitat flora and fauna serta memenuhi kehendak kehidupan manusia. Walaubagaimanapun, hutan diancam oleh pelbagai faktor yang memimpin kearah kebakaran hutan. Terdapat banyak kajian yang telah dilaksanakan untuk memahami dengan lebih baik berkenaan dengan keseimbangan ekologikal, manfaat ekonomi, dan impak degradasi tanah gambut hutan tetapi sedikit pengetahuan tentang kebolehbakaran spesis yang mana memberi maklumat tentang risiko pengurusan kebakaran hutan terutamanya kajian di hutan pata gambut tropika. Tujuan kajian ini adalah untuk menganggarkan index kebolehbakaran (FI) species tumbuhan yang dominan ditemui di kawasan pernah terbakar Hutan Simpan Raja Musa berdasarkan karekteristik bahan bakar. Tapak kajian ini terletak di Hutan Simpan Raja Musa, Selangor, Malaysia yang mana hutan ini pernah mengalami kebakaran teruk beberapa tahun lepas dan kini giat direhabilitasikan. Karekteristik bahan bakar yang dianalisis adalah kelembapan, nilai kalori, komposisi kimia dan kestabilan terma. 8 spesis mudah ditemui di plot kajian dan spesis ini adalah spesis pelopor di kawasan yang pernah terbakar ini dan mereka adalah *Scleria sumatrensis, Imperata cylindrica, Melicope latifolia, Melastoma malabathricum, Macaranga pruinosa, Lyodium flexuosum, Nephrolepis biserrata,* dan *Uncaria tomentosa*.. Keputusan kajian menunjukkan yang *I.cylindrica* mempunyai kedudukan kadar penyebaran dan kandungan abu tertinggi. *S.sumatrensis* adalah tinggi peratusan litupan dan kandungan selulosa manakala *L.flexuosum* diidentifikasikan sebagai bahan bakar yang baik untuk pembakaran oleh sebab kandungan kelembapan, masa pencucuhan, dan suhu pencucuhan yang rendah. *U.tomentosa* mempunyai nilai kalori dan peratusan ekstraktif tertinggi

daripada species yang dianalisa. Kajian ini mendapati kebolehbakaran hutan berbeza menerusi dasar karekteristik bahan bakar. Indeks kebolehbakaran menunjukkan *S.sumatrensis* dan *L.flexuosum* diindikasikan sebagai sangat mudah terbakar dan berfungsi sebagai bahan bakar yang baik untuk pembakaran. Hasil penemuan kajian ini memberi pandangan mengenai pengidentifikasian species yang mudah terbakar dan melawan api. Maklumat karekteristik bahan bakar dan kebolehbakaran adalah penting untuk mengenalpasti signifikasi ancaman api daripada species yang ada di kawasan itu selain daripada gambut, iklim dan sebab manusia. Penaksiran ini, tidak menggambarkan keseluruhan kawasan rehabilitasi di Hutan Simpan Raja Musa tetapi hanya untuk kawasan yang pernah terbakar di sana sahaja.

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I certify that a Thesis Examination Committee has met on 23 April 2015) to conduct the final examination of Gerald Anak Ulok on his thesis entitled "Fuel Characteristics of Selected Plant Species Regrow on Burnt Area in Raja Musa Forest Reserve, Selangor, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.
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LIST OF ABBREVIATIONS

DO	Dissolved oxygen
FMC	Fuel moisture content
RMFR	Raja Musa Forest Reserve
ROS	Rate of spread
TAPPI	Technical Association of the Pulp and Paper Industry
TGA	Thermogravimetric analysis

GLOSSARY

Calorific value
Combustion
Flammability
Forest fire
Fuel characteristics
Ignition
Peat swamp forest
Pyrolysis
Thermal stability

CHAPTER 1

INTRODUCTION

1.1 General Background

Tropical forests are considered to be one of the greatest assets and serve as important sources, which contribute to the world's economic growth and recreational purposes. However, the forests in tropical areas are gradually exposed to the risk of increasing population and higher demands for industrial activities such as forest conversion to timber plantation and agriculture (Smith and Scherr, 2003)

Malaysia is situated at the equator in which the forest is classified as the tropical rainforest as the whole country received more than 2000 mm of rain annually. This tropical rainforest can be categorized according to dipterocarp forest, montane forest, peat swamp forest, mangrove forest, and there are areas covered by heath forest and forest on limestone and quartz ridges (The Malaysian Rainforest., n.d). The high number of species in forest indicates high species diversification of tropical rainforest.

Peat swamp generally has less fauna biodiversity compared to lowland forest but still it is the home of endangered big mammals such as the Asian elephant (*Elephas maximus*) and tiger (*Panthera tigris*). Perhaps due to the high values of timber, the forest has been exploited and indirectly exposed the peat swamp forest to fire. Extensive and continuous disturbance of the forest has caused with a severe fire incidences in 1997-1998 near the Pahang coast (The Malaysian Rainforest, n.d)

Forest fire occurrence is usually due to several combined reasons and may be severe if not being controlled entirely. It is considered as one of the factors which alters the environment and determines the vegetation. Tsoi (2009) stated that the implication of biomass burning will affect the chemical composition in the atmosphere as well as global carbon cycle. Species such as *Macaranga* spp. and *Imperata cylindrica* can dominate the burned areas (Ainuddin and Goh, 2010). The loss of high value timbers, herbs, habitat and wildlife are totally inevitable once fire occurs.

Forest fire ignition can be caused by human activities or lightning. Human interferences are basically due to the increased population and lead to commercial forestland to other uses. Overexploitation of peat swamp forest has led to forest degradation and occurrences of forest fires (Ainuddin *et al.,* 2006). Dry areas are truly affected and drought season may aggravate the situation. However, fire occurrence in dry areas is also dependent on the availability of the fuel and fuel types. This is because different sources of fuels have different physical properties and chemical composition as well as biological characteristics.

Peat swamp forest is the most affected forest by fire incidents. However, during the dry season and due to more conversion of this forest to agricultural

production, fire can be ignited and spread to the forest. The spreading of fire for peat swamp forest may be visible when burning occurs on aboveground biomass but can be invisible when smoldering combustion takes place underground. The underground burning is visible with the production of smoke. According to the Selangor Forestry Department (2010), the areas destroyed by fire in the Raja Musa Forest Reserve, a peat swamp forest were 592 hectares since 2002 until 2009. Most of the fires were due to fires from the villagers of nearby settlements and small-scale agriculture practices.

Many studies have been conducted on the peat swamp forest and forest fire related studies. Most of the studies were on peat soil and forest fire impacts. However, limited study was conducted on aboveground biomass characteristics which influence the forest flammability.

1.2 Problem Statement

This study addressed on the issue of aboveground biomass characteristics to estimate the flammability. As mentioned, limited study was conducted to point out the impact of aboveground biomass characteristics as potential flammability risk in peat swamp forest specifically in Raja Musa Forest reserve. Peat swamp forest fire is typically associated with underground fire as it spreads downward compared to other forest types. Thus, little is known on the flammability of the aboveground fire.

The main concern of this study is to add up information on forest fire factors from aboveground biomass perspectives which narrow towards the characteristics. Lack of researches established on the aboveground fuel that propagates fire provides a significant drive to conduct this study. The information on the species availability and its characteristics could provide insights in fire spreading in peat swamp forest.

This study provides information and understanding on plant as fuel potential and plays roles in enhancing the fire spread above the ground. The study on peat materials and its flammability had neglected the aboveground fuel to be part of forest fire indicator. In establishing the study, fuel characteristics were evaluated as this study hypothesized that the plants are fuel potential and aid in propagating and sustain fire other than peat itself.

1.3 Research Objectives

The aim of the study is to estimate the flammability index (FI) of the dominant plant species that were found in burnt area in Raja Musa Forest Reserve based on its characteristics. As the parameters are interrelated, the fuel characteristics will eventually determine the forest flammability. The objectives of this research were,

a. To identify the main species found in burned Raja Musa Forest Reserve area through inventory.

b. To determine the flammability index of selected plant species using the above ground biomass characteristics.
c. To develop the flammability index for the burned area in Raja Musa Forest Reserve

Generally, the characterizing the fuel eventually provides better insights on how the fuel affects its flammability, thus precautionary can be taken towards the risk of forest fire reoccurrence. The information gained from characterizing the potential fuel can be used to identify the vulnerability of the species towards fire. In addition, a good fuel potential will indicate the fuel with high flammability and fuel with low flammability shows a good fire resistant. Knowledge about fuels is a fundamental part of fire management that is necessary to both conserve biodiversity and reduce the negative impact of forest fires. Forest fuel characteristics and flammability are essential information for the prediction of forest fire spread and behavior. The results of this study can help the authorities in prevention and controlling forest fires.

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APPENDICES

BIODATA OF STUDENT

Gerald Anak Ulok was born in Bintulu, Sarawak on 9 August 1988. He obtained his primary education in Sekolah Rendah Kebangsaan Dato' Traoh, Kota Samarahan, Sarawak and continued his secondary education in Sekolah Menengah Sains Kuching, Kuching, Sarawak. Upon finishing high school, he went to Labuan Matriculation College in Labuan Federal Territory for his foundation for 1 year program. Thereafter, he enrolled in Universiti Putra Malaysia, Serdang, Selangor in 2007 taking Bachelor of Science in Forestry. He graduated his bachelor degree in 2010 and embarking on a study related to forest fire for master degree.

LIST OF PUBLICATIONS

Gerald, U., Ainuddin, A.N., Rusea, G., Paridah, M.T. (2016). Leaves Calorific Values of Selected Species in Burnt Tropical Peat Swamp Forest in Selangor, Malaysia. *American Journal of Environmental Sciences*, 12 (2): 63.67