ASSESSMENT ON SOIL PHYSICO-CHEMICAL PROPERTIES OF SECONDARY AND REHABILITATED FORESTS IN UNIVERSITI PUTRA MALAYSIA BINTULU SARAWAK

MUHAMMAD KHAIRULDDIN BIN FADZIL

ASSESSMENT ON SOIL PHYSICO-CHEMICAL PROPERTIES OF SECONDARY AND REHABILITATED FORESTS IN UNIVERSITI PUTRA MALAYSIA BINTULU SARAWAK

By

MUHAMMAD KHAIRULDDIN BIN FADZIL

A Project Report Submitted in Partial Fulfilment of the Requirements
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DEDICATION

Specially dedicated to:

My father,

Fadzil Bin Mustafa

My mother,

Norhayati Binti Lee

Also, my siblings.

To all my friends,

Thank you for your encouragements, supports

And the sacrifices that you have given.

Thank you for everything.

May Allah bless all of us.

ABSTRACT

Assessment of the associated forest rehabilitation programme regarding soil fertility status by using soil indices could provide fundamental information on soil suitability for species preferences and to improve the technique for future tropical rainforest rehabilitation programmes. This study was conducted to determine the soil physico-chemical properties and to identify the soil fertility status of rehabilitated and secondary forests. Soil samples were collected from both locations which were rehabilitated forest and secondary forest (Nirwana forest) at Universiti Putra Malaysia, Bintulu Campus, Sarawak. The plot size for each site was 20 × 20 m for 18 experimental sites (at different ages after planting) were established, followed by soil sampling at 0-15 cm and 15-30 cm depths randomly. The samples were air-dried and sieved to pass a 2mm mesh sieve for further analysis. Standard soil analysis for physical and chemical properties was used to analyze the soil samples such as soil acidity, soil organic matter, total organic carbon, available P, exchangeable Al, exchangeable cations (Ca, Mg, K, Na) and Cation Exchange Capacity (CEC). The soil fertility status was evaluated using two indices, namely Soil Fertility Index (SFI) and Soil Evaluation Factor (SEF) for both rehabilitated and secondary forests. The results showed that there were significant differences ($p<0.05$) in pH (water and KCl), CEC, exchangeable Al, Ca, K, Na, total organic carbon and organic matter between depths. The results also showed that the selected physico-chemical properties had significant differences based on the age of planting of rehabilitated forests. The SFI and SEF for rehabilitation forests showed higher value as compared to secondary forests, suggesting forest rehabilitation had improved the fertility status of degraded forestland. In conclusion, both rehabilitated and secondary forests had significant differences based on the selected physical and chemical properties. Moreover, the soil fertility status at the rehabilitated plots was higher than those of the secondary forest, which proved that the forest rehabilitation technique was the ideal planting technique for rehabilitating and replenishing soil fertility status of abandoned degraded shifting cultivation land.

ABSTRAK

Penilaian terhadap program pemulihan hutan yang berkait rapat berkenaan status kesuburan tanah dengan menggunakan indeks tanah dapat memberikan maklumat asas mengenai kesesuaian tanah untuk pemilihan spesies dan memperbaiki teknik untuk program pemulihan hutan hujan tropika di masa hadapan. Kajian ini dijalankan untuk mengetahui sifat fizik dan kimia tanah dan mengenalpasti status kesuburan tanah di hutan pemulihan dan sekunder. Sampel tanah dikumpulkan dari kedua-dua lokasi iaitu di hutan pemulihan dan hutan sekunder (hutan Nirwana) Universiti Putra Malaysia, Kampus Bintulu Sarawak. Saiz plot untuk setiap tapak adalah 20 × 20 m untuk 18 tapak eksperimen (pada umur yang berbeza selepas penanaman) ditubuhkan, diikuti oleh pengambilan sampel tanah pada kedalaman 0-15 cm dan 15-30 cm secara rawak. Sampel tersebut dikeringkan dan disaring melalui penyaring 2mm untuk analisis selanjutnya. Analisis tanah yang lazim digunakan untuk sifat fizikal dan kimia sampel tanah ialah seperti keasidan tanah, bahan organik tanah, jumlah karbon organik, kehadiran P, pertukaran Al, pertukaran kation (Ca, Mg, K, Na) dan Kapasiti Pertukaran Kation (KPK). Status kesuburan tanah dinilai dengan menggunakan dua indeks, iaitu Indeks Kesuburan Tanah (IKT) dan Faktor Penilaian Tanah (FPT) untuk kedua-dua hutan rehabilitasi dan sekunder. Keputusan menunjukkan terdapat perbezaan yang signifikan ($p < 0.05$) dalam pH (air dan KCl), CEC, pertukaran Al, Ca, K, Na, jumlah karbon organik dan bahan organik antara kedalaman. Keputusan juga menunjukkan bahawa sifat-sifat fizik kimia yang terpilih mempunyai perbezaan yang signifikan berdasarkan umur penanaman hutan pemulihan. SFI dan SEF untuk hutan pemulihan menunjukkan nilai yang lebih tinggi berbanding dengan hutan sekunder, menunjukkan pemulihan hutan telah meningkatkan status kesuburan tanah di hutan yang menghadapi kemerosotan. Sebagai kesimpulan, kedua-dua hutan pemulihan dan sekunder mempunyai perbezaan ketara berdasarkan sifat fizikal dan kimia yang terpilih. Selain itu, status kesuburan tanah pada plot pemulihan adalah lebih tinggi daripada hutan sekunder, yang membuktikan bahawa teknik rehabilitasi hutan adalah teknik penanaman yang sesuai untuk memulihkan dan membaikpulih status kesuburan di tanah yang ditinggalkan selepas penanaman berpindah.

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APPROVAL SHEET

I certify that this research project report entitled “Assessment on Soil Physico-Chemical Properties of Secondary and Rehabilitated Forests in Universiti Putra Malaysia Bintulu, Sarawak” by Muhammad Khairulddin Bin Fadzil has been examined and approved as a partial fulfilment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Univeristi Putra Malaysia.

____
Assoc. Prof. Dr. Arifin Bin Abdu
Faculty of Forestry
Universiti Putra Malaysia
(Supervisor)

____
Prof. Dr. Mohamed Zakaria Bin Hussin
Dean
Faculty of Forestry
Universiti Putra Malaysia

Date: 5 January 2018

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LIST OF ABBREVIATIONS

UPM	Universiti Putra Malaysia
FAO	Food and Agriculture Organization of United Nation
H_2O	Water
KCL	Potassium Chloride
CEC	Cation Exchange Capacity
Al	Aluminum
H	Hydrogen
P	Phosphorus
Ca	Calcium
Mg	Magnesium
K	Potassium
Na	Sodium
TOC	Total Organic Carbon
OM	Organic Matter
SFI	Soil Fertility Status
SEF	Soil Evaluation Factor
SPSS	Statistical Package for the Social Sciences
ITTO	International Tropical Timber Organization

CHAPTER 1

INTRODUCTION

1.1 General Background

Tropical rainforest is well known as one of the complex ecosystem exist in the world. It is considering as a highly valuable forest than other forest types in term of biodiversity and species richness (Hughes, 2015). This type of forest plays an important role in the maintaining the ecosystem of environment and become a part of important habitat for living things such as flora and fauna (Vielliard, 1993). Tropical forest area is disappearing at the rate of 13.5 million ha per year, mainly due to clearing for plantation or agriculture and shifting cultivation (Daljit *et al*., 2011). According to FAO (2010), Malaysia's total forest area decreased by 434 000 hectares between 2005 and 2010 (an annual decline of 0.42%) and by 1.92 million hectares between 1990 and 2010 of the estimated 17.1 million hectares of dry inland forests, 5.48 million hectares are in Peninsular Malaysia, 7.83 million hectares are in Sarawak and 3.84 million hectares are in Sabah (ITTO, 2011). Every year this forest has been degraded due to deforestation. Unfortunately, according to Daisuke *et al*. (2013), tropical rainforests in Southeast have been degraded by commercial logging, agriculture land conversion and urbanization.

Several researchers have proved that in order to overcome degraded forest land into more productive areas, plantation forest or rehabilitation activities are considerate an important tool from a global perspective in terms of wood and ecosystem resources and eco-friendly environment services (Abdu *et al*., 2008a; 2008b; Cole *et al*., 1996; MacNamara *et al.,* 2006). In addition, forest rehabilitation also attempts to return the forest to a stable and productive condition in terms of soil fertility status, but not necessarily the original diversity, structure and function (Krishnapillay, 2007). Forest rehabilitation of rainforest is often undertaken with two primary reasons which are to restore the ecology stability for facilities, biological and chemical improvement of degraded sites and to restore productivity of degraded sites in order to gain economic returns through agriculture or forestry which commonly involves plantation of native and exotic species on degraded forest land (Lamb and Olsen, 1992). In order to overcome this problem, forest rehabilitation is one of effective solution to cover this situation by planting the same tree species or exotic tree species which can help to improve the soil quality of degraded land (Parrotta, 1997). Several projects have been done such as Tropical Forest Regeneration Experimental Project in 1990 at Bintulu, Sarawak with collaboration of UPM and Mitsubishi Corporation. The main objectives of this projects are to implement the techniques of planting Malaysia tree species which compatible to land on degrade sites such as abandoned shifting cultivation area, logged forest and other degraded sites (Akbar *et al*., 2010).

Soil plays a major role to ensure the growth and development of trees on forest. Trees are supported by the soil as it becomes the medium for water and nutrient intake. Soil comes from the parent material of different composition of mineral (Ulrich, 2006). The material in soil properties are influence the composition of forest vegetation and the rate of tree growth (Pritchett, 1987). The amount of growth or yield is a variable, dependent on the level of soil fertility but many other factors such as type of plant and growing conditions may also significantly affect growth (Armson, 1927). Physical, chemical and biological properties of the soil affected the growth of plants and it is also including how easily roots can function, how well nutrients are protected from leaching and how nutrients are available (Carletti, 2009).

1.2 Problem Statement and Justification

Forest rehabilitation activity on degraded tropical rainforest should emphasize on the ecosystem involving soil properties, soil fertility and species selection for the progress of rehabilitation techniques in the future (Abdu *et al.,* 2008a). The progress of rehabilitation program under tropical conditions has been reported by several researchers (Abdu *et al.,* 2008b; Cole *et al.,* 1996; MacNamara *et al*., 2006; Tilki and Fisher, 1998; Norisada *et al*., 2005). In Sarawak alone, besides forest harvesting and forest encroachment, shifting cultivation is the major cause of land degradation (Jomo *et al*., 2004). The removal of trees without sufficient reforestation has resulted in damage to habitat and biodiversity loss accompany with increasing soil compaction, erosion and decrease in soil fertility (Geist and Lambin, 2002; Williamson and Neilsen, 2000).

Prior to conversion of the areas into various land use types, the rehabilitation and secondary forests areas were considered as natural forests and subsequently subjected to forest logging with Selective Management System (SMS) in 1980s. Soil samples were collected from year 1991 until 2009 at rehabilitation forests (20 years after planting) and secondary forest of Nirwana Forest Reserve, Universiti Putra Malaysia (UPM) Bintulu Campus, Sarawak, Malaysia. The rehabilitation plots were planted with mixed dipterocarp and non-dipterocarp species since 1991.

Most works have focused on species selection for planting proposes in relation to the growth productivity at degraded forest; however empirical data on soil characteristics under rehabilitation program are still limited or even lacking. This research is important to determine the soil physical and chemical properties of a rehabilitated degraded forest land 20 years after planting with various indigenous species in comparison with adjacent secondary forests and to elucidate the soil fertility status in rehabilitated and secondary forests by using Soil Fertility Index (SFI) and Soil Evaluation Factor (SEF). The SFI (Moran *et al.,* 2000) and SEF (Lu *et al*., 2002) are recently recommended methods used for evaluating soil fertility and productivity of succession of secondary forest in humid tropical region (Abdu *et al.,* 2008a). Therefore, preliminary assessment of rehabilitation program in relation to soil fertility status using soil indices could provide information on soil suitability for species preferences and improve effective technique for future rehabilitation program also whether the rehabilitation project is success in recovering the forest and soil.

1.3 Objectives

The objectives of this study were:

1. To determine the soil physico-chemical properties of the secondary forest and rehabilitated forest in UPM Bintulu, Sarawak.
2. To identify the soil fertility status by using Soil Fertility Index (SFI) and Soil Evaluation Factor (SEF) of the secondary and rehabilitated forests in UPM Bintulu, Sarawak.

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