UNIVERSITI PUTRA MALAYSIA

EFFECTS OF RIMBAKA FOREST HARVESTING TECHNIQUE ON STREAM WATER QUALITY AND SOIL PHYSICAL PROPERTIES

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Chairman: **Professor Dato' Nik Muhamad bin Nik Ab. Majid, PhD**

Faculty: **Forestry**

Forest harvesting has raised public attention and has been blamed for environmental problems especially land slide, soil erosion, flooding and degradation of water quality. In Peninsular Malaysia, forest harvesting in the hill forest mainly uses ground based system with the combination of crawler tractors and winch. In an attempt to reduce soil disturbance and degradation of river water quality, Rimbaka Timber Harvester (RIMBAKA) was introduced as an alternative to the crawler tractor.

This study focused on the effects of forest harvesting using RIMBAKA technique on river water quality index and soil physical characteristics. The study was carried out at Hutan Simpan Gunung Benom, Raub, Pahang. This study is important to determine the effects of using RIMBAKA for forest harvesting as it can be considered as an alternative to the ground- based system which has been proven to result in negative impact on soil properties such as soil compaction, increased run-off and erosion and also caused degradation of river water quality. The main objective of this study is to determine the forest

harvesting effects on river water quality index and soil physical properties such as texture, bulk density, particle density, porosity and moisture content.

Sampling of river water quality and soil physical characteristics were carried out in the area that has been approved for logging at three stages namely before, during and after forest harvesting. In order to determine forest harvesting effects on water quality index, water samples were collected from the stream channel site that flows through the forest harvesting area, logging road and virgin forest area. In addition, river water quality index was also studied during the dry and wet seasons for each site and also forest harvesting phases. The soil was sampled randomly in the area approved for logging during each harvesting phase.

Analysis of Variance (ANOVA) was used to detect significant differences in river water quality index and soil physical characteristics for each forest harvesting phase. Duncan Multiple Range Test (DMRT) was used to determine differences between each phase. In order to determine significant differences between river water quality during dry and wet seasons, a T-test was conducted. Meanwhile, Pearson's correlation coefficient was used to determine the turbidity and TSS relationship. T-test was also used to determine differences between soil physical characteristics at two altitudes (below and above 550 meters above sea level (masl)).

It was found that RIMBAKA harvesting technique has adversely affected to water quality index. Water quality slightly decreased during the wet season as compared to the dry season. The decline in water quality index is caused by an increase in Total Suspended Solid (TSS). During wet seasons, TSS value before, during and after forest harvesting were 13.38 mg/L, 52.67 mg/L and 66.00 mg/L, respectively. The corresponding values during dry seasons were 7.58 mg/L, 33.08 mg/L and 27.83 mg/L, respectively.

Stream crossing during road construction is the main factor in that increase TSS concentration. During the harvesting phase in the wet season, TSS value in the stream water at the road crossing is 71.07 mg/L compared to 34.5 mg/L at the forest harvesting site and 28.83 mg/L at the control area. Meanwhile, after forest harvesting, TSS value at the forest road site, harvesting area and the control area are 88.75, 43.25 and 33.0 mg/L, respectively. However, an increase in TSS value only resulted in a slight effect on water quality index value. Water quality index before, during and after forest harvesting belong to Class I and II. Turbidity and suspended solids showed strong linear relationship ($r^2 = 0.769$).

The forest harvesting operation also changed the texture, increased the bulk density and soil particle density. Indirectly, the changes had caused a decline in the porosity and soil moisture ($P \leq 0.05$).

Based on this study, forest harvesting using RIMBAKA technique only resulted in slight negative effects on water quality index and soil physical characteristics. However, the negatives effects can be further reduced if the forest harvesting is confined to dry season only. It is recommended that in future studies, more sampling should be carried out in the logging area to provide a more complete picture of the changes in soil and river water quality.

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

Kesan Penuaian Hutan Kepada Ciri-ciri Fizikal Tanah dan Alur Kualiti Air

Oleh

Othman bin Deris

August 2009

Pengerusi : Professor Dato' Nik Muhamad bin Nik Ab. Majid, PhD

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ABSTRAK

Penuaian hutan telah menjadi perhatian umum dan dilihat sebagai penyebab kepada masalah alam sekitar terutamanya tanah runtuh, hakisan tanah, banjir dan kemerosotan kualiti air. Di Semenanjung Malaysia, penuaian hutan di hutan bukit adalah berasaskan kepada sistem heretan pada permukaan tanah iaitu kombinasi jentera berantai dan lori winch. Justeru itu Rimbaka Harvester (RIMBAKA) telah diperkenalkan sebagai alternatif kepada penggunaan jentera berantai untuk mengurangkan kerosakan tanah dan kemerosotan kualiti air sungai.

Satu kajian kesan penuaian hutan ke atas ciri-ciri fizikal tanah dan indeks kualiti air sungai telah dijalankan di Hutan Simpan Gunung Benum, Raub, Pahang. Kajian ini amat penting untuk menentukan samada kesan penuian hutan menggunakan RIMBAKA boleh dijadikan alternatif kepada sistem heretan pada permukaan tanah yang terbukti memberi kesan yang negatif kepada ciri-ciri tanah seperti pemadatan tanah, peningkatan larian air permukaan, hakisan dan juga kemerosotan kualiti air. Objektif utama kajian ini adalah untuk menentukan kesan penuaian hutan terhadap indek kualiti air dan ciri-ciri fizikal tanah seperti tekstur tanah, ketumpatan pukal, ketumpatan partikel, keliangan dan kandungan kelembapan.

Persampelan ciri-ciri fizikal tanah dan kualiti air sungai dilakukan dikawasan yang dilesen untuk pembalakan iaitu sebelum, semasa dan selepas penuaian hutan. Untuk menentukan kesan penuaian hutan terhadap indeks kualiti air, sampel air diambil dari alur sungai yang mengalir melalui lokasi penuaian hutan, jalan hutan dan kawasan hutan dara. Sebagai tambahan, kajian juga dilakukan pada musim kering dan musim hujan bagi setiap fasa penuaian hutan. Persampelan ciri-ciri fizikal tanah pula dilakukan secara rawak bagi setiap fasa penuaian hutan.

Analisa Varian (ANOVA) telah digunakan untuk mengesan perubahan yang ketara indek kualiti air sungai dan ciri-ciri fizikal tanah bagi setiap fasa penuaian hutan. DMRT pula digunakan untuk menentukan perbezaan bagi setiap fasa. Ujian t pula telah digunakan untuk menentukan perbezaan yang ketara diantara

kualiti air pada musim hujan dan musim panas. Sementara itu, Korelasi *Pearson's coefficient* telah digunakan untuk menentukan perhubungan dan kekuatan diantara kekeruhan dan jumlah pepejal terampai (TSS). Ujian t juga digunakan untuk menetukan perbezaan yang ketara diantara ciri-ciri fizikal tanah pada paras ketinggian 350-550 dan 551-750 meter di atas paras laut

Daripada kajian yang dijalankan didapati penuaian hutan memberi sedikit kesan negetif kepada indek kualiti air. Kualiti air sedikit menyusut pada musim hujan dibanding pada musim panas. Penyusutan indek kualiti air adalah disebabkan oleh peningkatan TSS. Semasa musim hujan nilai TSS pada fasa sebelum, semasa dan selepas penuaian hutan meningkat kepada 13.38 mg/L, 52.67 mg/L dan 66.00 mg/L. Pada musim panas pula nilai TSS sebelum, semasa dan selepas adalah 7.58 mg/L , 44.08 mg/L dan 27.83 mg/L.

Jalan hutan yang dibina merentasi alur sungai adalah merupakan antara faktor utama peningkatan nilai TSS. Semasa fasa penuaian hutan iaitu pada musim hujan, nilai TSS di kawasan alur sungai yang direntasi jalan hutan ialah 71.07 mg/L dibandingkan dengan 34.5 mg/L di kawasan penuaian hutan dan 28.83 mg/L di kawasan hutan dara. Walaubagaimana pun peningkatan TSS ini hanya memberi kesan yang sedikit kepada indek kualiti air. Indek kualiti air sebelum, semasa dan selepas penuain hutan masih dalam kelas I dan II. Ujian korelasi diantara kekeruhan dan TSS menunjukkan kedua parameter tersebut mempunyai hubungan linear yang amat kuat dengan nilai bacaan 0.769. Ini menunjukkan peningkatan kekeruhan akan meningkatkan nilai TSS.

Kajian juga menunjukan bahawa penuaian hutan memberi kesan yang negatif kepada ciri-ciri fizikal tanah. Kesan tersebut ditunjukkan melalui perubahan tekstur tanah, peningkatan ketumpatan pukal dan ketumpatan partikel. Secara tidak langsung perubahan tersebut menyebabkan penyusutan keliangan dan kelembapan tanah ($P \leq 0.05$).

Berdasarkan kepada kajian tersebut menunjukkan bahawa penuian hutan menggunakan RIMBAKA hanya memberi sedikit kesan negetif kepada indek kualiti air dan ciri-ciri fizikal tanah. Walaubagaimana pun kesan negetif tersebut boleh dikurangkan dengan melaksanakan penuaian pada musim panas. Justeru itu disyorkan agar kajian diteruskan dengan menggunakan lebih banyak sampel di lokasi pembalakan agar dapat memberi gambaran yang lebih tepat terhadap perubahan tanah dan kualiti air sungai.

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I certify that an Examination Committee met on date of viva voce to conduct the final examination of Othman bin Deris on his Master of Science thesis entitled **"Effects of Forest Harvesting on Physical Soil Properties and River Water Quality**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original research work except for quotations and citations, which have been duly acknowledge. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

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Othman Bin Deris

Date:

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LIST OF ABBREVIATIONS

AN	Ammoniacal Nitrogen
ANOVA	Analysis of Variance
APHA	American Public Health Association
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
dbh	Diameter at breast height
DID	Department of Irrigation and Drainage
DOE-WQI	Department of Environment -Water Quality Index
FDPM	Forestry Department Peninsular Malaysia
masl	meter above sea level
mg/L	milligram/liter
MUS	Modified Uniform System
NTU	Nephelometric turbidity Units
P	Probability
PRF	Permanent Reserve Forest
pH	in unit pH
RIL	Reduced Impact Logging
Rimbaka	Rimbaka Timber Harvester
r	Coefficient Of Correlation
SFM	Selective Forest Management
SIDO	Sub Index of Dissolved Oxygen

SIBOD	Sub Index of Biological Oxygen Demand
SICOD	Sub Index of Chemical Oxygen Demand
SIAN	Sub Index of Ammoniacal Nitrogen
SIPH	Sub Index of pH
SISS	Sub Index of Suspended Solid
SMS	Selective Management System
TSS	Total Suspended Solid
α	Alpha

CHAPTER ONE

INTRODUCTION

1.1 Background

In 2000, the world forest cover was estimated at 29.6% of the total land area or 3,869 million hectares which can be divided into four broad categories, namely temperate, boreal, subtropical and tropical forests. Temperate, boreal and subtropical forests occupy about 1.86 billion hectares and tropical forests occupy 2.01 billion hectares (Food and Agriculture Organization [FAO], 2005). Twenty nine countries have more than half of their land covered with forest. Malaysia is one of the countries having more than 50% of the land area covered with forest. The Malaysian tropical rain forests are one of the twelve mega-biodiverse countries in the world. The forest contains 14,500 species of flowering plants and trees, 600 species of birds, 286 species of mammals, 140 species of snakes and 80 species of lizards (Forestry Department Peninsular Malaysia [FDPM], 2004).

In 2006, the total forested land in Malaysia was 19.52 million hectares (59.50% of total land area), with 5.88 (44. 7 %) million hectares in Peninsular Malaysia, 4.40 (59.7%) million hectares in Sabah and 9.24 (75.1%) million hectares in Sarawak. From the 19.52 million hectares of forested land, 17.40 million hectares are dry inland forest or dipterocarp forest while the remaining 1.54 million hectares and 0.58 million hectares are swamp forest and mangrove

forest, respectively. In order to preserve the forest resources as a renewable resource, 14.39 million ha or 73 % of the forest areas have been gazetted as a Permanent Reserved Forest (PRF) for sustainable management. The area of PRF in Peninsular Malaysia, Sabah and Sarawak are 4.70 million hectares, 3.59 million hectares and 6.10 million hectares, respectively (Abdul Rahman, 2008).

The PRF in Malaysia has been systematically managed since the beginning of the century. The forests are managed into three broad forest types such as dipterocarp forest, swamp forest and mangrove forest. There are two management systems for dipterocarp forest in Peninsular Malaysia, namely Modified Malayan Uniform System (MUS) and Selective Management System (SMS). The aim of MUS and SMS is to manage the forest on a sustainable basis. However, the principle behind the system is different. Under the selective logging system there is an intention to harvest the timber at the end of the 30 years cutting cycle while under the uniform system one has to wait a complete rotation of 55 years or more until the regeneration has grown into harvestable trees (FDPM, 2003b).

The MUS consists of removing the matured crop in a single felling of all trees below 45 cm diameter at breast height (dbh) for all species while SMS entails selection of optimum management regimes based on pre-felling inventory data with the minimum cutting regime of 50 cm for dipterocarps, except Chengal

(*Neobalanocarpus heimii*) where the cutting limit would be above 60 cm dbh and 45 cm for non-dipterocarps (FDPM, 2003b).

The total forested areas to be managed under SMS and MUS are estimated at 1.3 million hectares and 1.54 million hectares respectively or 2.84 hectares of productive forests of the PFR (FDPM, 2005a). To ensure that the forest is better conserved and sustained, the annual coupe in Peninsular Malaysia has been scaled down under the 6th Malaysia Plan (1991-1995), 7th Malaysia Plan (1996-2000) and 8th Malaysia Plan (2001-2005) to 52,250 ha, 46,040 ha and 42,870 ha per annum, respectively (Azmi and Yap, 2004).

1. 2 Problem Statement and Objectives of the study

The forestry sector has significantly contributed to the socio-economic development of the country. In 2005, the forestry sector and wood products (including wood and rattan furniture) contributed about RM21.5 billion of the Malaysian Gross Domestic Product. This accounted for 4.0% of the total gross export of Malaysia at freight of board (f.o.b) of RM533.8 billion (FDPM, 2005a). However, harvesting in the hill forests draws public attention and has been blamed for environmental problems especially land slide, soil erosion, flooding and degradation of water quality. Currently, most of the harvesting operation is in the hill forests because of the reduction in areas of the lowland forests had been cleared for agriculture, industrial and urban expansion since the1960s