



**UNIVERSITI PUTRA MALAYSIA**

**SEDIMENTATION DYNAMICS OF A SMALL HILL  
FOREST CATCHMENT IN ULU LANGAT,  
SELANGOR, MALAYSIA**

**SOULISACK DETPHACHANH**

**FH 2000 14**

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SELANGOR, MALAYSIA**

**By**

**SOULISACK DETPHACHANH**

**Thesis Submitted in Fulfilment of the Requirement for the  
Degree of Master of Science in the Faculty of Forestry  
Universiti Putra Malaysia**

**December 2000**



**To my wife, children,  
parents and brothers**

**Abstract of thesis submitted to the Senate of the Universiti Putra Malaysia in  
fulfilment of the requirement for the degree of Master of Science**

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**Chairman: Associate Professor Lai Food See, Ph.D.**

**Faculty: Forestry**

This study assesses the sedimentation dynamics of a small hill forest catchment with an area of 2.6 km<sup>2</sup> in Ulu Langat Forest Reserve, Selangor, Malaysia. The study catchment was equipped with rainfall and water level recorder to assess the hydrological characteristics of the area.

The annual rainfall data recorded during the study period from July 1997 to June 1998 was 2051.6 mm. The maximum monthly rainfall of 431.4 mm was recorded in October 1997 while the minimum of 25.1 mm occurred in February 1998. In October-December of 1997 and May-June of 1998, high rainfalls were observed due to inter north-east monsoon and transition monsoon respectively.

Sedimentation dynamics in the study area was evaluated using the Helley-Smith bed load sampler and a two-weekly survey of stored sediment. Bed load was estimated using a bed load-rating curve and discharge time interval of half-hourly, hourly and daily mean values, there are the annual bed load was 4.61, 4.46 and 3.81 t respectively which presented about 17.0% of the total load.

Sediment deposition measurement was conducted fortnightly over a year showed the high sediment transported during two storms events. The sediment deposited about 3.064 t and 2.033 t during of 19 October to 1 November 1997 and 14 – 27 June 1998, compared with the annual load of 11.36 t, for the study period were transported.

The bed load particle size distribution is measured in order to determine the quality of the sediment transported. A wide range of particle size was observed. This ranged from 0.05 to 0.9 mm at  $D_5$ , 0.35 to 3.1 mm at  $D_{50}$  and 0.75 to 5.1 mm at  $D_{95}$  with average of 0.24, 1.1 and 2.16 mm, respectively.

Sedimentation dynamics was evaluated based on the bed load and sediment storage in the Sg. Pangsun watershed. High sediment loads were transported during storms, the proportion of the bed load and sediment storage load was year total: bed load versus sediment storage.

**Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk Ijazah Master Sains.**

**PERUBAHAN PEMENDAPAN DI TADAHAN KECIL  
BERHUTAN BUKIT DI ULU LANGAT,  
SELANGOR, MALAYSIA**

**Oleh**

**SOULISACK DETPHACHANH**

**Disember 2000**

**Pengerusi: Profesor Madya Lai Food See, Ph.D.**

**Fakulti: Perhutanan**

Penyelidikan ini mengkaji perubahan pemendapan di tadahan kecil berhutan bukit berkeluasan lebih kurang 2.6 km<sup>2</sup> persegi di Hutan Simpan Ulu Langat, Selangor, Malaysia. Kawasan penyelidikan ditengkingi dengan peralatan mengukur hujan dan paras air yang berujuan untuk menilai ciri hidrologi di kawasan kajian.

Data hujan tahunan yang direkod sepanjang waktu penyelidikan daribulan Julai 1997 hingga bulan June 1998 ialah 2051.6 mm. Didapati bahawa hujan bulanan maksimum ialah 2051.6 mm itu pada bulan Oktober 1997 manakala hujan bulanan minimum ialah 25.1 mm pada bulan Oktober 1998. Dalam jangka masa Oktober-Disember 1997 dan Mei - Jun 1998, hujan yang tinggi dicatatkan masing-masing disebabkan oleh musim monsun Timur Laut dan monsun peralihan.

Perubahan pemendapan di kawasan kajikan dinilai dengan menggunakan pengambil contoh muatan dasar sungai Helley-Smith dan pengukuran simpanan endapan dilakukan setiap dua minggu sekali. Muatan dasar sungai dianggarkan dengan menggunakan garis lengkung perbezaan, satu jam dan nilai purata harian. Muatan dasar sungai tahunan ialah 4.61, 4.46 dan 3.81 tan masing-masing yang mewakili lebih kurang 17.0% dari keseluruhan muatan.

Pengukuran endapan sungai yang dijalankan setiap dua minggu sekali selama satu tahun menunjukkan endapan yang tinggi yang didapati semasa dua kejadian ribut. Sebanjak lebih kurang 3.064 dan 2.033 tan diangkut dari 19 October sehingga 1 November 1997 dan dari 14-27 Jun 1998, sehingga berjumlah 11.36 tan secara keseluruhannya.

Penyebaran saiz partikel muatan dasar sungai diukur untuk menentukan kualiti dari endapan yang diangkut. Julat saiz partikel yang besar telah diperolehi. Julat saiz dari 0.05 sehingga 0.9 mm diperolehi pada  $D_5$ , 0.35 sehingga 3.1 mm pada  $D_{50}$  dan 0.75 sehingga 5.1 mm pada  $D_{95}$  dengan purata 0.24, 1.1 dan 2.16 mm masing-masing.

Perubahan pemendapan dinilai berdasarkan kepada muatan dasar sungai dan simpanan endapan di kawasan aliran sungai Pangsu. Muatan endapan yang tinggi didapati apabila terjadi ribut. Perbandingan muatan dasar sungai dan simpanan endapan ialah jumlah tahunan: muatan dasar melawan dengan simpanan endapan.

## **ACKNOWLEDGEMENTS**

I would like to express my profound gratitude to Assoc. Prof. Dr. Lai Food See, chairman of my supervisory committee, for this constant guidance, suggestions and encouragement throughout the preparation of thesis. I am highly indebted to my two other supervisors, Assoc. Prof. Kwok Chee Yan and Dr. Ahmad Ainuddin Nuruddin for invaluable suggestions and comments.

I would like also to take this opportunity to express my thanks to the Faculty of Forestry, Universiti Putra Malaysia for the permission given to undertake this study.

I am greatly thankful to Mr. Xame Samounty Director General of Lao-Forestry Department and Lao-Government, for granting me a scholarship and study leave to pursue this program.

I would also like to express deep gratitude to my father and mother, father and mother in law for all their support and encouragement during the course of this study and to my wife Ketkeo and my children, Toukta and Phouthasinh. I express my utmost gratitude to GOD, the invisible power, for providing me continuous flow of energy to undertake this study.



## LIST OF CONTENTS

	Page
DEDICATION.....	2
ABSTRACT.....	3
ABSTRAK.....	5
ACKNOWLEDGEMENTS.....	7
APPROVAL SHEETS.....	8
DECLARATION FORM.....	10
LIST OF TABLES.....	13
LIST OF FIGURES.....	15
LIST OF ABBREVIATIONS.....	17
<b>CHAPTER</b>	
<b>I INTRODUCTION.....</b>	
Problem Statements.....	18
Objectives of Study.....	20
Summary.....	21
<b>II LITERATURE REVIEW.....</b>	
Introduction.....	22
Sediment Related Hydrological Processes in Forest Watersheds....	22
Sediment Sources .....	23
Sediment Concentration.....	26
Sediment Yield.....	30
Bed Load.....	33
Proportion of Suspended to Bed Load Transport.....	36
Particle Size of Bed Load Transport.....	38
Sedimentation.....	40
Sedimentation Measurement Methods.....	40
Sedimentation Rate	42
Summary.....	43
<b>III MATERIALS AND METHODS .....</b>	
Site Description.....	44
Location.....	44
Climate.....	46
Geology .....	48
Soils.....	48
Vegetation.....	48
Instrumentation.....	49
Raingauge.....	49

Water Level.....	50
Digitizing Rainfall and Water Level Charts .....	51
Data Collection .....	51
Design and Study Plot Layout .....	51
Field Data Collection.....	53
Sediment Volume Computation.....	54
Bed Load Sampling.....	54
Laboratory Analysis.....	56
Conversion of Volume to Weight of Sediment Load.....	59
Summary.....	60
 IV. RESULTS AND DISCUSSION .....	61
Rainfall and Stream Discharge.....	61
Comparison of study site rainfall data with adjacent rainfall	64
Station.....	
Suspended Sediment Load Computation.....	66
Bed Load .....	68
Bed Load Computation.....	71
Particle Size Distribution.....	73
Sediment Storage.....	77
Sedimentation Dynamics.....	79
Sedimentation Pattern in Study Plot.....	83
Comparison of Between Bed Load and Sedimentation.....	94
Proportion of Suspended Load to Bed Load and Storage Load.....	95
Comparison of Bed Load and Sedimentation Data of Other Studies	99
Bed Load Sediment.....	99
Sedimentation.....	101
Summary.....	102
 VI. CONCLUSION AND RECOMMENDATIONS.....	103
Conclusion .....	103
Recommendations .....	105
 REFERENCES.....	106
 APPENDICES.....	121
A.....	122
B.....	130
 BIODATA OF THE AUTHOR.....	133

## LIST OF TABLES

Table	Page
2.1      Suspended sediment concentration (mg/l) and suspended sediment yield ( $\text{kg}/\text{km}^2/\text{yr}$ ) from Berembun catchments.....	26
2.2      Mean sediment concentration in undisturbed and partially disturbed catchment in Peninsular Malaysia.....	27
2.3      Sediment yield from forested and disturbed catchments in tropical countries.....	31
2.4      Comparison of bed load yields of upland basins in Peninsular Malaysia.....	34
2.5      Proportion of total stream sediment load of the study catchments ( $\text{t}/\text{km}/\text{yr}$ ).....	36
2.6      Proportion of total stream sediment load of the study catchments ( $\text{t}/\text{km}/\text{yr}$ ).....	37
2.7      Comparison of Particle size distribution between bed load and bed material from various studies.....	39
2.8      Summary of sedimentation of some countries	41
3.1      Summary of basin physiography.....	46
3.2      Layout of cross-sectional survey stations.....	52
3.3      Procedure for mineral sediment determination of bed load.....	57
3.4      Summary of sieve size used in grain size distribution of bed load sediment analysis (mm).....	58
3.5      Determination of sediment density stream operation.....	59
4.1      Monthly rainfall distributions and rainy day during the period of July'97-July'98.....	62
4.2      Rainfall data of study area and Empangan Ulu Langat.....	65
4.3      Monthly suspended load computed by using different mean discharge at Sg. Pangsun watershed.....	67
4.4      Bed load data (Mid-Section) at Sg. Pangsun.....	68

4.5	Relationship of particle size of bed load to stream discharge for sample of 11 May 1998.....	69
4.6	Monthly bed load computed by using different mean discharge at Sg. Pangsun watershed.....	72
4.7	Mean particle size distribution at the middle section of stream.....	74
4.8	Comparison of particle size distribution.....	75
4.9	Volume of sediment accumulative in the study plot.....	78
4.10	Cumulative sediment load at fortnight interval.....	81
4.11	Sediment pattern zone (t).....	84
4.12	Comparison of between bed load transport and sedimentation.....	95
4.13	Proportion of suspended load to bed load and sediment storage load.....	97
4.14	Comparison of bed load with other catchment in Malaysia and other countries.....	100
4.15	Comparison of sedimentation with other studies.....	101

## LIST OF FIGURES

Figure	Page
3.1 Location of Study Site at Sg. Pangsun Catchment Ulu Langat, Selangor.....	45
3.2 The tipping-bucket raingauge recorder at Sg. Pangsun.....	49
3.3 Streamflow station at Sg. Pangsun.....	50
3.4 Study Plot .....	52
3.5 Study plot before storm flow on 12 July 1997.....	53
3.6 The Helley-Smith bed load sampler.....	55
3.7 Bed load sampling using Helley-Smith bed load sampler.....	55
4.1 Monthly rainfall and mean discharge distributions (A) and rainy days distribution (B) during of July 1997 to June 1998.....	63
4.2 Comparison of the study site rainfall data with Empangan Ulu Langat rainfall station .....	65
4.3 Monthly suspended load at Sg. Pangsun watershed.....	67
4.4 Linear Regression at 95% Confidence Limit.....	70
4.5 Bed Load Rating Curve.....	70
4.6 Monthly bed load at Sg. Pangsun watershed.....	72
4.7 Comparison of Particle Size Distribution.....	76
4.8 Distribution of daily rainfall and mean daily discharge (A) and Accumulative load (B) during of 12 July'97 to 11 July'98.....	82
4.9 Sediment load on the study plot from (a) to (f).....	85
4.9 Sediment load on the study plot from (g) to (l).....	86
4.9 Sediment load on the study plot from (m) to (r).....	87

4.9	Sediment load on the study plot from (s) to (x).....	88
4.9	Sediment load on the study plot from (y) to (z).....	89
4.10	3D Surface sediment basin from (a) to (f).....	90
4.10	3D Surface sediment basin from (g) to (i).....	91
4.10	3D Surface sediment basin from (m) to (r).....	92
4.10	3D Surface sediment basin from (s) to (x).....	93
4.10	3D Surface sediment basin from (y) to (z).....	94
4.11	Proportion of suspended load to bed load and sediment storage in total sediment load.....	97

## LIST OF ABBREVIATIONS

°C	-	degree Celsius
3D	-	three dimension
C <sub>1</sub> , C <sub>2</sub>	-	catchment number (1) one and (2) two
cm	-	centimeter
DID	-	Drainage and Irrigation Department
FAO	-	Food and Agriculture Organization of the United Nations
g/cc or g/cm <sup>3</sup>	-	gram per cubic centimeter
g/m <sup>2</sup> /yr	-	gram per square meter per year
g/s	-	gram per second
ha	-	hectare
kg/s	-	kilogram per second
kg/s/m	-	kilogram per second per meter
km	-	kilometer
km/km <sup>2</sup>	-	kilometer per square kilometer
km <sup>2</sup>	-	square kilometer
LSFP	-	Lao-Swedish Forestry Programme
m	-	meter
m <sup>3</sup> /km <sup>2</sup> /yr	-	cubic meter per square kilometer per year
m <sup>3</sup> /s	-	cubic meter per second
mg/l	-	milligrams per litre
ml	-	millilitre
mm	-	millimeter
mt	-	Metric tonne
ppm	-	part per million
SFAP	-	Selected Field Area Project
t	-	tonne
t/km <sup>2</sup> /yr	-	ton per km <sup>2</sup> per year
TNB	-	Tenaga Nasional Berhad
UNESCO	-	United Nation Educational, Scientific and Cultural Organization
wt	-	weight

## **CHAPTER I**

### **INTRODUCTION**

The Malaysian tropical rain forest is species-rich, both in the lowland and hill areas. The total forested land in Malaysia is estimated to be 18.91 million ha or 57.5 % of total land area of 32.855 million ha (Tang, 1997). Of the 18.91 million ha, 16.41 million ha are Dipterocarp forests (86.8% of total forested land in the country) while the remaining 2.5 million ha and 0.7 million ha are freshwater swamps and mangrove forests respectively. The species rich tropical rainforest had, for centuries, afforded protective cover to keep soil erosion at low levels while sediment loads increased for most small and large rivers affected by land conversion, mining, urbanisation and forest practices. Competition for land in this part of the country has been largely for agriculture, in particular the rubber and oil palm industry.

Forests also play an equally important role in keeping the environmental balance and stability of the nation. On this, we often speak about the clean water and the rich aquatic life found in the streams flowing from forest catchments. The demand for water is growing at four percent annually and in year 2020, it will reach 20 billion m<sup>3</sup> (FAO, 1997). Rivers, which originate from forested watershed, provide about 97 per cent of the country's supply of clean water in Malaysia. Subsequently, its management, which hinges on the degree of forest protection in the up-stream, will become more crucial.



Presently, forest harvesting for timber resources occurs in hill areas of slopes of more than 20°. The encroachments of logging into the upper reaches have imposed great pressure on the environment.

Increasing soil deterioration, accelerated erosion and sediments in rivers are usually associated with vegetation removal in logging operations and land conversion for agriculture and development (Lai, *et al.*, 1995). These activities contribute high concentrations of solid materials in streams which could directly or indirectly alter the physical, chemical and biological characteristics, in turn jeopardizing the flora and fauna of aquatic systems (Zulkifli, *et al.*, 1987). Due to rapid deterioration of the ecosystem or forestland by such activities, the quality of forest streams has been continuously lowered.

Past studies had documented the effect of forest conversion on hydrological parameters (Bosch and Hewlett, 1982; DID, 1986; Abdul Rahim, 1987). The effect of partial forest removal or selective logging, which generally forms the basis for sustainable forest management particularly in the humid tropics, on the hydrological parameters had also been widely reviewed. (Zuklifli Yusop, *et al.*, 1987; Baharuddin Kasran, 1988; Abdul Rahim and Harding, 1992).

## **Problem Statement**

Uncontrolled erosion pose environmental problems because it removes productive topsoil, damage roads and fields by gullyng and landsliding, cause eutrophication and silting of river channels and reservoirs. Such environmental degradation can only be stopped with great effort and cost. Yet erosion is a complicated phenomenon, a result of many processes. The number of factors and their interactions limit our ability to predict rates of erosion, although we know that the most important factor influence soil erosion are climate, vegetation, soil characteristics, topography and land use.

The study of erosion and sediment yield from river basins is important for many reasons. Among them is deposition of sediment in a reservoir, which reduces its capacity thereby adversely, affecting water supply for irrigation, domestic and industrial use, and power generation.

Sediment yields are essentially products of overall interaction between water and the total biochemical and physical characteristics of the catchment. If accurately quantified, they reflect the basin dynamics well. For example, in Malaysia, information on sediment yield have been reported in the past (e.g. Douglas, 1968, 1990; Peh, 1981; Lai, 1993, 1995; Baharuddin, 1988), but few reported on the dynamics of sediment transport of hill catchments.

Studies of sedimentation dynamics of hilly watershed in tropics are also few. Research is therefore needed to develop the necessary monitoring and modelling strategies to improve our understanding of the sediment transport processes involved.

Sedimentation dynamics – is defined as the sediment movement with emphasis on sediment transport as controlled by basin morphology; sediment availability; storm character and timing, and stream power magnitude.

### **Objective of Study**

The general objective of the study is to examine the sedimentation dynamics of a hill forest watershed. The scope of work involved determination of:

- i) the hydrology of the study basin, specifically with respect to rainfall and runoff.
- ii) sediment transport in the study stream with emphasis on bed load and,
- iii) bed sediment particle size.

### **Summary**

Erosion and sediment in streams is a complicated phenomenon because many processes are involved. To unravel some of the problems addressed in the proceeding sections, the relationship between output of bed materials with the prevailing hydrological conditions will be examined in detail, using essential equipment and measuring procedures.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **Introduction**

This chapter presents an overview of past studies related to sediment yield and sedimentation of hill tropical forest catchments.

#### **Sediment Related Hydrological Processes in Forest Watersheds**

Hydrology is concerned with the circulation of water and its constituents through the hydrologic cycle. It deals with precipitation, evaporation, infiltration, groundwater flow, runoff and streamflow. The output of erosion within a catchment is known as sediment yield. It can be defined as the amount of sediment transported from a catchment over a specific time interval.

High sediment yield is associated with regions in arid, semiarid, seasonal Mediterranean and the tropics (Walling and Webb, 1983). A compilation of sediment yield for meso scale drainage basins by Reid and Frostick (1987) suggests that arid basins export 36 times more material than humid temperate basins and 21 times more than humid tropical equivalents.

Hydrologic characteristics of the soil, such as infiltration capacity and moisture content may control the amount of water that enters the soil. These are in turn affected by texture, structure, and organic content of the soil. High infiltration capacities are generally associated with sandy or heavy soil (high silt and clay content) that has a well-developed crumb structure (fine particles held together as aggregates). If such a soil is exposed to the beating action of raindrops, the aggregates are broken up with fine materials sealing the surface, thereby greatly reducing infiltration capacity.

Streamflow is the major output of the stream system in a watershed. Accurate measurement of streamflow is necessary for estimating sediment load since the relationship between runoff and sediment is usually a direct one.

### **Sediment Sources**

Sediment is the fragmented material produced from chemical or physical disintegration of rocks. Mass erosion, especially from the streambank collapse, and rainfall impact along the stream course also appeared to be the major contributors of sediments. (Fleming and Poodle 1970; Berg 1986; Burgess 1971; Brown and Krygier, 1971; Langford and O'shaughnessy 1977; Cornish 1980 and Veracion 1983). Human actions, for example timber harvesting operations in forest catchments, logging road and skid trail construction are the main sources of sediment production (Beschta, 1978).

Accelerated erosion can result in heavy river sediment content and shallowing of streams. Many studies reported that surface soil erosion is the main source of sediment in streams while erosion in streams usually occurs along channel beds (Eyles, 1970; Douglas, 1970; Morgan, 1977).

Sediment yield from drainage basins provides a useful index of erosion severity and trends. However, land development managers need more information about sediment sources and processes in value in mobilization of sediment, and also the relation between erosion intensity and controlling factors.

According to Singhal *et al.*, (1981), all sediment comes from:

- 1) Sheet erosion of land surface - the removal of material from surface by forces of rain drops impact and surface runoff or wind action.
- 2) Gullying - gullies are channels more than 15 cm deep, eroded by concentrated runoff in the soil or on unconsolidated rock.
- 3) Stream channel erosion - this is erosion of banks and scouring of beds and streams.
- 4) Flood erosion, construction erosion, mining, and industrial waters.
- 5) Mass movement - these include landslides, stumps, avalanches and creeps

While erosion and sedimentation are often viewed negatively from a biological point of view, they are essential to the ecological functioning of aquatic and terrestrial communities because they provide the sources and the surfaces necessary for habitat. In