UNIVERSITI PUTRA MALAYSIA

SUSPENDED SEDIMENT YIELD ANALYSIS USING A CONTINUOUS MONITORING SYSTEM IN THE SG. PANGSUN WATERSHED, ULU LANGAT, SELANGOR.

GEOFFERY JAMES GERUSU

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By

GEOFFERY JAMES GERUSU

Thesis Submitted in fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Forestry, Universiti Putra Malaysia

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This work is dedicated to
my Father and Mother.

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

Faculty : **Forestry**

The need for reliable sediment yield data is a topic which generates much discussion especially among hydrologists, scientists and those concerned with the river system. Various methods were used in the past, the most popular being the use of sampled sediment data to equate with river discharge to obtain sediment load. While river discharge can be accurately computed, sediment discharge presents greater difficulty. This study assesses the use of total suspended solids (TSS) analyser in generating suspended sediment data from the Sg. Pangsun watershed, a small headwater catchment located in Ulu Langat, Selangor. The steep montane basin, about 2.6 km^2 lies on the southern flank of the Main Range.

The study catchment was equipped with rainfall and water level recorders to assess the hydrological characteristics of the area. The TSS analyser uses a

sensor which transmits information to an analyser. The TSS readings were stored electronically in a data logger and downloaded once a fortnight using a notebook. The annual suspended sediment loads of Sg. Pangsun catchment was 21.1 tonnes or 8.1 t/km^2/yr.

The suspended sediment loads retrieved were regarded as actual values, and then were compared against data deriving from conventional methods such as uncorrected and bias-corrected rating curves. The rating-curve data have been grouped according to all-stage and stage-differentiated to provide various rating relationships. The use of uncorrected rating curves based on all-stage and stage-differentiated data overestimated actual annual sediment loads by +32.7% and +26.1 % respectively. Bias-corrected rating curves based on all-stage and stage-differentiated data, however, gave far higher overestimated loads by more than +100% compared to actual loads.

In this study, the use of different time-based such as hourly, daily and monthly discharge data underestimated the actual annual suspended sediment loads computed using 15-minute time-based by –2.8%, –20.4% and –39.8% respectively. The results suggested the TSS analyser would be of tremendous use for studies demanding accurate suspended sediment concentration monitoring.

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

MENGANALISA LUAHAN ENAPAN AMPAIAN MENGGUNAKAN SISTEM PENGUKUR SECARA BERTERUSAN DI KAWASAN LEGEH SG. PANGSUN, ULU LANGAT, SELANGOR.

Oleh

GEOFFERY JAMES GERUSU

Ogos 1999

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Fakulti : **Perhutanan**

Keperluan ketepatan data luahan enapan merupakan topik perbincangan yang hangat di kalangan ahli hidrologi, saintis dan sesiapa yang berminat terhadap sistem sungai. Pelbagai kaedah telah digunakan di masa lampau, dan yang terkenal adalah penggabungan data enapan dengan halaju aliran sungai bagi memperolehi beban enapan. Tetapi, penghitungan kadar luahan enapan adalah lebih sukar berbanding halaju aliran sungai yang dapat dihitung dengan tepat. Tumpuan kajian ini menilai penggunaan pengukur jumlah enapan ampaian untuk memperolehi data enapan ampaian daripada kawasan legeh Sg. Pangsun, Ulu Langat, Selangor. Kawasan legeh ini mempunyai keluasan 2.6 km^2, terletak di kawasan pergunungan curam di bahagian Selatan Banjaran Utama.

Kawasan kajian dilengkapi dengan pengukur hujan dan paras air untuk menilai sifat-sifat hidrologikal kawasan tersebut. Pengukur jumlah enapan ampaian ini menggunakan sinar pancaran dan data disimpan secara elektronik pada alat penyimpan data serta dikeluarkan setiap 2 minggu. Beban enapan ampaian tahunan yang diperolehi daripada kawasan legeh Sg. Pangsun adalah berjumlah 21.1 tan atau 8.1 t/km^2/tahun.

Nilai beban enapan ampaian yang diperolehi dianggap nilai sebenar dan dibanding dengan nilai yang diperolehi menggunakan graf kadar lengkung. Penggunaan graf kadar lengkung yang normal telah melampaui nilai sebenar sebanyak +32.7% untuk semua peringkat data dan +26.1% untuk berlainan peringkat data. Tetapi, penggunaan graf kadar lengkung yang diperbaiki memberikan nilai yang jauh melampaui nilai sebenar iaitu +100% bagi semua peringkat dan berlainan peringkat data.

Penghitungan luahan enapan menggunakan berlainan masa-asas data aliran menghasilkan nilai yang kurang iaitu –2.8% bagi setiap jam, -20.4% bagi harian dan –39.8% bagi bulanan, berbanding nilai sebenar yang dihitung menggunakan setiap 15 minit data aliran. Hasil kajian mencadangkan penggunaan alat pengukur jumlah enapan ampaian merupakan sebuah alat yang amat berguna di dalam penyelidikan enapan ampaian yang memerlukan kejituan yang tinggi.

CHAPTER ONE

INTRODUCTION

Suspended sediment yield represents a key parameter in understanding the global denudation system. River load data are also used by various researchers to assess global patterns of erosion and land denudation. It must also be recognised that sediment transport by rivers have an important social and economic dimension related to the problem of reservoir and channel siltation and other aspects of water resources development and environmental problems.

The growing significance of suspended sediment yield data has inevitably directed attention to the accuracy of measurement and reliability of available data. Factors considered in ensuring accurate measurement are intensive sampling schemes and careful selection of monitoring sites. These become even more critical when attempting to detect changes in suspended sediment loads of a particular stream system.

Increasing sediment loads in Malaysia streams has aroused much concern among relevant authorities, scientists, environmentalists and those affected by it.

Various studies in the past had documented changes in sediment discharge due to change in landuse, ranging from agriculture (e.g. Leigh, 1973), urbanization (e.g. Balamurugam, 1991) to forest harvesting (e.g. Lai, 1993; 1995). The stream sediment loads reported thus far had mostly been those derived from data obtained by pre-scheduled stream sampling or over storm events. They often pose problems in the reliability of data collected thereby affecting the strength of arguments forwarded by these studies.

Attempts by researchers in the past had been to resolve these difficulties through the development and improvement of instruments capable of automatic collection of sediment concentration data. The equipment range from the use of automatic pump-sampling instruments, turbidity meters and nuclear probes. New techniques such as remote sensing is also being employed to assess suspended sediment loads. These instruments, have limitation however. The efficiency of laboratory techniques employed to determine the concentration of individual suspended sediment samples has similarly received attention (Lai, 1994).

In sediment yield computation, use of the rating curve technique may be viewed as a classic example of an extrapolation procedure. This rating curve is employed to predict sediment concentrations based on sampled data. A limited number of sediment concentrations are extrapolated over the period of interest by developing a relationship between sediment concentration and stream discharge.

The load is then computed using stream flow records that covers the desired time period.

Estimates of suspended sediment load produced using these indirect load calculation procedures usually have problems. Studies by Walling (1977), Walling and Webb (1981, 1988) gave excellent reviews of the many problems involved when developing quantitative relationships between suspended sediment concentrations and water discharge for estimating loads. Their reports suggested that rating curves do not provide accurate estimation of sediment yields. However, the problem can be improved by deriving separate relationships for the rising and falling limbs of the hydrograph. For example, Loughran (1976), Walling (1977) and Lai (1993) have reported improved accuracy by separating the rating curve into rising and falling stages, compared to the use of all stage rating curves.

Further investigation by Ferguson (1986a and 1986b) highlighted on the underestimation bias inherent in the use of log-transformed regression to derive rating relationships. He suggested that this bias represents a major cause of error associated with rating curve estimates and that it can be largely be removed by applying a simple correction factor based on the standard error of the estimate derived in the logarithmic regression.

Others were less convinced on the ability of bias corrected rating curve to provide reliable values of suspended sediment yield. For example, Koch and Smillie (1986) indicated that bias correction factor produced suspended sediment yield estimates which significantly overestimated the actual mean annual suspended sediment yields and was generally less accurate than those estimated using uncorrected rating curve.

Because of the amount of data involved, the rating curve had in the past, been used in conjunction with hourly, daily, monthly or annual discharge data. The use of different time intervals produced different suspended sediment yield estimation (Loughran, 1976 and Balamurugam, 1989)

Although concern for the accuracy of suspended sediment load data has now been expressed by a number of the researchers above, it is suggested that this uncertainty require greater attention. Lai *et al.* (1995) for example, suggested close monitoring of sediment output because sediment transport, especially following disturbance in small basins, differ over short time periods. These differences occur because sediment output depends on sediment supply and transport by storms. When these factors are observed and monitored continuously, a clearer picture of catchment sediment yield changes is obtained.

Objectives

Because stream sediment discharge in Malaysia, and the tropics in general, is highly variable due to localised and high intensity rainfall, a well designed monitoring instrument is essential.

The primary objective of the study is :

To evaluate the total suspended solids (TSS) analyser in generating suspended sediment data from the Sg. Pangsun watershed.

The specific objectives are :

i) To compare data generated from TSS analyser with conventional methods used for deriving suspended sediment loads in order to determine the variance in suspended sediment computation.

ii) To develop an information system on sediment discharge by the combined use of TSS analyser, data logger and computer, reducing precious time for laboratory analysis.

It is hope that, with the information generated from this study, some essential remedies are identified for improving stream sediment computation in Malaysia, and the tropics in general.

Thesis structure

Chapter One discusses the need for reliable suspended sediment load measurement and describes the aims of the study. Chapter Two reviews the instruments used for suspended sediment data collection, varying from grab sampling, point and depth integrating samplers, automatic vacuum pump samplers, turbidity probes to the more sophisticated nuclear probes. Each has its own advantages and limitations. The problem associated with rating curve in estimates suspended sediment loads is described in Chapter Two.

Chapter Three describes the materials and methods used in the study including location of study site, criteria for site selection, climate, geology, basin physical characteristics and laboratory analysis. Chapter Four presents and discusses the results obtained from the study. The results are also compared with studies carried out eslewhere in the tropics and temperate region with the aim for further discussion. The conclusions and recommendations of the study are presented in Chapter Five.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter reviews previous studies on suspended sediment measurement and sediment load computations. Here, an analysis of literature addressing this subject, which varies in scope and methods, was carried out, encompassing both local and international research efforts. A summary is described in the final section.

Types of Sediment Load

Sediment may be defined as the fragmental material that originates from chemical or physical disintegration of rocks which are subsequently removed from the basin by streams and rivers (Ullah *et al.*, 1972). Such particles range in size from large boulders to colloidal size fragments and also vary in shape from rounded to angular. They also vary in specific gravity and mineral composition