

THROUGHFALL, STEMFLOW, AND INTERCEPTION LOSS DUE TO *Acacia mangium* AT UNIVERSITI MALAYSIA SABAH

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**THIS DISSERTATION IS PRESENTED AS A PREREQUISITE IN OBTAINING
THE BACHELOR'S OF SCIENCE WITH HONOURS DEGREE**

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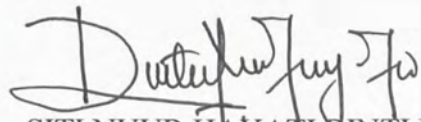
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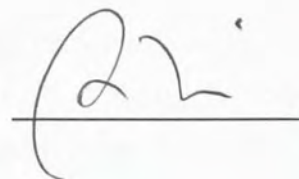


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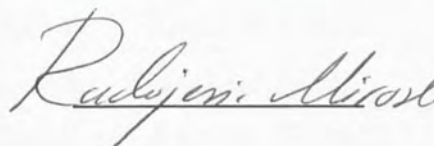
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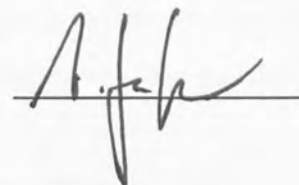
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ABSTRACT

This paper presents a study to measured throughfall, stemflow, and interception loss by *Acacia mangium* at Universiti Malaysia Sabah, Sabah, Malaysia between November 2004 to January 2005. The main objective of this study is to provide an estimate rate of throughfall, stemflow, and, interception loss from *Acacia mangium*. Measured total rainfall during this 3 month was 88.7 mm. Throughfall and stemflow comprised 56.3 mm (63.5%) and 3.0 mm (3.4 %), of the total rainfall respectively. These resulted interception losses fractions were estimated at 29.4 mm (33.1 %). Both throughfall and stemflow showed strong linear correlations against daily rainfall with r^2 values of 0.97 and 0.92. Descriptive analyses of the data show regression in total rainfall-throughfall, rainfall-stemflow, and rainfall-interception.

Keywords: *Acacia mangium*; Throughfall; Stemflow; Interception Loss



**CURAHAN TERUS, LELEHAN BATANG, DAN PINTASAN TERHADAP
POKOK *Acacia Mangium* DI UNIVERSITI MALAYSIA SABAH**

ABSTRAK

Kajian ke atas pokok *Acacia mangium* telah dijalankan di Universiti Malaysia Sabah, Sabah, Malaysia diantara bulan November 2004 sehingga Januari 2005. Sebanyak 88.7 mm hujan telah direkodkan sepanjang kajian ini. Kajian ini dijalankan bertujuan untuk menentukan jumlah curahan terus, lelehan batang, dan jumlah pintasan terhadap pokok *Acacia mangium*. Daripada jumlah ini, 56.3 mm (63.5%) dan 3.0 mm (3.4 %) daripada jumlah curahan telah membentuk curahan terus dan lelehan batang. Ini menghasilkan jumlah pintasan sebanyak 29.4 mm atau 33.1 %. Kedua-dua curahan terus dan lelehan batang menunjukkan kaitan yang sangat kuat terhadap jumlah curahan dengan nilai r^2 masing-masing 0.97 dan 0.92. Analisis diskriptif data menunjukkan korelasi yang signifikan antara jumlah hujan dengan curahan terus, lelehan batang, dan pintasan.

Katakunci : *Acacia Mangium*; Curahan terus; lelehan batang; pintasan



TABLE OF CONTENT

	Page
DECLARATION	ii
APPROVAL	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
LIST OF TABLE	ix
LIST OF FIGURE	x
LIST OF SYMBOL AND FORMULAS	xi
CHAPTER 1 INTRODUCTION	
1.1 HYDROLOGY CYCLE	1
1.1.1 Precipitation	3
1.1.2 Throughfall	5
1.1.3 Stemflow	5
1.1.4 Interception	6
1.2 TROPICAL FOREST	7
1.3 OBJECTIVE	10
CHAPTER 2 LITERATURE REVIEW	11
2.1 INTRODUCTION	11
2.2 PRECIPITATION	12



2.3	THROUGHFALL	13
2.4	STEMFLOW	15
2.5	INTERCEPTION LOSS	19
2.6	ACACIA MANGIUM	26
	2.6.1 Taxonomy	27
CHAPTER 3	METHODOLOGY	31
3.1	LOCATION	31
3.2	MEASUREMENT	32
	3.2.1 Measurement of throughfall	32
	3.2.2 Measurement of stemflow	33
	3.2.3 Measurement of interception loss	36
CHAPTER 4	RESULT DISCUSSION	37
4.1	RESULT	37
	4.1.1 Total Rainfall	37
4.2	DISCUSSION	42
	4.2.1 Throughfall	42
	4.2.2 Stemflow	45
	4.2.3 Interception	48
CHAPTER 5	CONCLUSION AND SUGGESTION	52
	REFERENCES	54



LIST OF TABLE

No of table		Page
2.1	Storm size and amount of stemflow in a tropical forest in Tanzania	16
2.2	Interception loss by different kinds of forest cover	22
2.3	Tree type and change in interception	24
2.4	Percentage of Average Total Rainfall	24
2.5	Interception study due to <i>Acacia Mangium</i>	29
2.6	Interception losses in forested and plantation sites in Malaysia	30
4.1	Basic statistics of daily rainfall, throughfall, stemflow, and interception loss of the study area between December 2004 and January 2005.	41
4.2	Percentage of precipitation component in different forested, plantation sites, and vegetation type in Malaysia	50



LIST OF FIGURE

No of figure	Page
1.1 The Component of Hydrological Cycle	3
1.2 Interaction between tropical forest canopies and receive rainfall	9
2.1 The characteristic of the branches due to the amount of stemflow	19
2.2 <i>Acacia mangium</i> tree	26
3.1 Diagram of the stemflow collar type gauge preparation.	34
4.1 Amount of rainfall during study period	38
4.2 Distribution of daily rainfall total of the study area from November 2004 to January 2005.	39
4.3 Variations in rainfall, throughfall, stemflow and interception	41
4.4 Regression of throughfall against rainfall.	43
4.5 Regression of stemflow against rainfall.	46
4.6 Regression of interception against rainfall.	48



LIST OF SYMBOL AND FORMULAS

%	percent
°	degree
DBH	density breast height
m	meter
mm	millimeter
P	precipitation
P_i	interception
P_t	throughfall
P_s	stemflow
r^2	regression
D_1	total number of trees in the plot
D_2	number of uncollared trees
B_1	total basal area of all trees (m^2 / plot)
B_2	total basal area of uncollared trees (m^2 / plot)
V_c	total volume of stemflow (liter / plot)
A	plot size, (m^2)



CHAPTER 1

INTRODUCTION

“ A tree uses what comes its way to nurture itself by accepting the rain that flow towards it, the tree perfects its character and become great. Absorbs, absorbs, and absorbs. That is the secret of the tree.” Deng Ming Dao, Everyday Tao

1.1 HYDROLOGY CYCLE

Hydrology is an earth science encompasses the occurrence, distribution, movement, and properties of the water of the earth. The continuous process which water is transported from the atmosphere, to the oceans to the land and back to atmosphere is called hydrology cycle that exist many subcycles process such as transpiration, evaporation, precipitation, interception, surface runoff, and groundwater flow.

Volume quantification of ecosystem water flows throughout the hydrologic cycle is extremely complex because, with few exceptions, it involves small differences between large quantities that cannot be measured with precision. The hydrologic cycle is driven by five principle climatic variables:



- precipitation
- air temperature
- humidity (vapor pressure)
- solar radiation
- wind speed

Figure 1.1 indicates the paths that precipitated water may take as it reaches the earth. The first encounters are with intercepting surface such as trees, plants, grass, and anything that cover the building including structures. Water delivered to the land surface may run off directly, as overland flow into streams to drain by way of rivers and lakes back into the sea, or infiltrate the soil.

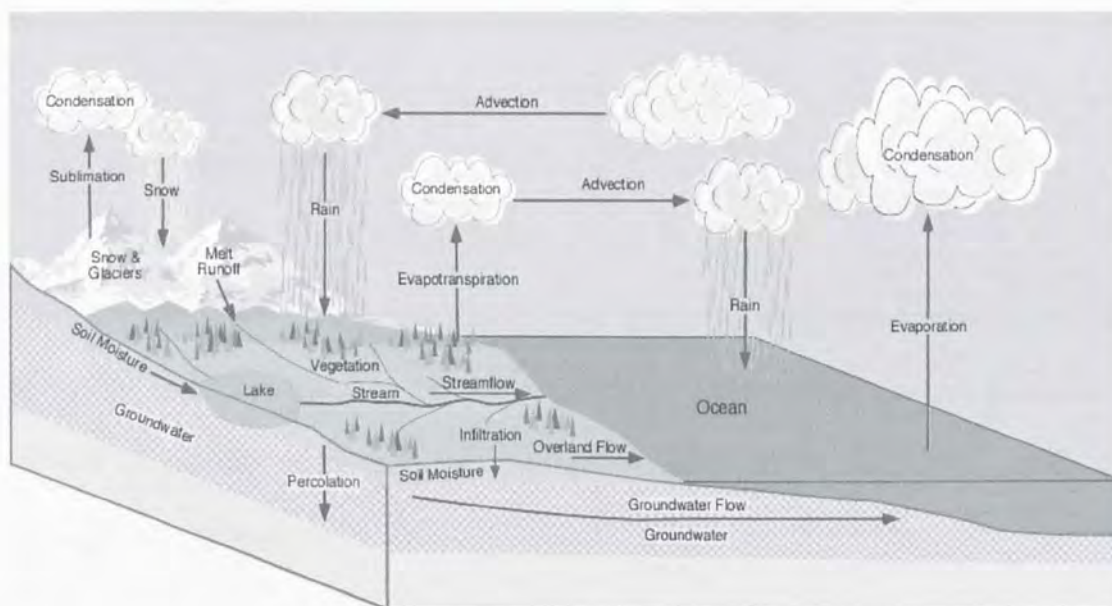


Figure 1.1 The Component of Hydrological Cycle.

Some water also evaporates directly from the soil and from the surfaces of oceans, lakes, and rivers. The oceans supply most of the evaporated water found in the atmosphere. Of this evaporated water, only 91 % is returned to the ocean basins by way of precipitation. The remaining 9 % is transported to areas over landmasses where climatological factors induce the formation of precipitation (Warren *et al.*, 1995). The resulting imbalance between rates of evaporation and precipitation over land and ocean is corrected by runoff and groundwater flow to the oceans.

It is known that part of the water that infiltrates the soil moves laterally through the upper horizons until it reaches a stream channel and does not become part of the ground water reservoir. This portion of subsurface flow is known as interflow or through-flow and, together with overland flow, constitutes what is generally referred to as surface runoff or, more properly, as direct runoff (Anthes, 1999; Diane, 2002; Evan *et al.*, 1988).

1.1.1 Precipitation (P)

The primary input vector in hydrologic cycle is precipitation, which form in rain, snow, and variation of these. It is derive from atmospheric water where its form and quantity are influenced by the action of other climatic factor such as wind, temperature, and atmospheric pressure.



Part of the precipitation that occurs may be evaporated, infiltrated, and intercepted by tree, grass, other vegetation and other forms of cover on the drainage area or become surface flow. The actual disposition depends on the amount of rainfall, soil moisture conditions, topography, and vegetal cover soil type (Warren *et al.*, 1995).

The amount of precipitation reaching the ground surface is greatly influenced by plant canopies (Warren *et al.*, 1995). Besides that, the amount of precipitation intercepted by plants also varies with leaf type, canopy architecture, wind speed, available radiation, temperature, and the humidity of the atmosphere. Precipitation on canopies can be divided into three components:

- i. Interception loss (P_i), water which is retained by plant surfaces and later re-evaporated to the atmosphere or absorbed into plant tissue.
- ii. Throughfall (P_t), water which falls directly through the canopy or drips off leaves reaching the forest floor either without interception or by dripping from the canopy.
- iii. Stemflow (P_s), water that trickles along leaves and branches to the main stem. Stemflow may or may not be included to the component of precipitation, but is usually relatively insignificant (Warren *et al.*, 1995).



1.1.2 Throughfall (P_t)

During the early stages of a precipitation event, much of the precipitation is stored on the foliage, branches, and stems, where it may be evaporated back to the atmosphere. As the precipitation continues, these surfaces reach their retention capacities and excess water drains to the soil surface as canopy throughfall.

According to Warren and Lewis (1995), determining factors for throughfall quantities include canopy coverage, total leaf area, number and type of layers of vegetation, wind velocity, and rainfall intensity. Throughfall over any period depends on the balance between precipitation, evaporation and canopy storage.

1.1.3 Stemflow (P_s)

Stemflow is a portion of the intercepted water that can travel from the leaves to the branches and then flow down to the ground via the plant's stem. It is part of the precipitation that travels down the surface of stems to the soil.

Stemflow is commonly a small water flux; however, this water is concentrated at the base of the tree and has relatively high concentrations of certain elements making it an important component of the hydrologic and nutrient cycles in some ecosystems. Studies

have show that 2-12% of the precipitation volume becomes stemflow (Asdak *et al.*, 1998), the quantity depending largely on the canopy structure and smoothness of the bark.

1.1.4 Interception (P_i)

Interception is part of the precipitation on the canopy that does not reach the ground. Interception can be defined as that segment of the gross precipitation input, which wet and adheres to aboveground object until it is returned to the atmosphere through evaporation (Warren *et al.*, 1995). It is a process whereby rainfall is evaporates from the canopy (canopy interception loss), intercepted by vegetation, buildings, or any other forms of cover on the drainage area before reaching the ground surface.

The physical aspect of interception is when precipitation start to fall over the ground surface. This precipitation will retained to some extent over these object in form of thin layer, which is subsequently evaporated and returned back to the atmosphere. If the rainfall is still continued, there is situation where vegetative foliage gets maximum storage and reaches to saturation stage, after that, whatever rainfall take place, it will directly fall over the land surface.

Several studies have shown that rainfall interception by forest canopy had major significances to the water budget, comparing to other vegetative covers (Calder, 1976; Gash and Stewart, 1977; Pearce and Rowe, 1979; Suzuki, 1991). A number of interception loss studies have shown that interception losses are of major importance in

determining the water yield of forested areas relative to yield from other vegetative cover (Calder, 1976; Gash and Stewart, 1977; Murdiyarso, 1986; Scatena 1990; Loustau *et al.*, 1992).

1.2 TROPICAL FOREST

The forest is characterized by three primary elements:

- i. The foliage above the ground forming a number of layers that compose the total thickness of the protective canopy,
- ii. The accumulation of dead and decaying plant remains on the ground surface constituting the forest floor, and
- iii. The forest soils that are formed below together with the living and dead roots and subsurface stems that permeate the soil.

These three elements account for the observed distinctive movement and action of water in the forest.

The tropical forest, especially the rain forest, owing to its opulence, forms an exceptionally effective screen or filter of climate between the free atmosphere above and the ground below. The unique hydrological effects of this forest reflect its special microclimate or bioclimatic and moisture regime.



According to Tricart (1965) the tropical forest owes its properties to the density of the vegetation, which is three or four times more than that of the forest of the temperate zone. It is often claimed that the vertical structure of the tropical forest consists of five layers, three of which are tree layers.

In South-East Asia the trees in the upper stratum, are 40-60 m height with umbrella-shaped crowns some tens of meters apart. The second tree layer, 20-30 m in height, is also discontinuous, with the gaps usually occurring below the emergent trees so that the upper two layers together form a more or less continuous canopy. The lower stratum is between 9 and 15 m high in West Africa and consists of many trees with narrow crowns reaching for light (Tricart, 1965).

In the tropical rain forest interception loss values for heavy rainfalls are less than for light falls. Observation in Peninsular Malaysia indicates that with a total annual rainfall of about 2,500 mm, the interception loss amounts to 450 to 500 mm, or 18-20%. Most of the rainfall seems to reach the ground surface by the process of throughfall (Lockwood, 1976).



The schematic diagram (Figure 1.2) of the interaction between tropical forest canopies and receive rainfall are as shown below :

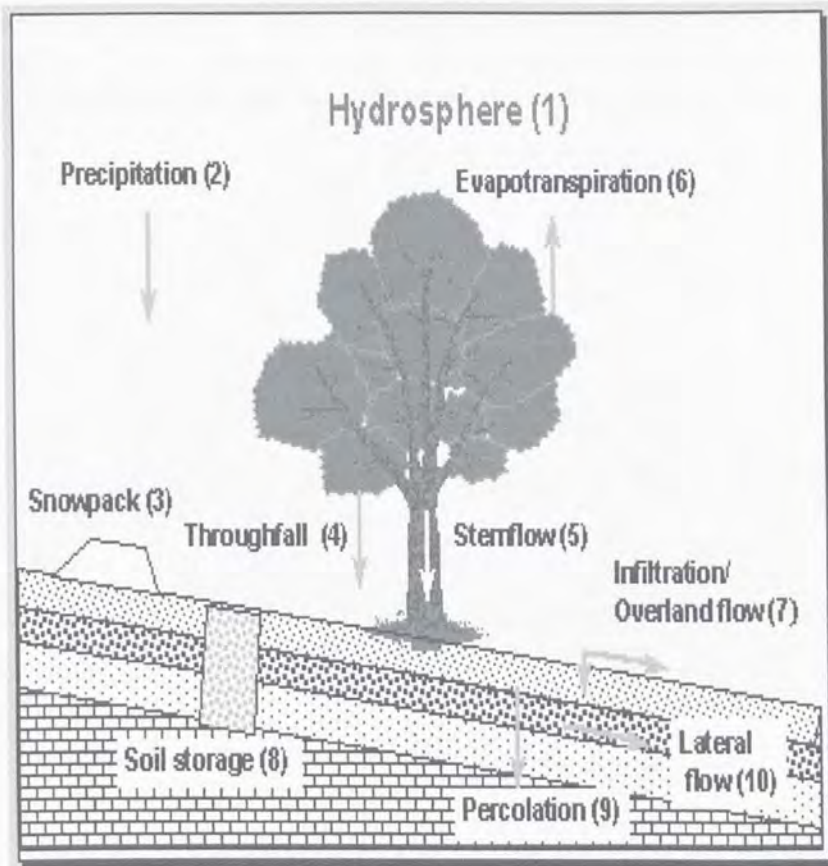


Figure 1.2 Interaction between tropical forest canopies and receive rainfall.

1.3 OBJECTIVE

The main objective of this study is to provide an estimate rate of throughfall, stemflow, and, interception loss from *Acacia mangium* in University of Malaysia Sabah. This measurement is necessary in order to understand the role of a forest cover in hydrological cycle in a forest ecosystem.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Hydrology is the science that studies the earth's water and its movement through the hydrologic cycle. The earth and its various abiotic and biotic systems are greatly influence by water. Water is essential for life and plays an important role in atmospheric and lithospheric processes.

The hydrologic cycle is used to model the storage and movement of water between the biosphere, atmosphere, lithosphere and hydrosphere. Water is stored in the following reservoirs: atmosphere, oceans, lakes, rivers, glaciers, soils, snowfields, and groundwater. It moves from one reservoir to another by processes like: evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, and groundwater flow (Haan *et al.*, 1994; Ward and Robinson, 1994).

There is a little consensus about the atmospheric and vegetation component of the hydrological cycle in a rainforest ecosystem, which together determines the evapotranspiration from regions. This represent a major factor in the water balance of



this environments, and may be critical for the management of forested drainage basins where only around 20 – 50% of the rainfall ever reaches the rivers (Anderson and Spencer, 1991).

2.2 PRECIPITATION

Precipitation can be defined as any aqueous deposit, in liquid or solid form, that develops in a saturated atmospheric environment and generally falls from clouds (Ward and Robinson, 1994). A number of different precipitation types have been classified by meteorologists including rain, freezing rain, snow, ice pellets, snow pellets, and hail. Fog represents the saturation of air near the ground surface. Classification of fog types is accomplished by the identification of the mechanism that caused the air to become saturated.

The distribution of precipitation on the Earth's surface is generally controlled by the absence or presence of mechanisms that lift air masses to cause saturation. It is also controlled by the amount of water vapor held in the air, which is a function of air temperature. Precipitation inputs to an ecosystem may take the form of rainfall, snowfall, and cloud condensation.

Precipitation falling on the ground surface can be modified by the presence of vegetation. Vegetation in general, changes this distribution because of the fact that it intercepts some the falling rain. How much is intercepted is a function of the branching structure and leaf density of the vegetation (Ward and Robinson, 1994).

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