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The water yield of Molawin watershed as influenced by rainfall, physiographic and anthropogenic factors

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ABSTRACT

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A study was conducted to determine the effects of rainfall, physiographic and anthropogenic factors on the water yield of Molawin watershed. Results showed that the total suspended solids was increased by the tractive force of streamflow and the activities of the people inside the watershed. Rainfall increased the streamflow volume but showed delayed response in the later part of the study.

The volcanic mud spring also decreased the water quality on the upper portion of the watershed. The emission of grayish mud from the mud spring caused high total suspended solids and turbidity of the river water. This natural condition could have also caused the low pH and chemical oxygen demand of water at the fifth station. The lower portion of the watershed, on the other hand, showed low dissolved oxygen but with high chemical and biological oxygen demands.

This study concluded that the continued influx of people into the watershed would further degrade the water quality and could cause unwanted streamflow fluctuations. Maintaining the present vegetation and controlling human activities are recommended.

Keywords: watershed. water quality. water regimen. water yield.

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INTRODUCTION

The destruction of the vegetative cover in many watersheds in the Philippines has caused profound impact on the quality, quantity and regimen of water of the river systems draining them. It has caused not only pollution but also undesirable streamflow quantity and regimen fluctuations. In addition, the physiographic and climatic characteristics of most of these areas tend to aggravate the problem. Fillezar (1989) reported that the country's topography, climate and soil make the land resources vulnerable to degradation. Of the 30 million hectares land area of the country, 59% or about 17.6 million hectares have a slope of 18% or greater. These areas generally have little vegetative cover and soils which are acidic and low in organic matter content. During rainy seasons, tons of soils are eroded and carried to the rivers resulting in sedimentation and flooding of lowland areas.

Baseline information on the water yield as influenced by rainfall, physiographic and anthropogenic factors is a very important take off point in the formulation of effective watershed management scheme. It is the basis for water pollution control, land use planning, flood forecasting and control, proper design of watershed infrastructure and various watershed management-related activities.

MATERIALS AND METHODS

The study site

The site of this study is the 921.8 ha Molawin watershed, part of the Makiling Forest Reserve in Los Baños, Laguna, Philippines. It is situated at $14^{0}08"$ north and $121^{0}11"$ east. The watershed which is composed of the Molawin, Pili and Maralas Creeks, contribute water to the Laguna lake. It is approximately 65 km southeast of Manila.

Data gathered

Rainfall. Secondary data on weekly rainfall covering a year were obtained from the National Agrometeorology Experiment Station at the University of the Philippines Los Baños.

Physiographic and anthropogenic characteristics. Topography, vegetation, land uses and anthropogenic factors were determined from the field as well as from recent topographic and geographic information systems maps of the Makiling Forest Reserve.

Water quality. Water samples were collected using sterilized glass containers in January 1996. Samples were obtained from the five sampling stations situated in areas suspected to have high impacts on water quality. These were immediately brought to the Institute of Chemistry, University of the Philippines at Los Baños, Laguna for analysis using standard procedures .

Water quantity and regimen. The area-velocity method was employed to determine the average quantity and regimen (the seasonal variation of stream flow in a watershed) of water. This method determined the average width and depth of water in the river in every sampling schedule. At the same time, the velocity of the running water was also determined from the selected measured reach of river using a stop watch and a floating object with a specific gravity of 1 g cm^{-3}.

The quantity and regimen were determined every week for one year near the mouth of the watershed.

RESULTS AND DISCUSSION

A. Water quality

Total Suspended Solids (TSS). The TSS of Molawin water ranged from 13.4 mg l^{-1} to 201 mg l^{-1}. The fifth station gave the highest TSS due to the grayish mud coming from the mud spring. On the other hand, values obtained from the fourth station down to the first station showed lower values compared to the fifth station but with an increasing trend.

Results also showed that TSS accumulated near the mouth of the watershed (Table 1). This situation was due to the tractive force of streamflow that brought suspended solids from the upper down to the lower portion of the watershed. This was expected since the mouth of the watershed was the outlet of streamflow discharge that carried the suspended solids. Besides, the lower portion of the watershed has many residents along the stream banks. Their activities also caused the high TSS in water.

Turbidity. Water turbidity ranged from 2.5 ntu to 13.6 ntu with the fifth station having the highest value. The high turbidity of water in the fifth station was due primarily to the grayish mud coming from the mud spring. This condition was aggravated by high rainfall events that enhanced downward transport of the mud to the river. The removal of the vegetation around the mudspring contributed further to the high water turbidity.

The lower portion of the watershed where the first station was located also showed high water turbidity. Observation showed that many people in the area caught fish, took bath and threw their waste into the river. Aside from these, they also used the river as a transportation channel and recreational area. These activities disturbed the sediments and soil of the river beds and banks, respectively, and consequently enhanced water turbidity.

The second, third and fourth stations gave lower turbidity values because there were few human activities during the time the samples were taken.

pH. The pH value of the water in the study area ranged from 4.15 to 7.54 (Table 1). The lowest pH value which was obtained from the fifth station was below the pH for water classes AA to C of 6.5 to 8.5 as recommended by the Department of Environment and Natural Resources (DENR). This low value could be due to the sulfuric acid from sulfur compounds commonly found in fumaroles or volcanic mudsprings.

Stations 1 to 4 had higher pH values that ranged from 7.3 to 7.54. These values are very acceptable based on the DENR Administrative Order No. 34 (1990). This alkaline condition could be due to the high calcium content of the water. A related study conducted by the La Tondeña Distillers, Inc. (undated) on the mineral composition of Makiling water revealed a calcium content of 48 mg l^{-1}. This could be the reason why the average pH is still within the acceptable range.

Dissolved oxygen (DO). The DO of the water samples ranged from 3.9 mg l^{-1} to 6.6 mg l^{-1} (Table 1). The minimum DO standard for AA to C classes is 5 mg l^{-1}. The second and third sampling stations showed values below the standard value.

The lower portion of the watershed where the first and second stations were located, has many residents. Observation showed that some garbage and waste from domesticated animals were directly thrown into the river. Besides, the lower portion obviously received waste from the upper portion including soil particles and plant debris. As a result, there was depletion of the dissolved oxygen in water due to oxidation and decomposition processes. According to Reinheimer (1974), microbial decomposition involves oxidation processes which lead always to a considerable oxygen consumption. Under unfavorable condition, the result may be complete disappearance of oxygen.

Accumulation of waste in the lower portion of the watershed was also reported by Borlagdan *et al.* (1992).

Chemical oxygen demand (COD). The COD of water ranged from 2.5 mg l^{-1} to 9.5 mg l^{-1}. The fifth station gave the highest value from among all stations (Table 1). It appears that there were substances in the area that were biologically resistant to decomposition. This condition could be due to the grayish mud

Table 1. The physico-chemical properties of Molawin water

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5
TSS (mg l^{-1})	39.10	24.60	19.1	13.0	201.2
Turbidity (ntu)	6.50	2.50	4.00	4.50	13.60
pH	7.54	7.30	7.48	7.39	4.15
DO (mg l^{-1})	4.20	3.90	5.70	6.60	6.40
COD (mg l^{-1})	5.57	5.00	3.75	2.50	9.50
BOD (mg l^{-1})	2.95	4.00	1.58	1.15	2.20

from the mud spring. Furthermore, there was an increase in COD from the fourth station down to the first. The increasing number of people residing in the watershed could have contributed to the situation. The waste they threw into the river could have caused the increase of COD in the water. Related findings of Borlagdan *et al.* (1992) showed that copper, organic matter and residues of chlorine accumulated in the lower portion of the watershed.

Biological oxygen demand (BOD). The BOD of water ranged from 1.15 mg l^{-1} to 4 mg l^{-1} (Table 1). The first and second stations had higher values compared to the third, fourth and fifth stations. The high BOD could be due to the waste and high organic matter in these stations. Continued accumulation of waste and organic matter could further increase BOD, reduce DO and lead to a more polluted aquatic ecosystem.

B. Water quantity and regimen

Results showed that streamflow discharge increased when rainfall increased, particularly during the early period of the study. However, it did not strongly respond to high rainfall events in the later months (Figures 1 & 2). This condition was due to the long dry months, notably from March to May 1997. This situation is expected since rainwater that reaches the soil must first fill the macro and micro pores before any significant surface runoff can occur.

CONCLUSION AND RECOMMENDATION

Rainfall greatly influenced the quality of water in the watershed. It caused soil erosion and enhanced the downward transport of waste, organic debris and volcanic mud to the river. High amount of rainfall also increased the stream discharge, specifically during the early period of the study. The volcanic mudspring and human activities also decreased the water quality of the watershed. Any further increase in the influx of people to the watershed would aggravate the degradation of the water quality.

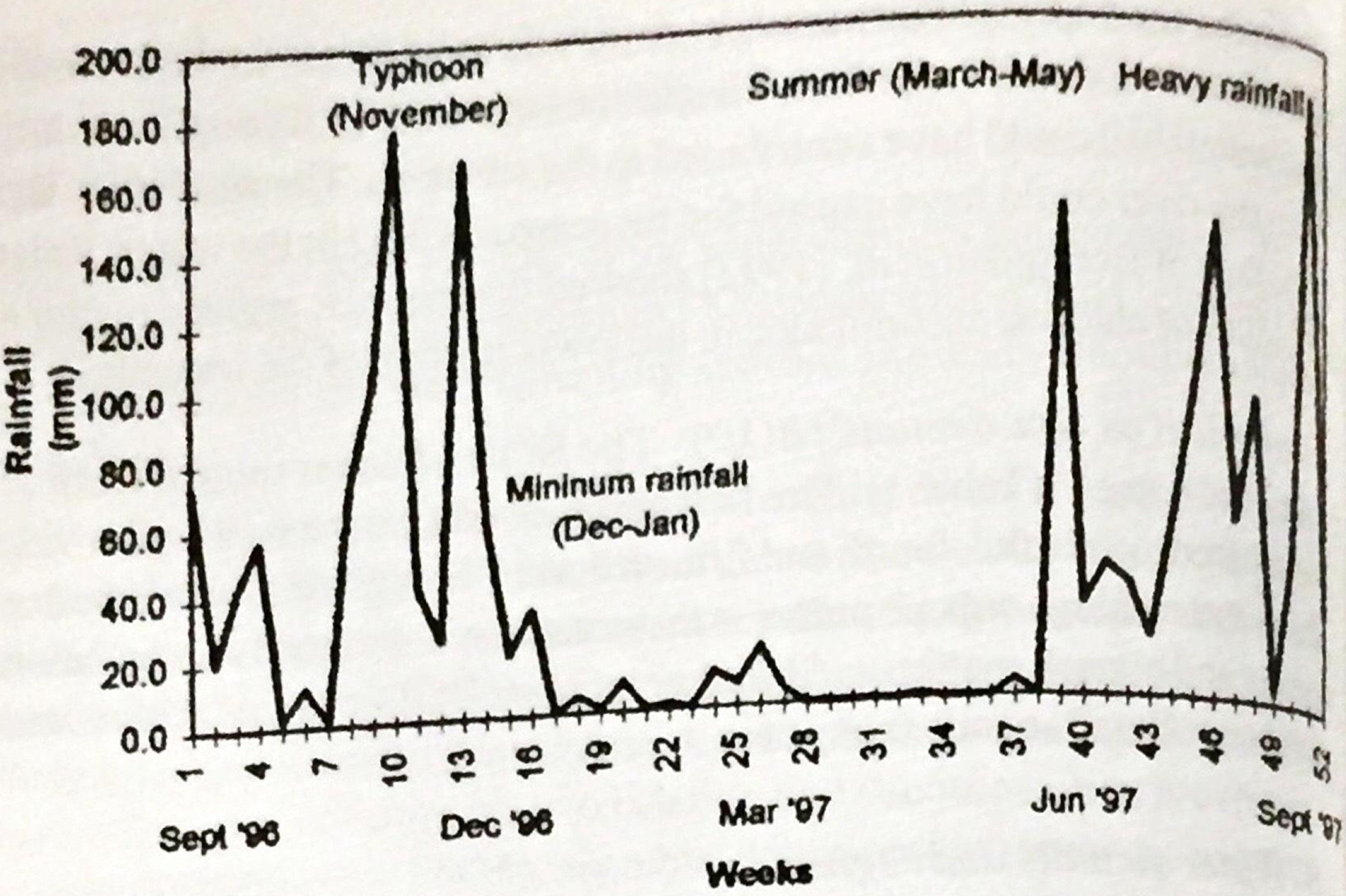

Fig. 1. Rainfall data of Molawin watershed

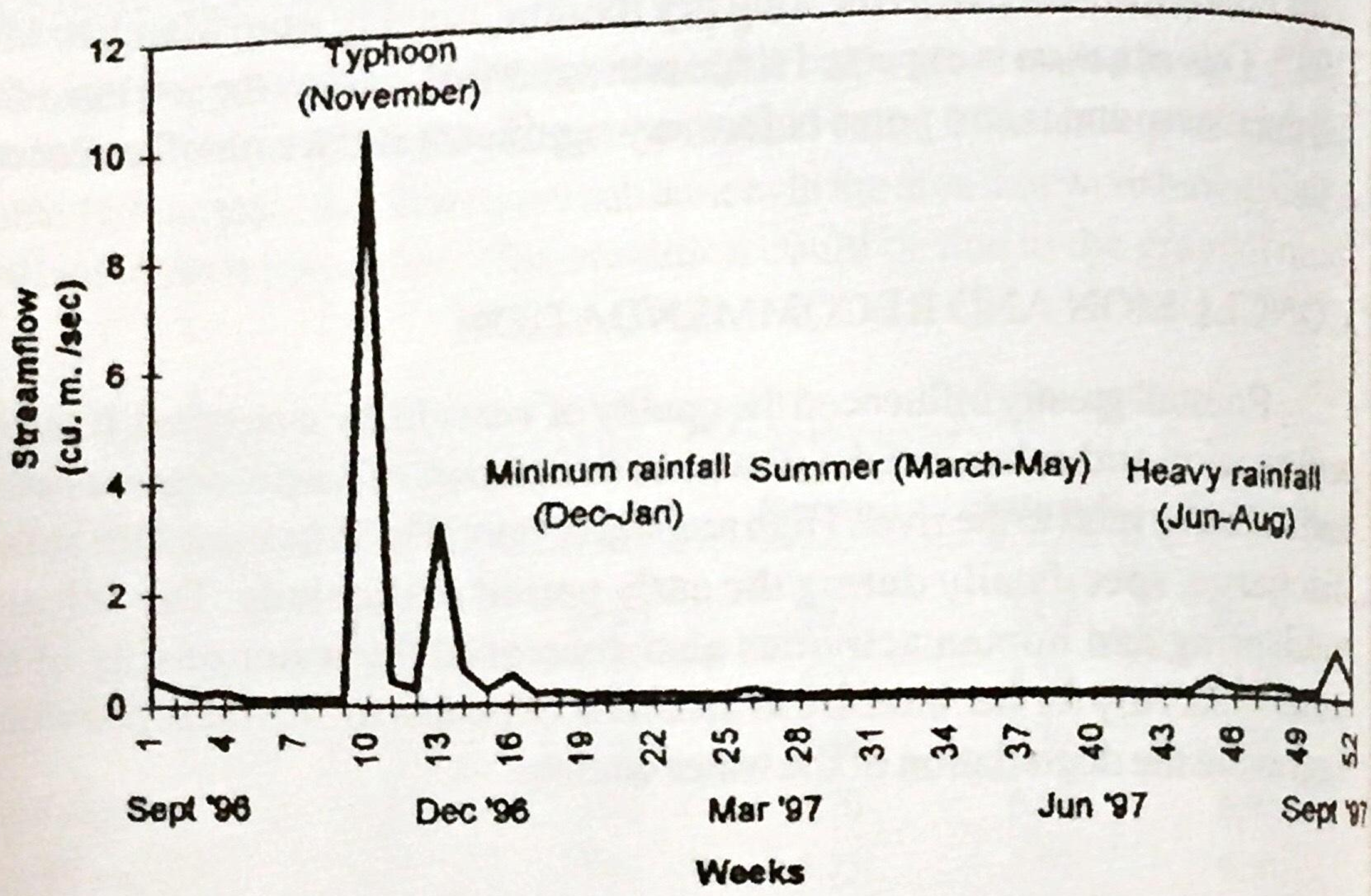

Fig. 2. Streamflow discharge and regimen of Molawin watershed

Maintaining the present vegetation and controlling human activities is very necessary. It is also recommended that a study be conducted to determine the composition of the grayish mud coming from the mudspring. It might contain heavy metals or substances hazardous to the water-consuming public.

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