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SEDIMENT YIELD ACCUMULATION AT RESERVOIR (BATANG AI DAM)

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SEDIMENT YIELD ACCUMULATION AT RESERVOIR
(BATANG AI DAM)

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To my beloved parents, family and friends

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ABSTRAK

Modified Universal Soil Loss (MUSLE) yang merupakan salah satu teknik ramalan empirikal telah digunakan untuk menganggarkan kehilangan tanah di kawasan tadahan empangan Batang Ai. Luas kawasan tadahan adalah kira-kira 1200 km^2 dan data hujan telah dianalisa untuk tempoh dua puluh tahun bermula dari 1989 sehingga 2008. Parameter-parameter untuk persamaan MUSLE seperti faktor kebolehakisan tanah,K telah dikenalpasti dengan menggunakan peta tanah yang mengandungi penerangan mengenai klasifikasi kebolehakisan tanah berdasarkan simbol siri yang terdapat pada peta tersebut. Lagipun, nilai bagi faktor panjang dan kecuraman cerun, LS telah dikira dari satu titik ke titik yang lain sepanjang takungan Batang Ai. Pekali air larian,C dan faktor penanaman dan pengurusan, CP diperolehi berdasarkan rujukan dan pemerhatian di kawasan kajian. Nilai K yang diperolehi adalah 0.438, manakala nilai LS ialah 0.782. Tambahan lagi, nilai bagi C dan CP masing-masing ialah 0.015 dan 0.010. Nilai maksimum dan minimum hasil mendapan tahunan yang diperolehi menggunakan kaedah ini adalah 70, 224 ton setahun dan 42,620 ton setahun. Selain itu, hubungan di antara hujan dan hasil mendapan yang diperolehi pula adalah $y = 17.12x – 320.3$ dengan $r^2 = 0.950$. Kajian ini adalah penting untuk menggambarkan keadaan hakisan tanah di kawasan kajian dan memberi idea bahawa hakisan tanah dan hasil mendapan adalah masalah yang serius dan memerlukan perhatian dari pihak yang bertanggungjawab. Hasil daripada kajian ini juga boleh digunakan untuk meningkatkan perlaksanaan sistem pengurusan tanah di kawasan kajian.

ABSTRACT

Modified Universal Soil Loss (MUSLE) which is one of the empirical prediction techniques was used to estimate the annual soil loss at catchment area of Batang Ai dam. The catchment area is about 1200km^2 and the rainfall data was analyzed for 20 years duration which from 1989 until 2008. The MUSLE parameters such as the soil erodibility factor, K was obtained from the soil map which contains the description of soil erodibility classification based on the symbol of series on the map. Moreover, the values of slope length and steepness factor, LS are taken from one point to another point of Batang Ai reservoir. The runoff coefficient, C and crop management factor, CP based on the references and determined by visual observation of the study area. The obtained K value is 0.438 whereas LS value is 0.782. In addition, the value of C and CP is 0.015 and 0.010 respectively. Maximum and minimum annual values of sediment yield obtained using the method is 70,224 tons per year and 42,620 tons per year. Besides, the relationship between rainfall and sediment yield obtained was $y = 17.12x – 320.3$ with $r^2 = 0.950$. This study is important to describe the soil erosion condition of the study area and give an idea about erosion and sediment yield which is a serious problem that needs more attention from the responsible party. The result of this study can be used in order to improve the implementation of the land management system at the study area.

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cm	centimeters
CP	Crop and Management Factor
GIS	Geographic Information System
ha	hacters
km	kilometers
km^2	square kilometers
km^3	cubic kilometers
m	meters
mg	milligram
mm	millimeters
m^3/s	meter cube per second
MOL	Minimum Operating Level
SESCO	Sarawak Electricity Supply Corporation
RS	Remote Sensing
ton	tones

LIST OF SYMBOLS

ºC	Celcius
C	Runoff of Coefficient
E	East
N	North
S	South

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CHAPTER 1

INTRODUCTION

1.1 General

Reservoir storage is necessary to use the highly variable water resources of a river basin for beneficial purpose such as municipal and industrial water supply, irrigation, hydroelectric power generation, and navigation. Dam and appurtenant structures also regulate rivers to reduce damages caused by floods. Public recreation, water quality, erosion and sedimentation, and protection and enhancement of fauna and other environmental resources are important considerations in management of reservoir systems.

It is important to view the reservoir as a part of a river in order to appreciate the influence of reservoir sedimentation on the environment. This is because before the existence of a reservoir, the rivers use to attain stability condition. Construction of a reservoir disturbs the normal flow pattern and sediment is deposited in the reservoir basin, in an attempt to restore the original progress that has been made towards stability.

In the construction of dam and reservoir, the stream equilibrium will always interferes by modifying stream flow and consequently, the sediment transport capacity of the stream. Sedimentation occurs in reservoirs when the eroded sediment is transported down the river system into the reservoir. The efficiency of the transport process is expressed by the sediment delivery ratio, which is the proportion of sediment eroded from the land that is discharged into rivers (Morgan and Davidson, 1986). All reservoir are subjected to some degree of sedimentation (sediment deposition), and eventually all reservoirs will fill with sediments. Some will fill faster than other, depending primarily on sediment yield of the tributary drainage basin, transport capability of the stream, and the size of the reservoir.

Sediment is derived from the erosion (wearing away) of the land surface by natural forces which are water, wind, ice and gravity. Sediment transported by streams is derived from the scour and erosion of the streambed and banks as well as from erosion of the land surface and rill of the drainage basin. Sediment yield varies with land slope, land use, vegetative cover, soil type, amount and type of precipitation, climate factors and nature of the catchment area. Natural erosion rates are accelerated by human activities, including deforestation, urbanization, farming, grazing and channelization of streams. Moreover, estimation of sediment yield has therefore become of great importance, especially when sediment is capable of seriously reduce the capacity of reservoirs (Amore et al., 2004).

Reservoir storage capacity is lost over time due to the sedimentation. Depending on flow rate and sediments load in the river flowing the reservoir, the rate of sedimentation deposition various tremendously between reservoir sites. Many reservoirs are subject to some degree of sediment inflow and deposition. It is estimated that some 0.5% - 1% of the world reservoir volume is lost from sedimentation annually (Mahmood et al., 1987). Moreover, reservoir sedimentation also varies greatly over time with the random occurrence of floods since sediment transport increases greatly during flood events.

The most critical problem associated with sediment is depletion of reservoir storage due to deposition in the reservoir. Depletion of reservoir storage capacity that occurred more rapidly than projected or is greater than projected is a very serious consideration in estimating project benefits. For examples, if conservation storage is significantly decreased over the first 20 years of project operation rather than as projected near the end of the 100 years project life, average annual yield will be decreased and future benefits will be less than projected with the full conservation storage available.

Streams transport sediments as both suspended and bed load. Where a river flows into a large body of water, such as a reservoir, the water depth and cross-sectional area increase and stream velocity decrease rather rapidly, thus reducing the sediment transport capacity of the stream and resulting in deposition of sediment in the headwaters of the reservoir. With time, some of the fine deposits move down through the reservoir and deposit against the dam, and some are flushed through the system. Typical deposition pattern are shown in Figure 1.1.

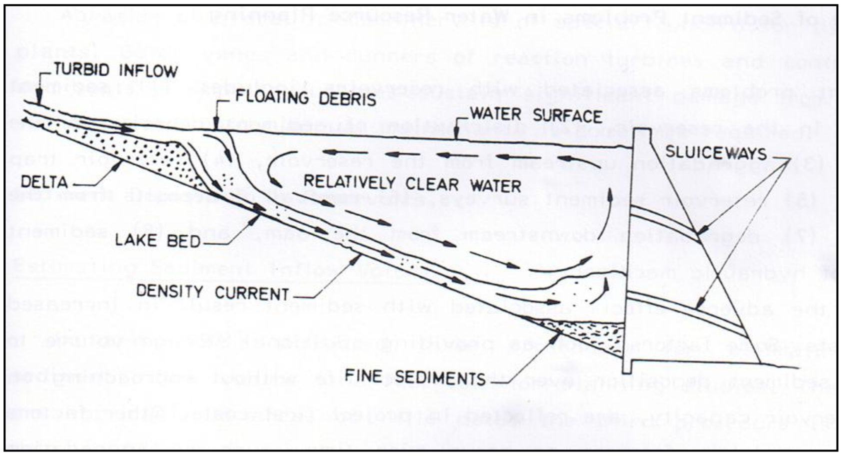

Figure 1.1: Typical Reservoir

1.2 Problem of statement

This study is conducted to estimate the sediments yield by analyzing sediment that accumulated in existing reservoir which is Batang Ai dam. One of the problems that always occur at reservoir is accumulation of sediment which cause by soil erosion processes.

Soil erosion is the detachment and transportation of the soil. Uncontrolled deforestation, forest fires, grazing, improper method of tillage, and unwise agricultural and land use practices accelerate soil erosion resulting in a large increase of sediment inflow into streams. The deposition of sediment in channels or reservoir creates a variety of problems, such as raising of stream beds, increasing flood heights, choking of navigation channels and, of course, depletion of capacity in storage reservoirs. Other than that, it may carry pollutants into water systems and cause significant water quality problems. In addition, the total quantity of sediment transported annually to the sea by rivers of the world is about 2×10^{10} tons or about 13.5 km^3 in terms of volume (Alma et al., 2001). Assuming that all this sediment enters into the reservoirs of the world, it would take about 481 years to fill up the estimated 6500 km^3 of the storage volume available.

In addition, Malaysia faces the reservoir sedimentation problem, for example, from Reservoir Sedimentation journal of Sultan Abu Bakar dam which is situated at Cameron Highland, Pahang (Choy and Hamzah, 1997). Since the early 1970s, mitigation measures for sedimentation have been carried out periodically at various locations in the Cameron Highlands Scheme to minimize its impact on the operation and maintenance of the five hydro stations (Goh and Hamzah, 1997). These measures include construction of a silt retention weir, pumping of sediment, and de-silting of tunnels, and have successfully reduced sediment inflow into the reservoir.

Other than that, according to journal of Bed Load Transport from a Regenerated Forest Catchment in Sarawak by Geoffery James Gerusu and Zulkifli Yusop, they were declared that because of the large scale forest and land clearing operation especially in the seventies had accelerated erosion and sedimentation rate in Malaysia and led to dramatic increases in sediment loads of major rivers. For example Klang River and Pari River recorded sediment load exceeded 5000 $t/km^2/yr$ (Leong, 1989). Until now, river sedimentation associated with agricultural and construction activities remain a major challenge in river management. While considerable number of studies has measured suspended sediment load (Douglas, 1968; Burgess, 1971) very few include the bedload portion. As such the scale of sedimentation problem might be underestimated.

1.3 Objective

The main objectives of this study are as follow:-

i) To investigate the sediment yield accumulation in a Batang Ai reservoir site.

ii) To determine accumulation rate of sediment at Batang Ai dam.

iii) To apply the MUSLE equation for sediment yield accumulation at Batang Ai dam.