

**STUDY ON BED MATERIAL
CHARACTERISTICS AND BED LOAD
CONCENTRATION IN SUNGAI JEMBERAU AT
TASIK CHINI**

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B. ENG (HONS.) CIVIL ENGINEERING

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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DEDICATION

This thesis dedicated to my parents, my family and friends for without their inspiration, coaching and enthusiasm none of this would be happened.
Thanks for everythings.

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ABSTRAK

Kajian ini telah dijalankan di Sungai Jemberau, Tasik Chini. Tujuan kajian ini adalah untuk mengenal pasti ciri-ciri dasar sungai dan kepekatan beban dasar di Sungai Jemberau disebabkan oleh aktiviti manusia dan juga dengan menggunakan kaedah yang tertentu dan untuk mengenal pasti corak corak mendapan / beban dasar yang disebabkan oleh proses pemendapan. Untuk menentukan ciri-ciri dasar sungai, dan ciri-ciri tanah, beberapa ujian yang berkaitan dengan ujian tanah telah dijalankan di Makmal Geoteknik, UMP. Ujian yang terlibat adalah taburan saiz zarah, kandungan kelembapan dalam usaha untuk mendapatkan ciri-ciri klasifikasi sample tanah. Keputusan ujian ayakan sample sedimen diklasifikasikan menggunakan jadual Unified Sistem Pengkelasan Tanah. Analisis untuk taburan saiz zarah menunjukkan keputusan yang paling tinggi adalah Sample 3 - 4.20mm diikuti oleh Sample 2 3.75mm, Sample 1 dan sample yang terakhir iaitu 2.75mm dan 1.15mm. Kandungan kelembapan sample pada waktu hujan iaitu untuk Jemberau 2A dan Jemberau 2B adalah 34.41% dan 39.12% dan diikuti dengan Chini 1A dan Chini 1B dengan catatan tarikh sample diambil selepas banjir adalah 29.99% dan 10.99%. Tambahan juga, hakisan permukaan juga memberikan sumbangan kepada peningkatan pengangkutan mendapan dan telah menjadi salah satu daripada masalah utama di Sungai Jemberau. Corak beban dasar pada setiap titik telah dikenal pasti melalui proses pemendapan. Corak beban dasar memberi perubahan mod pengangkutan mendapan di Sungai Jemberau. Beban dasar telah dinilai menggunakan dua formula yang berbeza yang iaitu Schoklitsch dan Duboys. Daripada analisis keputusan setiap formula Duboys boleh digunakan untuk meramalkan pengangkutan beban dasar untuk Sungai Jemberau.

ABSTRACT

The study conducted at Sungai Jemberau sample site. The purpose of this research was to identify the bed material characteristic and bed load concentration in Sungai Jemberau at Tasik Chini because of human activities and also to analyze the bed load discharge of Sungai Jemberau using selected method and to identify the sediment pattern/bed load pattern due to sedimentation process. In order to determine the bed material characteristic and bed load concentration and soil properties, several test were related soil testing conducted in the Geotechnical Laboratory, UMP. Testing that involved are a particle size distribution, moisture content that were carried out in classify properties of the soil sample. The sediment sample sieving test results was classified using Unified Soil Classification System (USCS). Analysis for particle size distribution were shown the highest particle size distribution were Sample 3 - 4.20mm followed by Sample 2 - 3.75mm, Sample 1 and last sample at were 2.75mm and 1.15mm. The moisture content for rainy day which is for Jemberau 2A and Jemberau 2B 34.41% and 39.12% and followed by Chini 1A and Chini 1B when recorded that date is after flood is 22.99% and 10.99%. Furthermore, the surface erosion also gives contribution to the increase of sediment transport and had become the one of main problem at Sungai Jemberau. The bed load pattern at each point were identified through the sedimentation process. The bed load pattern gave the variation of sediment transport modes at Tasik Chini. The bed load discharge were evaluated using two different methods which is direct sampling and formula predictions. Then, by using formulas which were Schoklitsch and Duboys equation. From the analysis of the results of each of the formula, Duboys can be used to predict bed load transport for Sungai Jemberau.

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LIST OF SYMBOLS

Q	Flow Rate of Water (m^3/s)
A	Area (m^2)
V	Velocity (m/s)
mm	Millimetre
km	Kilometre
m	Meter (m)
g	Gravitational Force (m/s^2)
n_s	Manning Coefficient
τ_c	Critical Shear Stress
τ_0	Actual Shear Stress
D_s	Mean Diameter (mm)
ν	Viscosity (m^2/s)
γ	Specific Weight (N/m^3)
S	Slope
G _s	Bed Load Discharge (lb/sec-ft)
d	Depth of River
B	Width of River

LIST OF ABBREVIATIONS

UMP	University Malaysia Pahang
USCS	Unifies Soil Classification System
US	United State
Cu	Uniformity Coefficient
Cc	Coefficient of Gradation
Nov	November
Dec	December
pH	Potential Hydrogen
TSS	Total Suspended Solid
HACH DR 5000 A(1A,2A)	Spectrophotometer Procedures Manual A is actually taken from malay word 'atas' which mean the sample is taken at the place with no flowing river water/ riverside. (1A means first sample at riverside for...)
B(1B,2B)	B is taken from malay words 'bawah' which means the sample is taken at in the river where the river water flow on it. (1B means first sample in the river for...)

CHAPTER 1

INTRODUCTION

1.1 Background

Sediment is natural earth material which consists of soil particles that are ranging in sizes from the smallest which are mud and sand to the larger sizes which include the gravels, cobbles and boulders. Sediment can move and deposited in a new location. Sediment can move from one place to another through the process of erosion. Erosion is the process of removal and transportation of rock or soil.

Sediment can be transported by a flow of water. Sediment transport can be in the form of bed-load and suspended load, which are depending on the size of the bed material particles and the flow conditions. Some factor which influence the sediment transport are flow conditions, sediment size and sediment density. Usually, the greater the flow of water, the more sediment will be transported while the movement of sediment will control the size and shape of bed forms.

The sediment load is varies from river to river. The velocity of the water is important in determining the way of how sediment is being transported. Bed-load transport depends on the flow characteristics and sediment properties, such as shear stress, surface roughness, and particle size, density, and shape. Bed load transport is the main connection between river hydraulics and river form and has a significant effect on restoring the channel geometry.

1.2 Background of Study

Tasik Jemberau is located in Tasik Chini, Pahang, Malaysia. The lake is located at the latitude and longitude coordinates of 3° 25' 31.8" (3.4255°) North and 102° 55' 8" (102.9189°) East. Sungai Jemberau is another river that connect with Tasik Chini. Besides, Laut Jemberau is a lake in Pahang and is nearby to Tanjung Kelantan, Tanjung Batu Busuk and Pulau Besar. Laut Jemberau is also close to Kawasan Cari Gali Batu Barik, Tasik Cini and Laut Gumum.

Human interference is one of the effects of sediment transport process that gives impacts on sediment load and bed load pattern. Vegetation removal from agricultural, logging activities, are the factor that will increase erosion and sediment loads of rivers. Erosion will cause the bed load to increase at the river. Therefore, the depth of river will decrease. When the depth of the river decreases, the volume of the flow rate remain same, and it will cause the flood.

The effect of excessive sediment in river will shorten the lifespan of dams and reservoirs. When a river is dammed and a reservoir is created, the sediments that used to flow along with the relatively fast-moving river water are, instead, deposited in the reservoir. Reservoirs will slowly fill up with sediment and mud.

Environmental science research there has been a great deal of important scientific research concerning issues relating to the Tasik Chini ecosystem and health of the lake, including the impact of the dam, the Sungai Chini Navigation Lock, deforestation and subsequent mining, and logging. This scientific research has highlighted problems, as residual fraction, with heavy metal concentrations, namely Cadmium, Copper and Lead, in the lake and sediment, although there is still a high level of organic content within the lakes (Ebrahimpour and Idris, 2008a). This indicates some hopefulness in respect of re-establishing the lake's ecology and future sustainability. Further research compared mean metal concentrations in Tasik Chini with a range of water quality standards showing that the mean metals concentration in surface water were low and within the range of natural background except for iron and aluminium, with increased localized concentrations being associated with natural causes such as the monsoon season but influenced by human activities through mining. The

greatest concentrations were found at three sites, Tanjung Jerangking and Melai (Shuhaimi-Othman et al., 2008). It is possible to speculate that mining activity has increased the concentrations reaching the lake during the monsoon season.

1.3 Problems Statement

In 1995, a barrage was built at the estuary of the Tasik Chini to raise the lake water level to benefit tourism. The barrage has drastically reduced the dynamism of the water movement of the lake. Furthermore, extensive human activities such as farming, produce mining and logging have adversely affected the ecosystem of the lake, causing the widespread growth of the aquatic weed *Cabomba furcata* and reduction of water quality.

The people can no longer use the lake water for washing, bathing or drinking without concern. At Kampung Ulu Melai they have been obliged to pay for piped water from the mining companies that are culpable for the environmental damage in the first place, adding to a local sense of grievance and injury. The people complain that their health is being damaged by the contaminants from mining and logging. They inform us that skin problems and respiratory diseases are more common across all age groups now, as are stomach problems and bloating, sore throats and headaches. Through this study, bed load pattern through the sedimentation process at Sungai Jemberau can be determined (Sara Ashencaen and Jonathan Parker, April 2014)

1.4 Objectives

To conduct a study, the aim of the ultimate objective of the study should be specified so that the study can be done thoroughly according to its aim. Several objectives have been set which is:

- To identify bed material characteristic in Sungai Jemberau at Tasik Chini.
- To determine bed load concentration in Sungai Jemberau at Tasik Chini.

REFERENCES

- Arman Haddadchi, Mohammad H.Omid (2013). Bed load equation analysis using bed load-material grain size. *Journal of Hydromech*, 241-249.
- Baeirlein. Anthony A.Infante (1971). Pressure-Induced Dissociation of Sedimenting Ribosomes. *Effect on Sedimentation Pattern*, 1780-1785.
- Ballanceet, J. Bartam. (1996). *Water Quality Monitoring*. London: E & FN Spon.
- C.H.J. Bong, T. L.Lau (n.d.). Incipient Motion of Sediment in Open Channel. A Comparison between Laboratory Data and Site Observation.
- Chun Kiat, C. a. (2011). Sediment Transport in Kulim River, Kedah. In D. S. Ginsberg, *Sediment Transport* (pp. 175-196). China: InTech. Retrieved from www.intechopen.com
- Geoffery, Zulkifli Yusof. (n.d). *Bed Load Transport from Regenerated Forest Catchment in Sarawak*
- Graf, Oner Yucel. (1973). Reservoir Sedimentation. *Bed Load Deposition and Delta Formation*, 2-34.
- G.M. Kondolf, H. Piegay. (2002). Channel response to increased and decreased bedload supply from land use change: Contrast between Two Catchment. *Geomorphology*, 35-51.
- Hoong, Chow Chew Hoong. (2007). Flood Forecasting. *Development of Forecasting Model for Sungai Kelantan*, 1-59.
- Ishraq Alfadhli, Sivakumar. (2012). Does the critical Shields stress for sediment transport depend on channel bed slope. 117-128.
- James P.M. Syvitski, David C. (2012). *Fjords: Processes and Products*. Springer-Verlag.
- J.M.Buffington. (2007). *Bed Load Transport in Gravel Bed Rivers*, 1-163.
- J.R Simões. (2008). *Estimating Sediment Discharge*. 1065-1086.
- Knut M. Møen, Jim Bogen. (2010). *Bedload Measurement in Rivers Using Passive Acoustic Sensors*. U.S. Geological Survey Scientific Investigations Report, 336-351.
- Luna B.Leopold. (1953). *The hydraulic geometry of stream channels and some physiographic implications*. United States Geological Survey, 252.

- Lund. (2009). Sediment Transport Studies in Punatsanchu river, Bhutan. Water Resources Engineering.
- M.A.Othman. (2014). Trends of Extreme Rainfall Events: A Case Study in Sungai Pahang River Basin.
- Martin. (2003). Geomorphology. Evaluation of bed load transport formulae using field evidence, 75-95.
- Marwan A. Hassana, Richard. D. Woodsmith. (2003). Bed load transport in an obstruction-formed pool in a forest, gravel bedstream. Geomorphology, 203-221.
- Mehrdad Poorhosein, Hossein Afzalimehr. (2014). International Journal of Hydraulic Engineering. Empirical Bed Load Transport Equations, 93-101.
- Mohsen Tahmasebi Nasab. (2015). Assessment of Some Bed Load Formulas Based On Sediment Sampling. International Journal of Hydraulic Engineering, 93-101.
- Nadiatul Adilah Ahmad Abdul Ghani, Fatin Adilah. (2013). Preliminary study on sediment load at Sungai Galing, Kuantan, Pahang.
- Noah J. Finnegan, Gerrard Roe. (2005). Geology. Controls on the channel width of rivers: Implications For Modeling Fluvial Incision of Bed Rock, 229-232.
- Nor Azazi Zakaria, H.Md.Azamathulla (2010). Gene expression programming for total bed material load estimation- a case study. Science of the Total Environment, 5078-5085.
- P.Meunier, F. Metivier. (2006). Flow Pattern and Sediment Transport in a Braided River. Journal of Hydrology, 496-505.
- Powell. (1998). Progress in Physical Geography. In,. D. Powell, Progress in Physical Geography (pp. 1-32). Arnold.
- R.J.Garde,(1995). History of Fluvial Hydraulics. New Age International.
- Roges Bettis (2008). Sediment transport & alluvial resistances in rivers. Environment Agency.
- S.A.Schum. (1960). The Shape of Alluvial in Channels in Relation to Sediment Type. Washington: United States Government Printing Office.
- Sara Ashencaen Crabtree & Jonathan Parker.(April 2014). Report on Ethnographic Work at Tasik Chini, 1-29.
- V.J.Singh. (1996). Dam Breach Modeling Technology. Springer Science & Business Media.

- Wan Hanna Melini Wan Mohtar. (2015). Statistical Characterisation of Grain-Size Distribution in Fluvial Sediment. *Journal of Sedimentary Research*, 1-192.
- W.E.Wrather. (1944). *Surface Water Supply of Hawaii*. U.S. Government Printing Office.
- W.J.Young, T.R.H.Daviest. (1990). Prediction of bed load transport rates in braided:a hydraulic model study. *Journal of Hydrology (NZ)*, 75-92.
- William R.Brownlie. (1981). Prediction of Flow Depth and Sediment Discharge. 1-228.
- W.O.Smith, C.P. Vetter (1948). *Comprehensive Survey of Sedimentation in Lake Mead*. U.S. Government Printing Office.
- Wolman, L. B.Leopod (1957). *Physiographic and Hydarulics Studies. Rivel Channel Patterns: Braided, Meandering and Straight*, 39-85.
- Yibing Zhang. (1999). *Bed Form Geometry and Friction Factor*, 1-1277.
- Zarina Md. Ali, Dwi Tjahjanto. (2008). A Study of Sediment Load: Case Study at Parit Botak Channel, Batu Pahat, Johor, Malaysia. *International Conference on Enviroment*, (pp. 1-7).
- Zhao-Yin Wang, H.Joseph. (2014). *River Dynamics and Integrated River Management*. Berlin: Springer Berlin Heidelberg.
- Zhou Liu. (2001). *Sediment Transport. Laboratoriet for Hydraulik Havne by gning*.