

**STUDY ON CHARACTERISTIC OF  
SEDIMENT AND BED LOAD TRANSPORT IN  
SUNGAI JEMBERAU AT TASIK CHINI**

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## **SUPERVISOR'S DECLARATION**

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

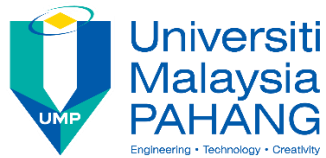
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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti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

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TRANSPORT IN SUNGAI JEMBERAU AT TASIK CHINI

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Thesis submitted in fulfillment of the requirements  
for the award of the  
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2018

## **ACKNOWLEDGEMENTS**

By the name of Allah, Most Gracious, Most Merciful. Praise to Him the Almighty that in his will and given strength to me for completing my progress report.

On the completion of this thesis with the title ‘Study on Characteristic of Sediment and Bed Load Transport in Sungai Jemberau at Tasik Chini’. I would like to present my highest gratitude to Allah S.W.T for His love and mercy. Praise and peace be upon Prophet Muhammad S.A.W, his family, and his companions.

First of all, I like to express my high appreciation to my supportive supervisor, Madam Nadiatul Adilah binti Ahmad Abdul Ghani for her great commitment in guiding, facilitating, motivate and support during my hard moment in completing this research work.

I am also very thankful to have great colleagues and technicians at Soil Mechanics and Geology Laboratory and Environmental Laboratory, and Environmental Laboratory for their team work and assistance during my laboratory works.

Lastly, I would like thank to my family especially my parents for giving me spiritual support and greatest caring along the way to complete this study.

## ABSTRAK

Kajian ini dijalankan di Sungai Jemberau, Tasik Chini. Objektif utama kajian ini adalah mengenalpasti ciri-ciri sedimen dan pengangkutan beban dasar di Sungai Jemberau. Pengangkutan beban dasar dianalisis dengan menggunakan kaedah ramalan melalui formula DuBoys dan Schoklitsch dan pengukuran terus melalui alat Helley-Smith. Oleh itu, kedua-dua kaedah ini dibandingkan dengan mendapatkan ramalan terbaik pengangkutan beban dasar di Sungai Jemberau. Untuk mengenal pasti ciri-ciri sedimen iaitu saiz dan ketumpatan sedimen, Analisis Saringan/Ayak dan Analisis Ketumpatan Zarah telah dijalankan di Makmal Geoteknik, UMP. Klasifikasi sedimen daripada hasil analisis ayak dikelaskan menggunakan Skala Udden-Wentworth. Analisis taburan saiz zarah menunjukkan saiz median sedimen tertinggi ( $d_{50}$ ) adalah 4.30mm untuk Sampel 3 pada 5 Mac 2017 (cuaca hujan) diikuti oleh 3.80mm untuk Sampel 2 pada 1 Disember 2016 (cuaca cerah), 3.20mm untuk Sampel 5 pada 12 November 2017 (cuaca hujan) dan Sampel 6 pada 30 Januari 2018 (cuaca hujan), 2.70mm untuk Sampel 1 pada 24 September 2016 (cuaca cerah) dan terakhir ialah 1.20mm untuk Sampel 4 pada 17 Mei 2017 (cuaca hujan). Kebanyakannya, sampel sedimen dikelaskan sebagai jenis kerikil. Sementara itu, hasil analisis ketumpatan sedimen di Sungai Jemberau berada antara 2.34g/cm<sup>3</sup> hingga 2.97g/cm<sup>3</sup>. Saiz dan ketumpatan sedimen ini mempengaruhi pengangkutan sedimen di Sungai Jemberau. Aktiviti perlombongan yang tidak terkawal meluas berhampiran Sungai Jemberau menyebabkan proses hakisan berlaku. Hasilnya, ia meningkatkan arus sedimen mengalir ke Sungai Jemberau dan keadaan bertambah teruk semasa ribut atau hujan. Jumlah sedimen yang banyak akan termendap di dalam dasar sungai dan membuat kedalaman sungai menjadi cetek jika pemendapan berlaku. Sekaligus, kawasan Sungai Jemberau akan menghadapi banjir kerana air sungai akan melimpah kesan daripada proses pemendapan. Dengan itu, menggunakan formula DuBoys dan Shoklitsch, pengangkutan beban dasar di Sungai Jemberau boleh diramal. Daripada perbandingan hasil pengangkutan beban dasar melalui kaedah ramalan dan pengukuran terus, DuBoys telah dipilih sebagai ramalan terbaik untuk pengangkutan beban dasar di Sungai Jemberau kerana pengangkutan beban dasar yang diramalkan oleh DuBoys lebih dekat dengan pengangkutan beban dasar yang diukur terus menggunakan alat Helley-Smith berbanding dengan pengangkutan beban dasar yang diramalkan oleh Schoklitsch. Walau bagaimanapun, hasil perbandingan menunjukkan pengangkutan beban dasar yang diramalkan menggunakan persamaan DuBoys dan Schoklitsch adalah terlebih anggaran banyak kerana kedua-dua persamaan yang digunakan berasal dari luar negara dan tidak begitu sesuai untuk digunakan di sungai di Malaysia.

## ABSTRACT

This study conducted in Sungai Jemberau at Tasik Chini. The objectives of this research was to identify the sediment characteristic and bed load transport in Sungai Jemberau. The bed load transport are analyzed using predicted by DuBoys and Schoklitsch equation, and measured method by Helley-Smith Sampler. Thus, these two methods was compare to obtain the best prediction of bed load transport in Sungai Jemberau. As to identify the sediment characteristics which are particle size and density, the Sieve Analysis and Particle Density Analysis were carried out in the Geotechnical Laboratory, UMP. The classification of sediment from sieving test results was classified using Udden-Wentworth Scale. Analysis for particle size distribution shown the highest median grain size ( $d_{50}$ ) was 4.30mm for Sample 3 on 5<sup>th</sup> March 2017 (Rainy) followed by 3.80mm for Sample 2 on 1<sup>st</sup> December 2016 (Sunny), 3.20mm for Sample 5 on 12<sup>th</sup> November 2017 (Rainy) and Sample 6 on 30<sup>th</sup> January 2018 (Rainy), 2.70mm for Sample 1 on 24<sup>th</sup> September 2016 (Sunny) and lastly 1.20mm for Sample 4 on 17<sup>th</sup> May 2017 (Rainy). Mostly, the sediment samples was classified as gravel type. Meanwhile, the density of sediment in Sungai Jemberau were range from 2.34g/cm<sup>3</sup> to 2.97g/cm<sup>3</sup>. These particle size and density of sediment were influence the sediment transport in Sungai Jemberau. Extensive uncontrolled mining activities nearby the Sungai Jemberau were lead to erosion process to occur. In result, it increase the sediment flows into Sungai Jemberau and it becomes worsen during storm or rainfall event. High amount of sediment will settle down in stream bed and make the depth of river become shallow if the sedimentation occurred. At once, the area will face flooding because the river become overflow due to sedimentation process. Then, using DuBoys and Shoklitsch equation, the bed load transport in Sungai Jemberau can be predicted. From the comparison of predicted and measured bed load transport result, DuBoys were selected as the best prediction of bed load transport in Sungai Jemberau because the bed load transport predicted by DuBoys equation were more closest to measured bed transport using Helley-Smith Sampler compared to bed load transport predicted by Schoklitsch equation. However, shown that the predicted bed load transport using DuBoys and Schoklitsch equation were over-estimate because the both equations was develop from abroad and not really suitable to use in river at Malaysia.

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## LIST OF SYMBOLS

N	North
E	East
mm	Milimeter
%	Percent
$\phi$	Phi
in	Inch
D	Diameter
$\rho_s$	Mass per unit volume ( $\text{g/cm}^3$ )
R	Hydraulic radius (m)
n	Total manning roughness
lb	Pound
ft	Feet
$G_s$	Bed load discharge (lb/sec)
$g_s$	$G_s / T_w$ , Bed load discharge per unit width (lb/sec/ft)
b	Width (m)
d	Depth (m)
V	Flow velocity (m/s)
A	Area ( $\text{m}^2$ )
$\tau_o$	$\gamma d S$ , Bed shear stress (lbs/ft <sup>2</sup> )
$\tau_c$	Critical bed shear stress (lb/ft <sup>2</sup> )
$\psi$	Coef. depending on mean size of bed material (ft <sup>3</sup> /lb/sec)
$\gamma$	Specific weight of water (lb/ft <sup>3</sup> )
S	Slope (m/m)
Q	Flow rate or discharge ( $\text{m}^3/\text{s}$ )
$D_{si}$	Mean grain size (ft)
q	Discharge per unit width
$D_{50}$	50 percent finer by weight in the size distribution curve
mg/L	Weight per volume, TSS
$^{\circ}\text{C}$	Temperature in celcius

## LIST OF ABBREVIATIONS

UMP	Universiti Malaysia Pahang
UNESCO	United Nations Educational, Scientific and Cultural Organizations
DMS	Degree, Minutes and Seconds
GPS	Global Positioning System
TSS	Total Suspended Solids
Dec	December
Sept	September
Jan	January

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Sediments are the fragments of rocks and minerals that comes from the weathering of rock and are carried and deposited by wind, water or ice. When the rainfall occur, the materials are dislodged and transported on the land surfaces. Rivers and streams will act as a passage for the movement of sediments and deposition will occur when there is no enough energy to transport the sediments. These passages will carry the sediment as they flow depending on the sediment supply along their course.

Sediment transport or sediment load deals with the interrelationship between flowing water and sediment particles which means the material in suspension and or in transport. Typically, the greater the flow, the more sediment will be transported. During transport in water body, the total sediment load are divided into two categories which are wash load and bed-material load. While in term of movement, the sediment can be identified as bed load transport and suspended load. The several factors affecting the sediment transport are velocity, depth of flow, particle sediment size, geometry cross section and course of river flow.

A river or stream can be considered stable when its water flow and sediment flux are in balance over time. The sediments is natural component in a river but if the sediment present in excess, it can be damaging. For example, it can disrupt ecosystem, water quality, increase water level and then causing flood. The sediment production are from the weathering of rocks, erosion by the flow of water over soil surfaces, channel bed erosion and bank caving (Habibi, 1994).

In addition, catchment clearing and “river training schemes” result in the indirect mobilisation of sediments into stream systems. Sediments may also enter stream or river as result of other human activities such as the construction of dams and mining activity within a catchment. Also, the construction of roads is known to be a major contributor of sediment to waterways (Till & Trayler, 2000).

Once the sediment has entered waterways, it is difficult and expensive tasks to remove where engineering solutions and heavy equipment are required. A question on how much sediment would be carried by a river under a given hydraulic condition makes the study of sediment transport is one of great engineering importance using the suitable methods or functions.

## **1.2 Background of Study**

Tasik Chini is a lake in Pekan District, Pahang, Malaysia which locate at coordinates of 3 26’N 102 55’E. The 12,565 acres or 5,085 hectares Tasik Chini is the second largest fresh water lake in Malaysia and is made up of a series of 12 water bodies, referred to as ‘sea’ by the local inhabitants which are fed by the tributaries surrounding the water catchment areas of Chini forest before flowing into the Pahang River via the Sungai Chini. Tasik Chini is one of the UNESCO Biosphere Reserve status sites in Malaysia. Sungai Jemberau and Sungai Chini is the river that connect with Tasik Chini. In addition, Sungai Jemberau is one of the seven feeder river of Tasik Chini. While, Sungai Chini is the river that drains Tasik Chini into Pahang River for about 4.8 km.

While sediment movement is a natural part of a functioning freshwater ecosystem, human activities around waterways such as dam or road construction or land use change from native forest to pasture can greatly increase the amount of sediment that enters the system. This situation can have considerable effects on water quality, plant and animal live there, and water level. The addition of sediment to rivers and streams above normal levels is a serious issue. This means, the study of sedimentation rate is quite important since the problem related to our human society such as floods and water quality can be avoid. For example, the depth of river become shallow if the sedimentation occurred. It will make the quantity of aquatic life will reduced and the area will face flooding because

the river become overflow due to sedimentation process (Ahmad Abdul Ghani, Othman, & Baharuddin, 2013).

At the same time, when the sediments in river system are high and it is still behind a dam, the sediments will sink to the bottom of the reservoir. This situation refers to reservoir sedimentation. Then, as the sediment are accumulated in the reservoir, the dam will rapidly reduce its usefulness or lifespan to store water. This accumulation of sediment in reservoirs may have several effects such as reduce the useful storage volume, change water quality, increase flooding level upstream and influence stability of the stream at downstream of dam.

As to maintain its Biosphere Reserve status by UNESCO, Tasik Chini faced many threats of uncontrolled logging, mining, plantation activities and small barrage that bring negative impacts to the ecosystem and water quality. The uncontrolled activities around the lake also contributes to the sedimentation problem in the river that flows into Tasik Chini. Indirectly, it also can affect the lake too.

### **1.3 Problem Statement**

After the sluice was built in 1995, the water level of Tasik Chini has changed while blocking the flow of the water. Since 2000, the lotus flower garden scene has disappeared. Lotus flowers usually blossomed from August to January but since the water level was raised, it is difficult for lotus flowers to grow and even if they are able to grow, the rising water in rainy season is unable to flow out and thus, the flowers are drowned. Then now, the number of tourists have significantly reduced because they are coming for flower viewing. Originally, the sluice was built to improve the water level to facilitate the boatmen, but has unexpectedly destroyed the ecology of the lake instead. It blocks the natural flushing of Tasik Chini when Sungai Pahang has high water levels twice a year. The natural flushing used to remove pollutants and safeguard water quality. That is negative hydrological impact. The Orang Asli want the sluice to be removed and they said that was the start of their problem.

## REFERENCES

- Ahmad Abdul Ghani, N. A., Othman, N., & Baharuddin, M. K. (2013). Study on Characteristics of Sediment and Sedimentation Rate at Sungai Lembing, Kuantan, Pahang. *Procedia Engineering*, 81-92.
- Ali, H. L., Mohammed, T. A., Yusuf, B., & Aziz, A. A. (2016). Testing The Accuracy of Sediment Transport Equations using Field Data. *Malaysian Journal of Civil Engineering 28 Special Issue (1)*, 50-64.
- Ariffin, J., Abd Ghani, A., Zakaria, N. A., & Yahya, A. S. (2002). Evaluations of Equations on Total Bed Material Load. *International Conference on Urban Hydrology for 21st Century*, 321-327.
- Bang Namin, N. S. (2017). *Study on Bed Material Characteristics and Bed Load Concentration in Sungai Jemberau at Tasik Chini*. Univeristi Malaysia Pahang.
- Barry, J. J., Buffington, J. M., Goodwin, P., M. ASCE, King, J. G., & Emmett, W. W. (2008). Performance of Bed-Load Transport Equations Relative to Geomorphic Significance: Predicting Effective Discharge and Its Transport Rate. *Journal of Hydraulic Engineering Vol. 134, Issue 5*.
- Bettes, R. (2008). *Sediment Transport and Alluvial Resistance in Rivers*. Bristol, United Kingdom: Environment Agency.
- Bidorn, B., A. Kish, S., F. Donoghue, J., Bidorn, K., & Mama, R. (2016). Sediment transport characteristics of the Ping River basin, Thailand. *Procedia Engineering 154*, 557-564.
- Bong, C. H., Lau, T. L., & Ab. Ghani, A. (2014). Sediment Size and Deposition Characteristics in Malaysian Urban Concrete Drains - A Case Study of Kuching City. *Urban Water Journal Vol 11, No. 1*, 74-89.
- Chan Chun Kiat, A. A. (2011, April 26). *Sediment Transport in Kulim River, Kedah, Malaysia, Sediment Transport Book by Silvia Susana Ginsberg*. Retrieved from IntechOpen: <https://www.intechopen.com/books/sediment-transport/sediment-transport-in-kulim-river-kedah-malaysia>

- Chavan, B. S., & Prakash, H. (2016). Prediction of Sediment Inflow in Reservoirs. *International Journal of Innovative Research in Computer Science & Technology (IJIRCST) Volume-4, Issue-1*, 19-23.
- Gao, P. (2011). An Equation for Bed-Load Transport Capacities in Gravel-Bed Rivers. *Journal of Hydrology*, 297-305.
- Garcia, M. H. (2008). *Sedimentation Engineering: Processes, Measurements, Modelling and Practice*. American Society of Civil Engineers.
- Government of Western Australia, D. o. (2000, January 1). *Water Notes: Sediment in Streams*. Retrieved from Department of Water, Western Australia Website: [www.water.wa.gov.au/\\_\\_data/assets/pdf\\_file/0017/3158/11444.pdf](http://www.water.wa.gov.au/__data/assets/pdf_file/0017/3158/11444.pdf)
- H. Hassanzadeh, S. F. (2011). Estimate of Sediment Transport Rate at Karkheh River in Iran using Selected Transport Formulas. *World Applied Sciences Journal* 13 (2), 376-384.
- Habibi, M. (1994). Sediment transport estimation methods in river systems. *Universities of Wollongong Thesis Collection*, 27-66.
- Haddadchi, A., H. Omid, M., & A. Deghani, A. (2013). Bedload Equation Analysis using Bed Load-Material Grain Size. *J. Hydrol. Hydromech*, 61, 241-249.
- Hassanzadeh, Y. (2012, March 14). *Hydraulics of Sediment Transport, Hydrodynamics Book by Jin Hai Zheng*. Retrieved from IntechOpen: <https://www.intechopen.com/books/hydrodynamics-theory-and-model/hydraulics-of-sediment-transport>
- Hirshfield, F., & Sui, J. (2011, April 26). *Changes in Sediment Transport of the Yellow River in the Loess Plateau*. Retrieved from IntechOpen: <https://www.intechopen.com/books/sediment-transport/changes-in-sediment-transport-of-the-yellow-river-in-the-loess-plateau>
- Holmes, R. R. (2010). Measurement of Bedload Transport in Sand-Bed Rivers: A look at Two Indirect Sampling Methods. *U.S Geological Scientific Investigation Report*, 236-252.

- Iwuoha, P. O., Adiola, P. U., Nwannah, C. C., & Okeke, O. C. (2016). Sediment Source and Transport in River Channels: Implications for River Structures. *The International Journal of Engineering and Science (IJES)*, 19-26.
- Kiat, C. C., Ab. Ghani, A., Abdullah, R., & Zakaria, N. A. (2011, April 26). *Sediment Transport in Kulim River, Kedah, Malaysia*. Retrieved from IntechOpen: <https://www.intechopen.com/books/sediment-transport/sediment-transport-in-kulim-river-kedah-malaysia>
- Kiat, C. C., Ab. Ghani, A., Zakaria, N. A., Abu Hassan, Z., & Abdullah, R. (2004). Measurement of Bed Load Transport for Selected Small Streams in Malaysia. *1st International Conference on Managing Rivers in the 21st Century: Issues and Challenges*, 236-241.
- Kuhnle, R. A., Wren, D. G., & Langendoen, E. J. (2014). Predicting Bed Load Transport of Sand and Gravel on Goodwin Creek. *Journal of Hydro-environment Research* 8, 153-163.
- M. Nawawi, M. A. (2017). *The Study of Sediment Behaviour Changes at Sungai Lembing between 2008 and 2016*. Universiti Malaysia Pahang.
- Mays, L. W. (2010). *Water Resources Engineering Second (2nd) Edition: Chapter 18 Sedimentation and Erosion Hydraulics*. John Willey and Sons Inc.
- Md. Ali, Z., Tjahjanto, D., Rahmat, N., Mohamad Masirin, M. I., Musa, S., & Abd Manan, I. (2008). A study of Sediment Load: Case Study at Parit Botak Channel, Batu Pahat, Johor, Malaysia. *International Conference on Environment 2008 (ICENV 2008)*, 1-8.
- Mohamad Prim, F. A., & Ahmad Abdul Ghani, N. A. (2013). Preliminary study on sediment load at Sungai Galing, Kuantan, Pahang. *Malaysia Technical Universities Conference on Engineering & Technology (MUCET)*.
- Mohd Nor, N., Mat Peah, K., & Hamzah, M. Z. (n.d.). *Civil Engineering Laboratory Manual (3rd Edition)*. Faculty of Civil Engineering & Earth Resources, Universiti Malaysia Pahang.



- Papalaskaris, T., Dimitriadou, P., & Hrissanthou, V. (2016). Comparison between Computations and Measurements of Bd Load Transport Rate in Nestos River, Greece. *Procedia Engineering* 162, 172-180.
- Raja Idnan, R. I. (2016). *Study On Sediment Size And Discharge At Lebir River Due To 2014 Flood*. Universiti Malaysia Pahang.
- Schumm, S. A. (1985). Patterns of Alluvial Rivers. *Annual Reviews Earth Planet Science* 13, 5-27.
- Shannon, & Wilson. (2009, June). *Lower Puyallup River Flood Protection Investigation Without-Project Analysis: Chapter 4 Sediment Transport and Deposition*. Retrieved from Pierce County Web site: <https://www.co.pierce.wa.us/>
- Stop Mining Activities at Tasik Chini*. (2012, August 15). Retrieved from Transparency International Malaysia: <http://transparency.org.my/what-we-do/forest-governance-and-integrity/stop-all-mining-activities-immediately-at-tasik-chini/>
- Till, B., & Trayler, K. (2000, January 1). *Water Notes: Sediment in Streams*. Retrieved from Department of Water, Western Australia Website: [www.water.wa.gov.au/\\_\\_data/assets/pdf\\_file/0017/3158/11444.pdf](http://www.water.wa.gov.au/__data/assets/pdf_file/0017/3158/11444.pdf)
- Tipper, J. C. (2016). Measured rates of sedimentation: What exactly we estimating and why? *Science Direct: Sedimentary Geology* 339, 151-171.
- Toriman, M. E., Kamaruddin, M. K., Hj. Idris, M., Jamil, N. R., Gazim, M. B., & Abd Aziz, N. A. (2009). Sediment Concentration and Load Analyses at Chini River, Pekan, Pahang, Malaysia. *Research Journal of Earth Sciences* 1 (2), 43-50.
- Wentworth, C. K. (1922). A Scale of Grade and Class Terms for Clastic Sediments. *The Journal of Geology*, Vol 30, No. 5, 337-392.