Study on Characteristic of Bed Material and Bed Load Discharge in Sungai Jemberau, Tasik Chini due to Mining and Logging Activities

N. Adilah A. A. Ghani[1,2*], N. Syamimi B. Namin[1], Norashikin .A.Kamal[3] and Junaidah Ariffin[3].

[1]Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang, Kuantan, Pahang, Malaysia.
Centre of Earth Resources Research & management (CERRM), Universiti Malaysia Pahang, Kuantan, Pahang, Malaysia.
[3]Faculty of Civil Engineering, Universiti Teknologi Mara, Shah Alam, Selangor, Malaysia.

Tasik Chini is one of the two natural lakes in Peninsular Malaysia, which is located in the state of Pahang about 100 km from Kuantan, the capital of the state of Pahang. Based on the topographical map, most of the lowland within the study area has been converted into agricultural and including rubber and oil palm plantations and mixed crops. This logging and mining activities gave impact to sediment characteristics and discharge. The purpose of this study was to identify the bed material characteristics and to determine the bed load discharge in Sungai Jemberau at Tasik Chini. Bed material sample was collect at Sungai Jemberau in 24 November 2016, 1 December 2016 and 5 March 2017. Bed load results gave the variation of sediment transport modes in Sungai Jemberau cause by human activities nearby. The bed load discharges were estimated by using Duboys and Schoklitsch equation. From the analysis of the results, Duboys Equation was more suitable to predict and estimate the bed load discharges for Sungai Jemberau at Tasik Chini. This is because the equation is more suitable for uniform sediments with the specific gravity that are varying from 1.25 to 4. The particle size range for the Duboys equation is between 0.01–4.0mm.

Keywords: Bed Load, Characteristic, Discharge, Sungai Jemberau, Tasik Chini

1. INTRODUCTION

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 and logging activities is the main factor that will increase the erosion and sediment loads of rivers. Mining and logging activities near to Sungai Jemberau cause the erosion and contribute to the sedimentation process during the rainy day.

Sediment processes, by shaping the river channel, also affect the flow conditions in a river and hence the conveyance of a river, the distribution of velocity and depth and the composition of the bed sediments. Thus sediment processes are intimately connected with both mining activities defence and also the ecology of rivers.

There is an interaction between the movement of sediment and the flow. The flow determines the sediment transport but the movement of sediment controls the size and shape of bed forms which in turn affects the hydraulic resistance and hence the flow. Sediment transport is very sensitive to flow conditions and increases dramatically during floods, mining activities [1].

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 factors which influence the sediment transport are flow conditions, sediment size and sediment density. Usually,

*Email Address: nadiatul@ump.edu.my

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 most important property of the sediment particle or grain is based on the size[2].

Bed load is the stony material, such as gravel and cobbles, that moves by rolling along the bed of a river because it is too heavy to be lifted into suspension by the current of the river. The measurement of bed load is extremely difficult. Most bed load movement occurs during periods of high discharge on steep gradients when the water level is high and the flow is extremely turbulent. Such conditions also cause problems when making field measurements.

The aim of this study is to identify the bed material characteristic and the bed load discharge in Sungai Jemberau at Tasik Chini. The characteristic of bed material were determined according to the size by using Udden Wentworth scale. Based from the results of bed material characteristics, Duboys equation was used to estimate the discharge as the function due to its suitability for coarse sands and gravel and small flumes.

2. STUDY AREA

Tasik Chini recently has undergone devastating situation as a lake environment since 1984 or earlier due to development activities in the surrounding areas such as oil palm plantations and residential developments[3]. The conditions of Tasik Chini become worst when a small dam was built in 1995 to retain water in the lake for tourism purposes[4].

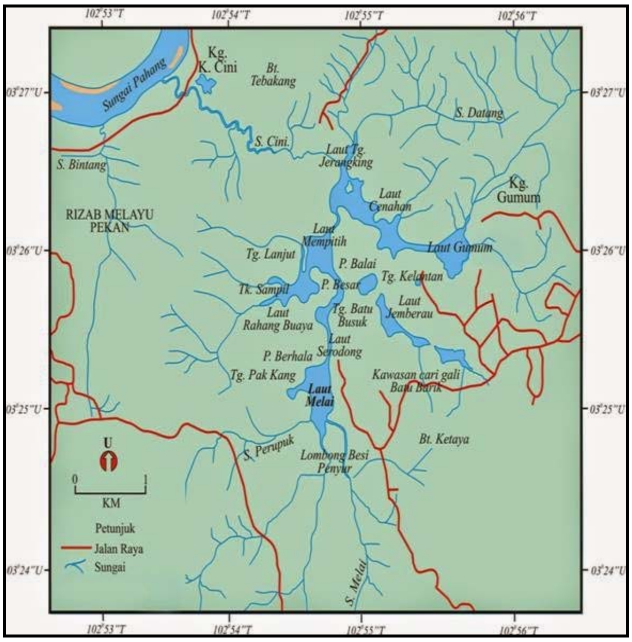

Fig.1. Location of Sungai Jemberau in Tasik Chini

Sungai Jemberau (Laut 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 connects with Tasik Chini. Besides, Sungai Jemberau is a lake in Pahang and is nearby toTanjung Kelantan, Tanjung Batu Busuk and Pulau Besar. Sungai Jemberau is also close to Kawasan Cari Gali Batu Barik, Tasik Cini and Laut Gumum.

Figure 1 show the sampling location of Sungai Jemberau which is one of the river that connect to Tasik Chini. Figure 2 shows the view of logging and mining activities closed to Sungai Jemberau.

Fig.2. Land clearing and logging activities closed to Sg Jemberau

Sample of the bed material had been collected at the field site to be further testing in the soil laboratory. The test that had been conducted was sieve analysis to obtain the grain size for the bed material.

Other than that, flow velocity, and river depth also be measured during the sampling of bed material. The data collection for bed material sampling was done on 24th November 2016, 1st December 2016 and 5 March 2017. In January 2017 and February 2017, sample cannot be collect as the site has been flooded start from end of December until end of February. Figure 3 show the view at Sungai Jemberau during flooding. The picture was taken on 2 February 2017.

Figure 4 shows the sampling point of bed material scollection. The velocity and width of the river had been measured as show in Figure 5. This data is important to calculate the cross section area at that point. From this data the flow discharge can be determine.

Fig 3. : Flooding and overflow at Sg Jemberau (2 Feb 2017)

Fig.4. Location of bed load sampling at Sungai Jemberau

Fig.5. Measurement of river width

Details of the flow discharge is tabulated in Table 1 based on the flow velocity and river data at sampling point for different dates of sampling.

Table 1. Flow velocity and river width at sampling point

Date	Velocity (m/s)	Width (m)
24 Nov 2016	0.06	6.3
1 Dec 2016	0.081	6.5
5 Mac 2017	0.211	11.1

2.1. SIEVE ANALYSIS TEST

The grain size of bed material is analysed through the sieve analysis test in the soil laboratory. Grain size can be defined as the size of the bed material that is transported. The grain size of the sediments was determined using the standard dry and wet sieving techniques. Samples which consist of more than 90% sand were analyses using the dry sieving method. The sample was sieved using 5.000, 3.350, 2.000, 0.600, 0.212, 0.063 mm sieves sizes (refer Figure 6).

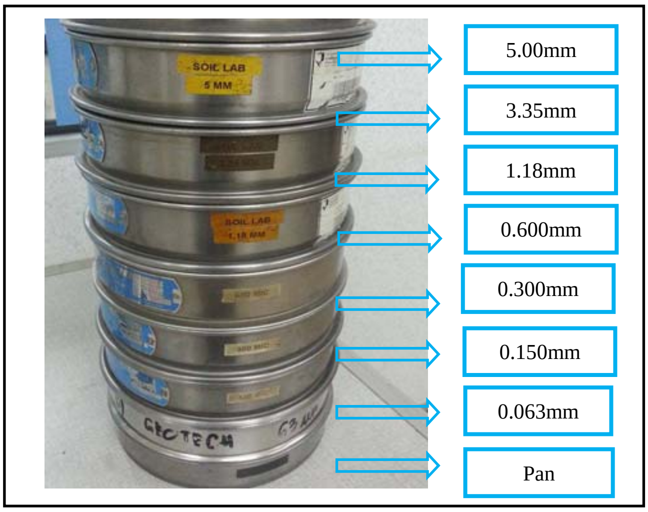

Fig. 6. Size of sieves used for sieve test

Bed material samples were taken to Soil Laboratory. First, the samples were being put in the tray for the air dry. Then, 1000 gram samples from each station were put in oven dry for 24 hours. Next step, the samples are ready for sieve. Figure 7 show the bed material sample before dry and after dry using oven for 24 hours.

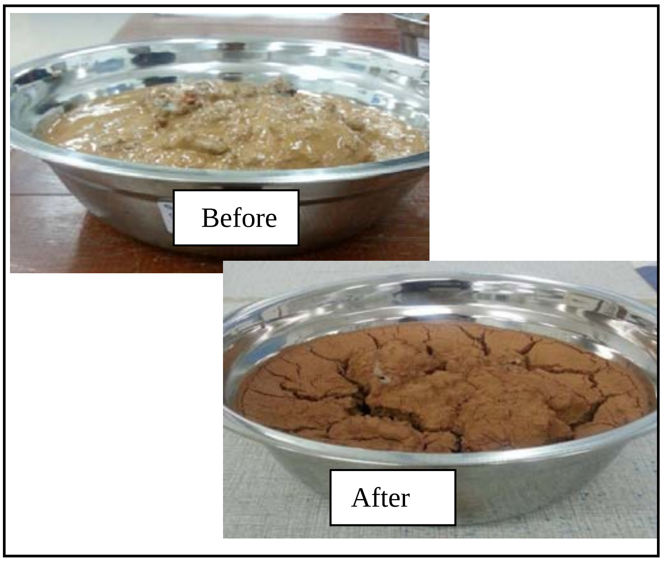

Fig.7. Sample of bed material (a) before oven dry and (b) after oven dry

2.2. SCHOKLITSCH

Schoklitsch was the pioneer that use discharge for the estimation of bed load. Gilbert in 1914-purpose bed-load transport rate formula for particle size of sediment ranging from 0.3 to 6mm as:

Unigranular materials (D_{50}):

$$Gs = \frac{86.7}{\sqrt{D}} S^{\frac{3}{2}} (Q - T_W q_0) \quad \text{(Eq. 1)}$$

Where;

Gs	=	Bed load discharge, lb/s
D	=	D_0 (mean grain diameter), inches
S	=	The energy gradient, ft/ft
Q	=	The discharge ft^3/s
T_W	=	The width in ft
Q_c	=	The critical discharge, ft^3/s per ft of width
q_0	=	$0.00532\, d / S^{\frac{4}{3}}$

2.3. DUBOYS

Duboys is one of the first successful developments of sediment discharge formula. Although the model of sediment transport was incomplete, the proposed relationship for bed load transport rate has been proven to be in good agreement with a large amount of experimental measurements.

The Duboys can be expressed as follows:

$$Gs = K\tau_0 \, (\tau_0 - \tau_c) \quad \text{(Eq.2)}$$

Where;

K	=	Parameter dependent on the thickness of the moving bed layer
τ_c	=	Critical shear stress
$(\tau_0 - \tau_c)$	=	Excess shear stress

The model are based on the assumptions that the bed material moves in layers of uniform thickness and the mean velocity of the layers increases linearly toward the bed surface.

3. PROPERTIES OF BED MATERIAL (SIZE)

The particle size distribution were obtained for each different dates. The particle size distribution is one of the important factor that affects the sediment transport in river (refer Figure 8).

According to Figure 8, by using Udden Wentworth scale, soil distribution were most retained at 5.00mm at the sieve pan. Most of the distributions of sample soil at each date were dominated by Fine Gravel which is the average of sediment particles is 4-8mm. The average of particles size, (d_{50}) recorded between 2.75mm and 4.20mm.

Fig 8.Bed material size on bed material sampling date

From the analysis in Figure 9, the median bed material size (d_{50}) size is 2.75 mm at 24th November 2016. According to sieve analysis result, bed material sample most retained at phi value (1-0) which is about 30.58%. Based on Wentworth scale, phi value (-3 to -2) at sieve 5.00mm, it can be concluded that the bed material is Fine Gravel type. Sediment transport function was characterized by the median bed material size median or particles size (d_{50}). Based on sieve analysis, the medium grain size (d_{50}) has passing between (1.18mm-3.35mm).

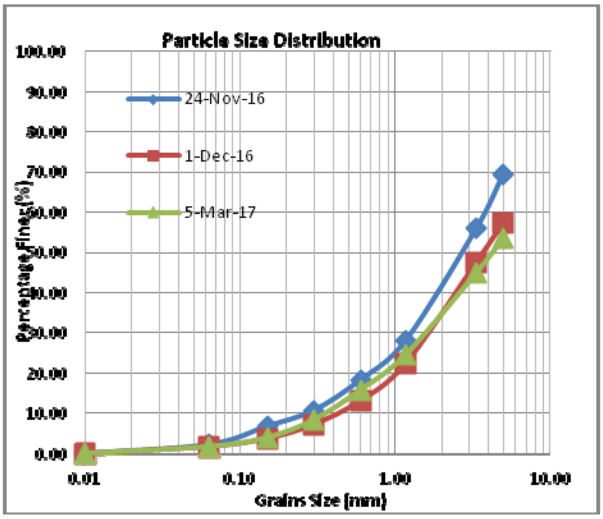

Fig. 9. Particle Size Distribution

From the analysis, the median bed material size (d_{50}) size is 3.75mm at 1st December 2016. According to sieve analysis result, bed material sample most retained at phi value (1-0) which is about 42.63%. Based on Wentworth scale, phi value (1-0) at sieve 0.600mm, it can be concluded that the bed material is Fine Gravel type. Sediment transport function was characterized by the median bed material size median or particles size (d_{50}). Based on sieve analysis, the medium grain size (d_{50}) for this date has passing between (3.35mm-5.00mm).

From the analysis, the median bed material size (d_{50}) size is 4.20mm at 5th March 2017. According to sieve analysis result, bed material sample most retained at phi value (1-0) which is about 37.95%. Based on Wentworth scale, phi value (-2 to -1) at sieve 0.600mm, it can be concluded that the bed material is Fine Gravel type. Sediment transport function was characterized by the median bed material size median or particles size (d_{50}). Based on the sieve analysis, the medium grain size (d_{50}) for this sample has passing between (3.35mm-5.00mm).

3.2. BED LOAD EQUATIONS (DISCHARGE)

To determine the bed load prediction results, there were two different bed load equations used to evaluate bed load transport which were Schoklitsch and Duboys equation.

Table 2. Description of bed load equations used in this study

Function Name	Type	Particle Size (mm)C	Type of data and description
Schoklitsch	Bed Load	0.30-5.0	Well sorted and graded sediment in small flumes.Not applicable for hyper-Concentrate sand based river
Duboys	Bed Load	0.01-0.4	Not applicable for sand bed stream carrying suspended load

For Duboys equation, negative result for bed load transport is on 1st December 2016 which is -0.0131lb /sec-ft. The prediction of bed load transport is 0.0030 lb /sec-ft at 24th November 2016 and for 5th March 2017, the value is 0.0560 lb /sec-ft.

Comparison in between these formula shows that bed load transport data for Duboys gives better prediction of bed load functions which is the function is suitable for Fine Gravel. For Schoklitsch equation is not suitable as it gave negative results for all prediction date.

The measurement sampling had done in 8, 15 and 22 December 2016. The suspended load was high during the wet weather condition with heavy rain and high tide. The highest total sediment load during the sampling measurement was found during the high tide condition in 22 December 2016 which was estimated to be 1732.5 kg for total load/day. Table 3 shows the results of sediment load estimation for Sungai Jemberau[5].

Table 3. Result for total load sampling in Sungai Jemberau

Date of Sampling	Weather Condition during sampling	Suspended Load (kg/day)	Bed Load (kg/day)	Total Load (kg/day)
8 Dec 2016	Sunny	266.56	10.62	277.18
15 Dec 2016	Sunny (Tide)	60.43	6.13	66.56
22 Dec 2016	Sunny (High Tide)	1715.60	16.92	1732.50

4 CONCLUSIONS

In conclusion, the size and types of bed material were identified at Sungai Jemberau, Tasik Chini. The bed load discharge was evaluated using two different formulas which were Schoklitsch and Duboys equations. From the analysis of the results of each of the formula, Duboys can be used to predict bed load transport for Sungai Jemberau as it is suitable for uniform sediments with specific gravity that are varying from 1.25 to 4. The particle size range for the Duboys is between 0.01 – 4.0mm. This result also shows that Duboys gives a better and reliable prediction for bed load discharge and concentration at Sungai Jemberau. The bed load results predicted by Duboys equation shows that there were increasing value of bed load discharge happen in Sungai Jemberau after that area had facing a flooding situation. The size of bed material also increases from 2.75mm in 24 November 2016 to 4.2mm in 5 March 2017. After flood, Sungai Jemberau also becomes wider due to the erosion and riverbank failure at that area.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the University Malaysia Pahang for granting this research project which the vote number is RDU170344. Many thanks also to the researcher members from Universiti Malaysia Pahang, Universiti Teknologi Mara, Shah Alam who were participating in this project and finally achieve the objectives.

REFERENCES

[1] R. Bettes, Sediment Transport & Alluvial Resistances in rivers. Environment Agency (2008)

[2] A. Haddadch, Bedload Equation Analysis Using Bed Load-Material Grain Size. Journal of Hydromech 2, p.241-249 (2013)

[3] M. B. Gasim, M.. E. Toriman, Z. A. Rahman, M. S. Islam & T.C. Chek, Flow characteristics of the Tasik Chini's feeder rivers, Pahang, Malaysia, Bulletin of the Geological Society of Malaysia 55 (2009).

[4] Mushrifah Idris & A. A. Kutty, Trends of physicochemical water quality in Tasik Chini. In Khazanah Tasik Chini. Bangi: Universiti Kebangsaan Malaysia Publisher.p. 20-29.(2005).

[5] Norlida M. Dom, Sharina Sulaiman, Norashikin A. Kamal, Saerahany L. Ibrahim, Nadiatul A. A. Ghani, Junaidah Ariffin, Sediment Load Analysis In Lake Chini. The Journal of Water Resources Management (JoWRM) – in progress.