Study on Characteristic of Bed Material and Bed Load Discharge in Sungai Jemberau, Tasik Chini

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Tasik Chini is located in the state of Pahang about 100 km from Kuantan, the capital of the state of Pahang. 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. Bedload discharge also measured between these date. The bed load discharges also estimate by using Duboys and Schoklitsch equation to identify the suitable predicted method for this area. 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 because the predicted value closer to measured value.

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

I. INTRODUCTION

Sediment is the nonpoint source pollutants coming from a number of sources and washed into our waterways by surface runoff. When land disturbing activities occur, soil particles are transported by surface water movement. Soil particles transported by surface water movement are often deposited to streams, lakes, and wetlands, resulting to cross section and morphology changes, as well as bed load increase. The process of sediment deposition is also dependent on river discharge and speed of river flow. Thus, faster water velocity would result in higher amount of sediment deposited.

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 (Gasim *et al.*, 2006).

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.

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Sediment transport is very sensitive to flow conditions and increases dramatically during floods, mining activities (Bettes, 2008).

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. Factors which influence the sediment transport are flow conditions, sediment size and sediment density. Sediment transport not only depends on the characteristics of the flow but also depends on the properties of the sediment. According to Haddadchi (2013), the most important property of the sediment particle or grain is its size. 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.

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 was determined according to the size by using Udden Wentworth scale. Based on the results of bed material characteristics, Duboys and Schoklitsch equation was used to determine the most accurate predicted results compare to measured bed load discharge.

II. 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 (Gasim *et al.*, 2009). The conditions of Tasik Chini become worst when a small dam was built in 1995 to retain water in the lake for tourism purposes (Idris and Kutty, 2005).

Figure 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 one of a feeder river that connects with Tasik Chini and is nearby to Tanjung 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 rivers that connect to Tasik Chini.

Figure 2 shows the view of logging and mining activities in the surrounding area of Sungai Jemberau which these could bring to the increment of sediment loadings in Sungai Jemberau. The activity in the surrounding areas of river will influence the sedimentation loading.

Figure 2. Land clearing and logging activities closed to Sungai Jemberau

III. MATERIALS AND METHODS

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 could not be collected 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 3. Flooding and overflow at Sungai Jemberau on 2 February 2017

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.

Bed material samples were taken to Soil Laboratory. First, the samples were being put in the tray for the air dry. Then, 1000g samples from each station were put in oven dry for 24 hours. Next step, the samples are ready for sieve. Figure 6 show the bed material sample before dry and after dry using oven for 24 hours.

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

Unigranular materials (D_{50}):

$$Gs = \frac{86.7}{\sqrt{D}} S^{\frac{3}{2}} (Q - T_{Wqo}) \qquad (1)$$

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= $0.00532d/S^{\frac{4}{3}}$

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:

$$Gs = K\tau_0(\tau_0 - \tau_C) \qquad \text{(Eq. 2)}$$

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 is 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.

IV. RESULTS AND DISCUSSIONS

The particle size distribution was obtained for each different date. The particle size distribution is one of the important factors that affects the sediment transport in river (refer Figure 4).

According to Figure 5, by using Udden Wentworth scale, soil distribution was 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.

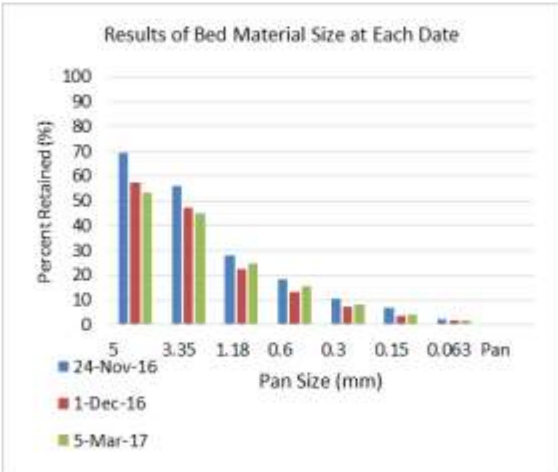

Figure 4. Bed material size on bed material sampling date

From the analysis in Figure 5, the median value (d_{50}) of bed material 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).

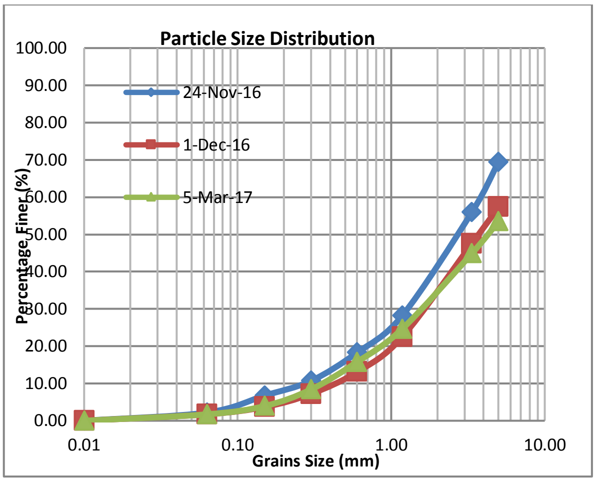

Figure 5. Particle Size Distribution

From the analysis, the median value (d_{50}) of bed material size size is 3.75mm at 1st December 2016. According to sieve analysis result, bed material sample was 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 of bed material size 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 value of bed material size (d_{50}) 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 size of bed material 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).

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 1 shows the particle size range and explanation for Duboys and Schoklitsch equation. Both of bed load equations are not suitable for sand bed type.

Table 1. Description of bed load equations used in this study

Name	Size (mm)	Comments
Duboys	0.01-4.0	The formula is not applicable for sand-bed streams that carry suspended load
Schoklitsch	0.30-5.0	It is a bed load formula that should not applied to sand-bed streams that carry considerable bed sediments in suspension

Table 2 shows results of bed load discharge using Duboys and Schoklitsch equation. For Duboys equation, the highest and lowest discharges are 1.0435lb/sec and 0.0132lb/sec respectively. Meanwhile for Schoklitsch equation, the highest and lowest discharges are 5.5723lb/sec and 0.9090lb/sec respectively. The highest and lowest bed load discharge from both Duboys and Schoklitch are representing the same sample which Sample 3 on 5th March

2018 (Rainy) and Sample 1 on 24th September 2016 (Sunny) respectively.

Table 2. Results of Bedload Discharge using DuBoys and Schoklitsch equation

Date	Weather	Duboys (lb/sec)	Schoklitsch (lb/sec)
24thSept	Sunny	0.0132	0.9090
1st Dec	Sunny	0.4350	1.9835
5th March	Rainy	1.0435	5.5723

Table 3. Comparison between Measured and Predicted Bedload Discharge in Sungai Jemberau

Date	Duboys (lb/sec)	Measured Bedload (lb/sec)
24th Sept	0.0132	N/A
1st Dec	0.4350	N/A
5th March	1.0435	$1.08{\times}10^{-5}$

From Table 3, the DuBoys gives better prediction of bed load discharge in Sungai Jemberau which the equation is applicable for gravel type sediment and the prediction result are more closely to the measured result. The Duboys equations are developed from abroad and considered river from there. Consequently, the result over predicted from measured data.

Table 4. Flow Rate versus Predicted Bedload Discharge in Sungai Jemberau

Duboys (lb/sec)	Schoklitsch (lb/sec)	Flow Rate (ft^3/s)
0.0132	0.9090	2.0836
0.4350	1.9835	3.2489
1.0435	5.5723	12.3248

IV. SUMMARY

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.

V. ACKNOWLEDGMENT

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.

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