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Study on characteristics of sediment and bed load discharge in Sungai Jemberau at Tasik Chini

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Abstract. This study had been carried out to identify sediment characteristics in Sungai Jemberau at Tasik Chini, and to compare their bed load dischargedata between the measured and predicted methods. It was observed that extensive uncontrolled mining activities nearby Sungai Jemberau had led to erosion and hence increasing bedload discharge. This situation hadbecome worst during storm or rainfall events because of increased sedimentation process.The river depth hadbecome shallow as the river bed was filled with bedload settles on the riverbed. Due to this situation, flooding becomes more severe as the river overflows. From here, the bedload discharge can be estimated using the DuBoys and Schoklitsch equation. Sediment size was classified using the Udden Wentworth Scale. Mostly, the median grain size (d_{50}) wasin a range of 2.0mm to 4.0mm, and was classified as Very Fine Gravel (VFG). Meanwhile, the density of sediment was in a range of 2.34g/cm^3 to 2.97g/cm^3. Lastly, the comparison between the measured and predicted bedload discharge shown that DuBoys equation gives better prediction of bedload discharge in Sungai Jemberau.

1.0 Introduction

Sediment transport is an important element in the field of sedimentary geology, geomorphology, civil engineering and environmental engineering. It is the movement of solid particles, typically due to a combination of gravity acting on the sediments or the movement of the fluid in which the sedimentsare entrained. Knowledge of sediment transport is most often used to determine whether erosion will occur, with the magnitude of this erosion or deposition and the distance over which it will occur [1]. It is well known that water flowing down a slope in channels with erodible beds may scour the loose particles resting on the bed or banks and move them downstream. This process is referred to as 'sediment transport' [2]. Usually, the greater the flow, the more sediment will be conveyed or transported. Total sediment transport in streams or rivers are categorized into bedload which are transported near or along the bed by rolling, bounding and sliding; and suspended load which are carried in suspension through the water column [3]. This study was focused on the bedload discharge of sediment in Sungai Jemberau at Tasik Chini. Since Sungai Jemberau are facing uncontrolled mining activities that lead to occurrence of sedimentation.DuBoys and Schoklitsch equations or functions are used to estimate bedload discharge in an alluvial channel. The results for Duboys indicated that the sedimentation rate is related to the mean size of sediment and cross section of the river. However, using Schoklitsch equation, the results depend on the flow rate or discharge of the river. As the flow rate is higher, the bedload discharge will be greater [4].Furthermore, the process of sediment deposition is dependent on river discharge and speed of river flow. As such, higher discharge and water velocities would result in higher amount of sediments. Time is another factor, whereby the longer the sediment deposition process, the higher is the sediment load [5]. In results over a period of time, the high amount of sediment will settle down and the accumulated sediment will eat up the river bed thus causing the river to overflow its banks, or flooding.

2. Methodology

In this study, the methodology part was divided into in-situ measurement and laboratory analysis [6]. During in-situ measurement, the river characteristics, such as, flow depths, widths and velocities were measured and recorded. Meanwhile, for laboratory analysis, such as, Sieve Analysis to determine particle size distribution of sediment, Particle Density test to determine the density of sedimentswere conducted [7].Velocities in Sungai Jemberau are determined by three levels based on the depth of water. If the depth of water, d is less than 0.5m, the velocities are measured at 0.6d. If d is higher than 1.0m, the measurement is taken at 0.2d, 0.6d and 0.8d. This study had used 0.2d, 0.6d and 0.8d since the depth of flow was mostly more than 1.0m. In-situ portable current meter (Swoffer Model 3000) was used to measure the velocity in Sungai Jemberau. The width of Sungai Jemberau was measured using laser distance or measuring tape. The width of the river was taken from the river bank to the opposite river bank. Laser distance device (Nikon Forestry Pro) was used to measure the width of Sungai Jemberau. The depths of Sungai Jemberauweremeasured using water depth sensor or staffs gauge. Each depth was measured from the water level to river bed. At the same time, the distances from the river bank to where the depth measured, were recorded. Then, the cross section of the point of river could be drawn. In addition, the bedload sediment in Sungai Jemberau was collected using Helley-Smith sampler. This apparatus is a medium-weight sampler containing a polyester sampling bag. The sampler operation is limited to flow velocities of less than 2.5m/s and the sample bag allows the collection of gravel and sand with a diameter greater than 0.25mm. Each bedload sample was taken in a 15-minute period. The nozzle of Helley-Smith was placed in the direction of flow of wateras shown in Figure 1.

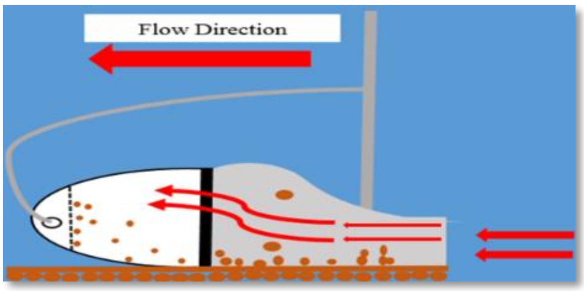

Figure 1. The nozzle of Helley-Smith Samplerplaced in the flow direction in Sungai Jemberau [3]

During the laboratory analysis, the soil sample underwent Sieve Analysis to get the particle size distribution curve. After that, the sediment was classified using the Wentworth Scale [8]. The particle density test was conducted to get the range of density of sediment in Sungai Jemberau, as seen in Figure 2.

Figure 2. The density bottle, filled with distilled water and sample without stopper

3. Result and Discussion

3.1 Characteristics of sediment

The particle size distribution of each samples wereplotted, as in Figure 3. Classification of sediment was determined using Udden-Wentworth Scale based on range of grain diameters of each sediment class. There were detailed classification scheme, such as, boulders, cobbles, pebbles and a coarser classification, such as, gravel, sand, and mud.

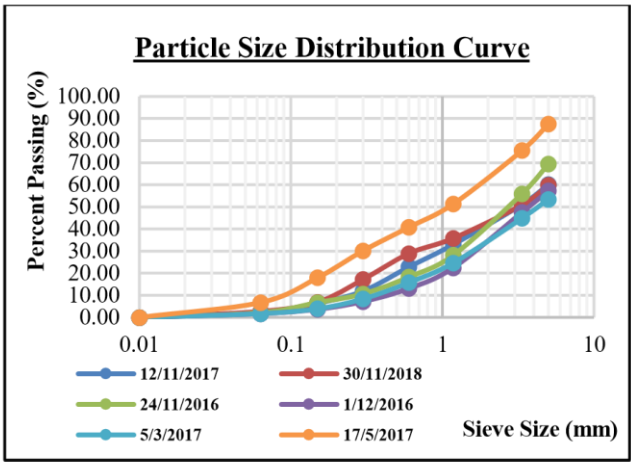

Figure 3. Particle Size Distribution Curve for all samples.

From the graph, the median grain size (d_{50}) was 2.70mm for Sample 1 on 24th September 2016, 3.80mm for Sample 2 on 1st December 2016, 4.30mm for Sample 3 on 5th March 2017, 1.20mm for Sample 4 on 17th May 2017, 3.20mm for Sample 5 on 12th November 2017 and 3.20mm for Sample 6 on 30th January 2018. This indicated the range of median grain size (d_{50}) in Sungai Jemberau was between 1.20mm to 4.30mm, where the sediment was classified as Very Coarse Sand to Very Fine Gravel. The sediment transport function was characterized by the median bed material size or particles size (d_{50}), as listed in the following Table 1.

Table 1. Sediment Classification using Wentworth Scale based on median grain size, d_{50}

Date	d_{50} (mm)	Wentworth Class
24th Sept 2016	2.70	Very Fine Gravel
1st Dec 2016	3.80	Very Fine Gravel
5th March 2017	4.30	Fine Gravel
17th May 2017	1.20	Very Coarse Sand
12th Nov 2017	3.20	Very Fine Gravel
30th Jan 2018	3.20	Very Fine Gravel

3.2 Bedload Discharge

Two bed load equations, namely the DuBoys and Schoklitsch equations were used to determine the prediction bedload discharge in Sungai Jemberau.

a. The DuBoys equation

DuBoys in 1879 introduced the tractive force or bed shear stress which was an entirely new concept. He expressed transport rate in terms of shear stress and the critical shear stress for initiation of sediment motion. DuBoys developed the following formula [9];

$$g_s = \psi \tau_o [\tau_o - \tau_c] \tag{1}$$

b. The Schoklitsch equation

The bed load formula of Schoklitsch was based on discharge relationship and represents essentially the same form as the DuBoys formula. Schoklitsch formula can be expressed as follows [9];

$$g_s = \sum_{i=1}^{n} g_{si} = \sum_{i=1}^{n} i_b \frac{25}{\sqrt{D_{si}}} S^{\frac{3}{2}} (q - q_0) \tag{2}$$

Table 2 shows the results of bedload discharge using DuBoys and Schoklitsch equations. For DuBoys equation, the highest and lowest discharge was 28.5612lb/sec and 0.0132lb/sec respectively. Meanwhile for Schoklitsch equation, the highest and lowest discharge was 6.1796lb/sec and 0.9090lb/sec respectively. The highest and lowest bedload discharge from both DuBoys and Schoklitch represented the same sample, i.e. Sample 6 on 30th January 2018 (Rainy) and Sample 1 on 24th September 2016 (Sunny) respectively.

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

Date	Weather	Duboys (lb/sec)	Schoklitsch (lb/sec)
24th Sept 2016	Sunny	0.0132	0.9090
1st Dec 2016	Sunny	0.4350	1.9835
5th March 2017	Rainy	1.0435	5.5723

17th May 2017	Rainy	0.3243	3.4817
12th Nov 2017	Sunny	0.1220	2.9429
30th Jan 2018	Rainy	28.5612	6.1796

From Table 3, the DuBoys equation gives better prediction of bedload discharge in Sungai Jemberau. This equation was applicable for gravel type sediment and the prediction results were closer to the measured results. The DuBoys equation was based on assumptions that the bed material moves in layers of uniform thickness and the mean velocity of the layers increases linearly towards the bed surface [10]. Thus, the results found had actually over predicted measured data.

Table 3. Comparisons between Measured and Predicted Bedload Discharges in Sungai Jemberau

Date	DuBoys (lb/sec)	Measured Bedload (lb/sec)
24th Sept 2016	0.0132	N/A
1st Dec 2016	0.4350	N/A
5th March 2017	1.0435	1.08×10^{-5}
17th May 2017	0.3243	2.56×10^{-5}
12th Nov 2017	0.1220	7.96×10^{-8}
30th Jan 2018	28.5612	N/A

Table 4 shows the relationship between flow rate and predicted bedload discharge using DuBoys equation and Schoklitsch equation. For Sample 1 on 24th September 2016, bedload discharge was 0.0132lb/sec when the flow rate was 2.0836ft^3/s. Then, for Sample 2 on 1st December 2017, the bedload discharge was 0.4350lb/sec when the flow rate was increase to 3.2489ft^3/s. The flow rate continues to increase to 12.3248ft^3/s and bedload discharge was 1.0435lb/sec for Sample 3 on 5th March 2016. For Sample 4 on 17th May 2017, the flow rate had surged to 68.4045ft^3/s and bedload discharge was 0.3243lb/sec. The flow rate suddenly drops to 11.088ft^3/s and bedload discharge was 0.1220lb/sec for Sample 5 on 12th November 2017. Lastly, for Sample 6 on 30th January 2018, bedload discharge was 28.5612lb/sec and the flow rate had increased to 19.9175ft^3/s.

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
0.3243	3.4817	68.4045
0.1220	2.9429	11.0888
28.5612	6.1796	19.9175

By using Schoklitsch, for Sample 1 on 24th September 2016, the bedload discharge was 0.9090lb/sec when flow rate is 2.0836ft^3/s. Then, for Sample 2 on 1st December 2017, the bedload discharge was 1.9835lb/sec when flow rate increases to 3.2489ft^3/s. The flow rate continues to increase to 12.3248ft^3/s and the bedload discharge was 5.5723lb/sec for Sample 3 on 5th March 2016. For Sample 4 on 17th May 2017, the flow rate make a sharp increase to 68.4045ft^3/s and bedload discharge was 3.4817lb/sec. The flow rate suddenly drops to 11.0881ft^3/s and bedload discharge was 2.9429lb/sec for Sample 5 12th November 2017. Lastly, for Sample 6 on 30th January 2018, the bedload discharge was 6.1796lb/sec when the flow rate increases to 19.9175ft^3/s. Table 5 shows the relationship between average velocity of flow and predicted bedload discharge. The lowest predicted bedload discharge was 0.0132lb/sec and 0.9090lb/sec for DuBoys and Schoklitsch respectively on 24th September 2016. The highest bed load discharge was 28.5612lb/sec and 6.1796lb/sec for DuBoys and Schoklitsch respectively on 30th January 2018. Slower moving rivers havelower rates of sediment movement.

Table 5. Average Velocity of Flow versus Predicted Bedload Discharge in Sungai Jemberau

Duboys (lb/sec)	Schoklitsch (lb/sec)	Flow Velocity (ft/s)
0.0132	0.9090	0.14862
0.4350	1.9835	0.23852
1.0435	5.5723	0.68077
0.3243	3.4817	0.52165
0.1220	2.9429	0.36147
28.5612	6.1796	0.53806

4. Conclusions

Based on the median grain size, mostly the sediments were classified as gravel type, which was suitable to employ theDuBoys and Schoklitsch equations for prediction of bedloads in Sungai Jemberau. Higher flow discharge or flow rate would increase bed load discharges in Sungai Jemberau. The data on sediment sizewas important as it would determine the type of material that wassubmerged at the bottom of the river. The DuBoys equation was found to be the better option to predictbedload discharge in Sungai Jemberauin comparison to the Schoklitsch equation, as indicated by the prediction resultswhich were closer to the measured results. This is because the equation was more suitable for gravel type sediments found in Sungai Jemberau.

References

[1] Iwuoha PO, Adiela PU, Nwannah C C and Okeke O C 2016 Sediment Source and Transport in River Channels: Implications for River Structures *The International Journal of Engineering and Science (IJES),* pp. 19-26
[2] Habibi M 1994 Sediment Transport Estimation Methods In River Systems. *Universities of Wollongong Thesis Collection,* pp. 27-66
[3] Bidorna B, Kisha SA, Donoghueb JS, Bidornb K and Mamad R 2016 Sediment Transport Characteristics Of The Ping River Basin, Thailand. *Procedia Engineering 154,* pp. 557-564
[4] Ghani N Adilah AA, Othman N and Baharuddin MKH 2013 Study on Characteristics of

Sediment and Sedimentation Rate at Sungai Lembing, Kuantan, Pahang. *Procedia Engineering*, pp. 81-92

[5] Prim FAM and Ghani N Adilah AA 2013 Preliminary Study On Sediment Load At Sungai Galing, Kuantan, Pahang *Malaysia Technical Universities Conference on Engineering & Technology (MUCET)*

[6] Md. Ali Z, Tjahjanto D, Rahmat N, Masirin MMI, , Musa S and Manan IS 2008 A Study Od Sediment Load: Case Study At Parit Botak Channel, Batu Pahat, Johor, Malaysia. *International Coference on Enviroment 2008 (ICENV 2008),* pp. 1-8

[7] Mohd Nor N, Mat Peah K. and Hamzah M Z, n.d.*Civil Engineering Laboratory Manual (3rd Edition).* s.l.: Faculy of Civil Engineering & Earth Resources, Universiti Malaysia Pahang.

[8] Wentworth C K, 1922 A Scale of Grade and Class Terms for Clastic Sediments. *The Journal of Geology, Vol 30, No. 5,* pp. 337-392

[9] Mays LW, 2010 *Water Resources Engineering Second (2nd) Edition: Chapter 18 Sedimentation and Erosion Hydraulics.* s.l.: John Willey and Sons Inc.

[10] Ghani N Adilah AA, Namin NS, Kamal NA and Ariffin J 2017 Study on Characteristic of Bed Material and Bed Load Discharge in Sungai Jemberau, Tasik Chini due to Mining and Logging Activities *4th International Conference On Southeast Asian Natural Resources And Environmental Management 2017 (SANREM 2017)*

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