Measurement of Bed Load Transport for Selected Small Streams in Malaysia

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ABSTRACT
This paper describes a bed load measuring technique and the results of bed load transport rate measurement obtained from May 2000 until October 2002 at Kinta River Catchment. Helley-Smith bed load sampler was used to sample bed load during the study period. The study sites consist of four rivers which are situated at Kinta River Catchment, namely Kinta River, Pari River, Raia River and Kampar River. Comparisons of bed load transport rate between seven-point measurement and three-point measurement methods also have been carried out. The objective of this paper is to show the probability of sampling bed load by using three-point measurement method.

Keywords: Bed load, sediment transport, small stream.

1 Introduction

Bed load transport occurs when sediment particles along alluvial river starting move, either is rolling, sliding or sometimes jumping along the river beds when the flow condition exceed the criteria for incipient motion.

In the past, attempts have been made to determine the bed load discharge in three general ways (Hubbell, 1964):

i) Direct measurement by some type of apparatus.
ii) Definition of physical relations from which the bed load could be estimated, and
iii) Quantitative measurement of the results of some sedimentation process.

However, there is no single apparatus and procedure whether theoretical or empirical that has been accepted for the determination of bed load discharge. Bed load transport measurements are widely discussed by Hubbell (1964), Emmett (1980), Hubbell et al. (1985), Carey (1985) and Yuqian (1989).

Currently, the most commonly used bed load sampler is the Helley-Smith Sampler since the model was introduced early 1971. The Helley-Smith sampler was

developed for use in stream where sediment ranged in size from course to medium gravel.

This paper describes the bed load measurement adopted at six study sites located at Kinta River Catchment by using Helley-Smith sampler. The calculations of bed load transport rate are also discussed in this paper.

2 Study Sites

The study sites consist of four rivers, namely Kinta River, Pari River, Raia River and Kampar River, which are situated in Kinta River Catchment as depicted in Figure 1 (DID, 2003).

Six study sites were chosen based on the following criteria:

(a) Natural reach (undeveloped upper or middle reach), which are less than 30% catchment development – Kampar River @ KM 34 (Figure 2a).

(b) Natural reach (Developed middle reach), which are more than 30% development – Raia River @ Kampung Tanjung (Figure 2b) and Batu Gajah (Figure 2c).

(c) Modified reach (Developed middle reach), which are more than 30% development – Kinta River (Figure 2d), Pari River @ Manjoi (Figure 2e) and Buntong (Figure 2f).

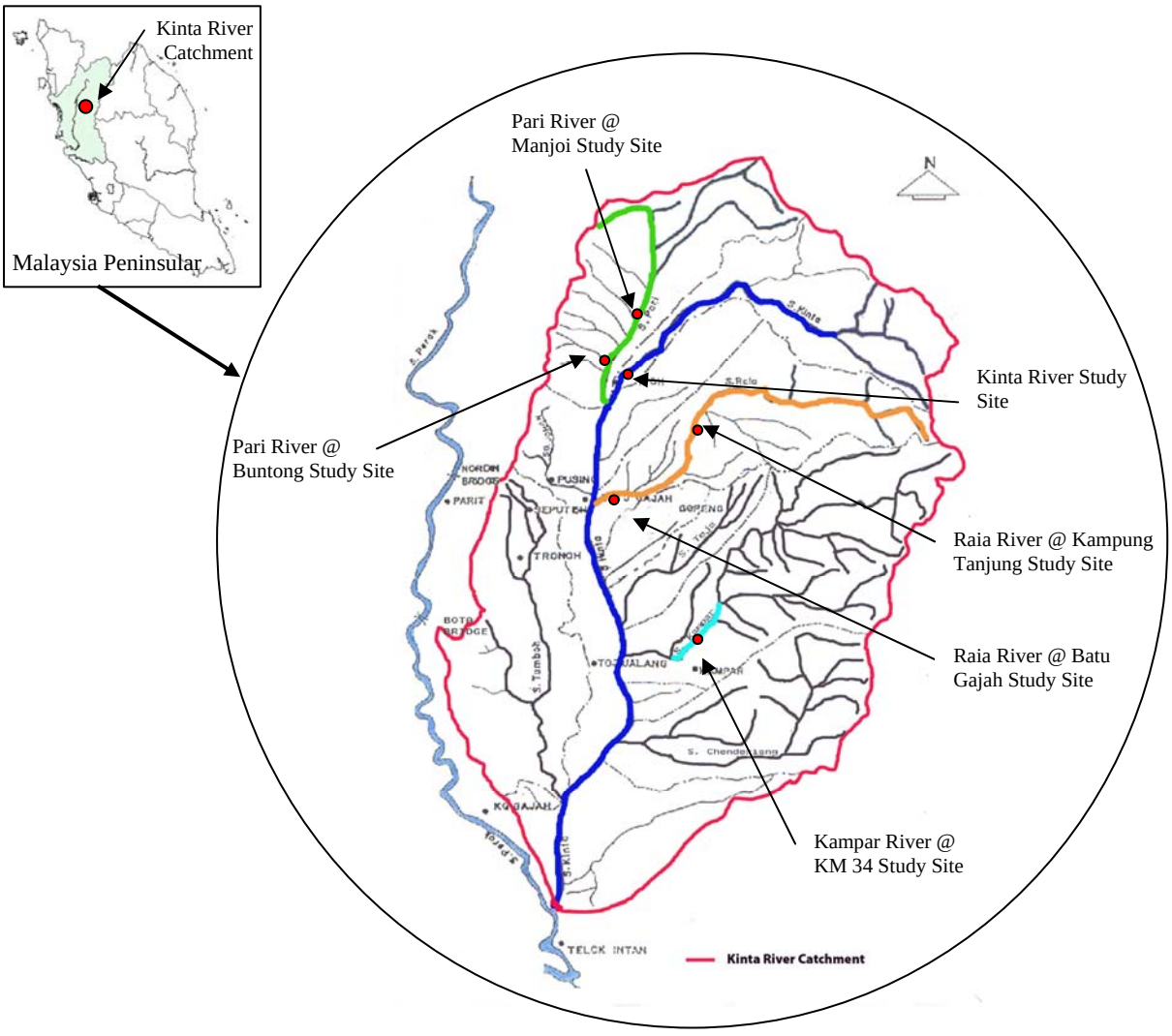


Figure 1 Kinta River Catchment.

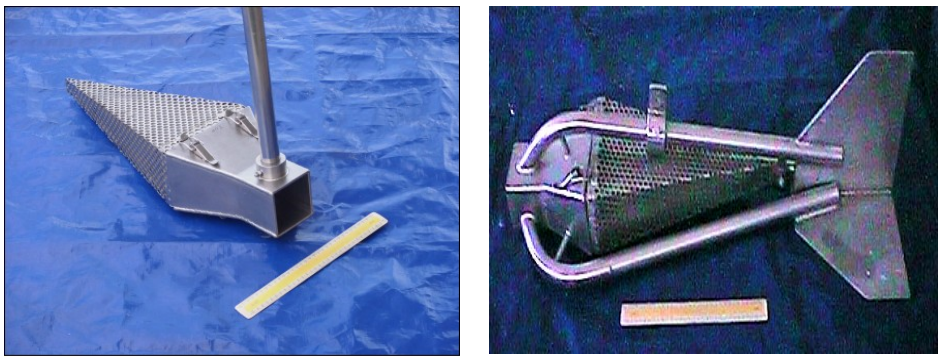
(a) Kampar River @ KM 34 (b) Raia River @ Kampung Tanjung (c) Raia River @ Batu Gajah

(d) Kinta River (e) Pari River @ Manjoi (f) Pari River @ Buntong

Figure 2 Study Sites.

3 Instrumentation

Field measurements were taking along the selected cross section at the six study sites at Kinta River Catchment during May 2000 to October 2002. Sediment transport in the layer 0 to 76 mm above river bed was measured with a Helley-Smith Sampler (Figure 3), which collects bed load samples in a collecting bag of 460 mm long and size mesh of 2.5 mm. The bed load sample that was trapped in the collecting bag was emptied into labeled plastic bag.



(a) Low Flow (b) High Flow

Figure 3 Helley-Smith Sampler.

The Helley-Smith Sampler was placed on the river bed facing upstream end during the measurement of bed load. At each cross section, 10 minutes bed load samples measurements were taken at each measuring points. There are seven evenly spaced measuring points in the cross section from left bank to right bank as defined at Figure 4. The spacing between measuring points differs for one cross section to the other and depends on the river width.

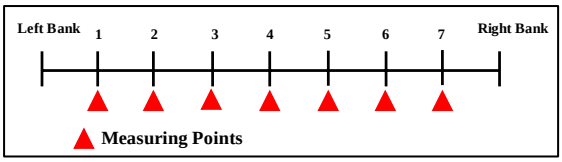


Figure 4 Bed Load Transport Measuring Points (Seven-Point Measurement Method).

4 Computation of Bed Load Measurements

Typically, bed load transport rates vary from zero or small near banks through larger values toward midstream.

The sectional bed load transport rate (g_b, in kg/s) (Figure 5) may be computed by equation:

$$g_b = \frac{\overline{w_i}}{(T \times h_s)} \times b \qquad (1)$$

Where, $\overline{w_i}$ is mean weight bed load sample of the vertical for n section, in kilograms, T is time the sampler on the bed, in seconds, h_s is width of sampler nozzle, in meter and b is section width of the stream, in meter.

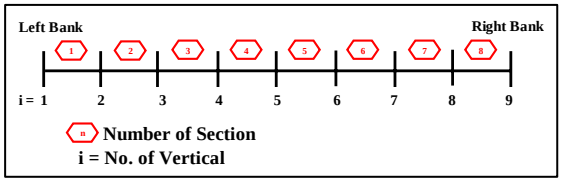


Figure 5 Computed Sectional Bed Load Transport Rate with Seven-Point Measurement Method.

Thus, the bed load transport rate (Q_b) for the complete cross section then is computed by the following equation:

$$Q_b = \sum_{n=1}^{8} g_b \qquad (2)$$

5 Results

Computed bed load transport rate for the 6 study sites were analysed against discharge. Table 1 shows the summary of the data collection at the six study sites and the results of bed load transport rate against discharge are shown in Figure 6.

Table 1 Range of Field Data for Kinta River Catchment.

Study Sites	No. of Sample	Discharge, Q (m^3/s)	Width, B (m)	D_{50} (mm)	Q_b (kg/s)	
					7-Point Method	3-Point Method
Kampar River @ KM 34	21	7.98 - 17.94	20.2 - 21.1	0.85 - 1.10	0.40 - 1.25	0.03 - 1.15
Raia River @ Kampung Tanjung	20	3.60 - 8.46	22.2 - 25.6	0.60 -1.60	0.20 - 1.82	0.16 -2.35
Raia River @ Batu Gajah	21	4.44 - 17.44	17.3 - 20.8	0.50 - 0.85	0.25 - 1.37	0.11 - 1.24
Kinta River	20	3.80 - 9.65	24.6 - 28.0	0.40 - 1.00	0.02 - 1.21	0.01 – 0.81
Pari River @ Manjoi	20	9.72 - 47.90	20.3	1.70 - 3.00	0.40 - 0.80	0.31 – 1.10
Pari River @ Buntong	20	9.66 - 17.04	19.3 - 19.5	0.85 -1.20	0.35 - 0.79	0.25 - 0.99

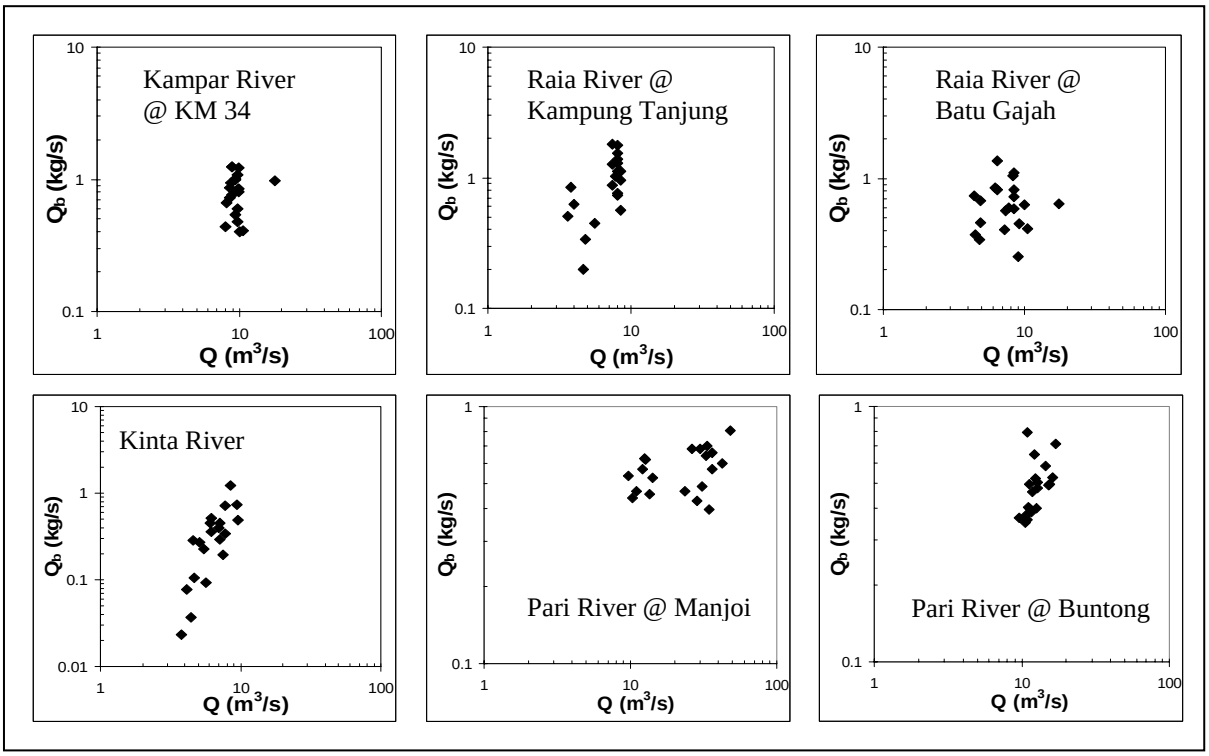


Figure 6 Bed Load Rating Curves.

6 Alternative Method of Computed Bed Load Measurement

The additional calculation of bed load transport rate by using three-point measurement method (4 sectional) also had been done to estimate the bed load transport rate and compare the results between the two method. In this condition, the bed load sampling points only done for points 2, 4 and 6, which shown in Figure 4. Figure 7 shows the computed sectional bed load transport rate for three sampling points.

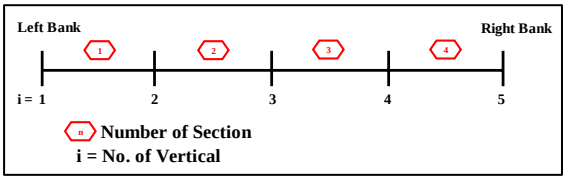


Figure 7 Computed Sectional Bed Load Transport Rate with Three-Point Measurement Method.

Figure 8 shows the results of comparison of bed load transport rate between seven-point (8 sectional) measurement method and three-point (4 sectional) measurement method.

7 Conclusions

Heley-Smith Sampler has been opted the best intrument to sampling bed load in a small stream. The results of comparison for bed load trasport rate calculation between seven-point measurement method and three-point measurement method also shows that there is not much difference. The results may suggest that bed load measurement in a small stream can be carried out using the three-sampling point. Moreover, three-point measurement method also save time, man power and cycle time in order to sampling bed load.

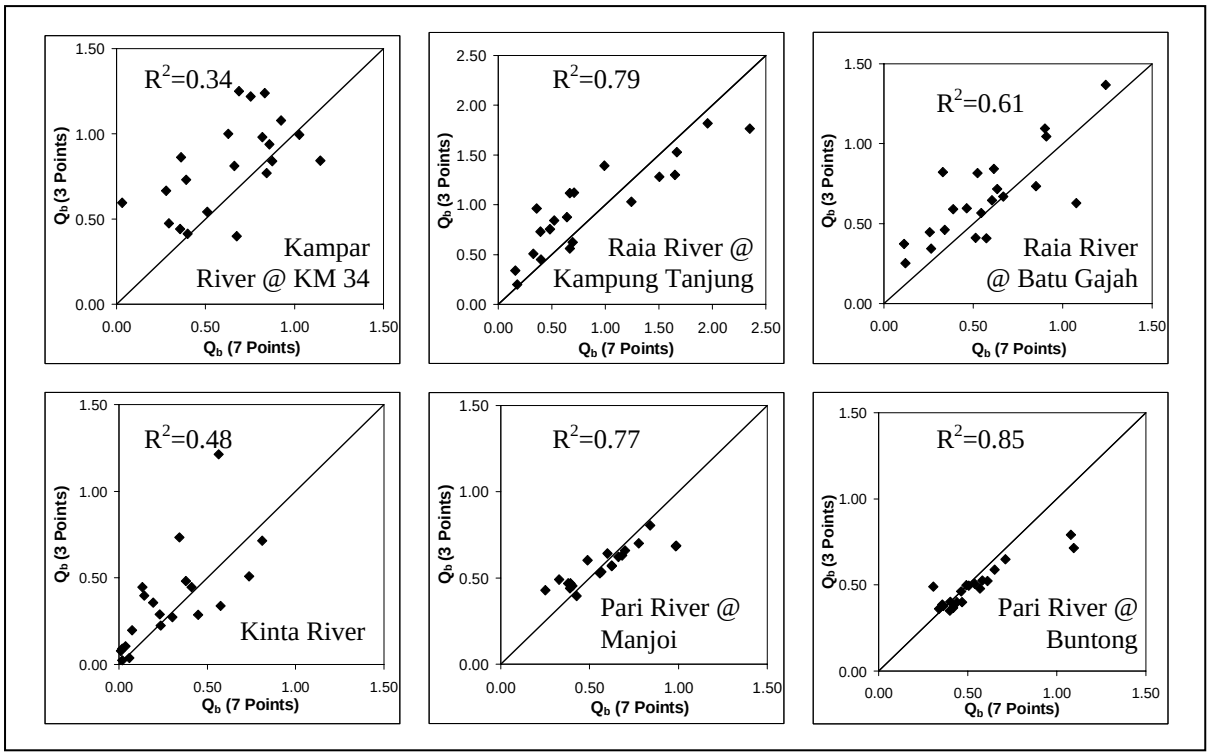


Figure 8 Comparison of Computed Bed Load Transport Rate Between Seven-Point Measurement Method and Three-Point Measurement Method.

Acknowledgments

The research study is funded by Department of Irrigation and Drainage Malaysia (JPS (PP)/SG/2/2000). The authors gratefully acknowledge Prof. Pierre Y. Julien from Colorado State University, USA for his consultation. They are also grateful to Mr. Mohamad Fauzi Ahmad Shah, Mr. Paker Mohamad for their involvement in this project.

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