Sediment Transport Equation Assessment for Selected Rivers in Malaysia

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ABSTRACT

This paper describes a total of 122 sediment data obtained from May 2000 until October 2002 at Kinta River Catchment in the river sediment collection and analysis project. Data collection including suspended load, bed load, bed material and flow discharge have been carried out at six study sites consists of four rivers which are situated at Kinta River Catchment, namely Kinta River, Pari River, Raia River and Kampar River. The sediment transport equation assessments have been carried out using Yang, Engelund & Hansen, Ackers & White and Graf equations. The results of Yahaya (1999) and Ariffin (2002) studies for Kerayong River, Kulim River and Langat River catchment (224 sets of data) also included in this present study.

Keywords: Sediment transport, alluvial river, flood mitigation, erosion, deposition.

1 Introduction

An alluvial river frequently adjusts its cross-section, longitudinal profile, course of flow and pattern through the processes of sediment transport, scour and deposition. In order to sustain cultural and economic developments along an alluvial river, it is essential to understand the principles of sediment transport for application to the solution of engineering and environmental problems associated with natural events and human activities.

The objectives of the study include the following:

(a) Establishment of a sediment transport database for alluvial rivers within a range of low and high flows for a different landuse and development.
(b) Establishment of relationship between flows and sediment loads for the assessment of the stability of river channel due to erosion and deposition for different type of catchment developments
(c) Establishment of relationship between flows and sediment loads for design and evaluation of new and existing flood mitigation projects.

2 Project Site

This study includes collection and analyses of all sediment data related to sediment transport for various alluvial rivers (Ibrahim 2002, Darus 2002, Abdul Ghaffar 2003, DID 2003). The study sites consist of four rivers, namely Kinta River, Raia River, Pari River and Kampar River, which are situated in Kinta River Catchment as depicted in Figure 1.

Six study sites for this study were chosen based on the following criteria:

(a) Natural reach: undeveloped upper or middle reach (less than 30% catchment development) – Kampar River @ KM 34 (Figure 2a).
(b) Natural reach: Developed middle reach (more than 30% development) – Raia River @ Kampung Tanjung (Figure 2b) and Batu Gajah (Figure 2c).
(c) Modified reach: Developed middle reach (more than 30% development) – Kinta River (Figure 2d), Pari River @ Buntong (Figure 2e) and Manjoi (Figure 2f).

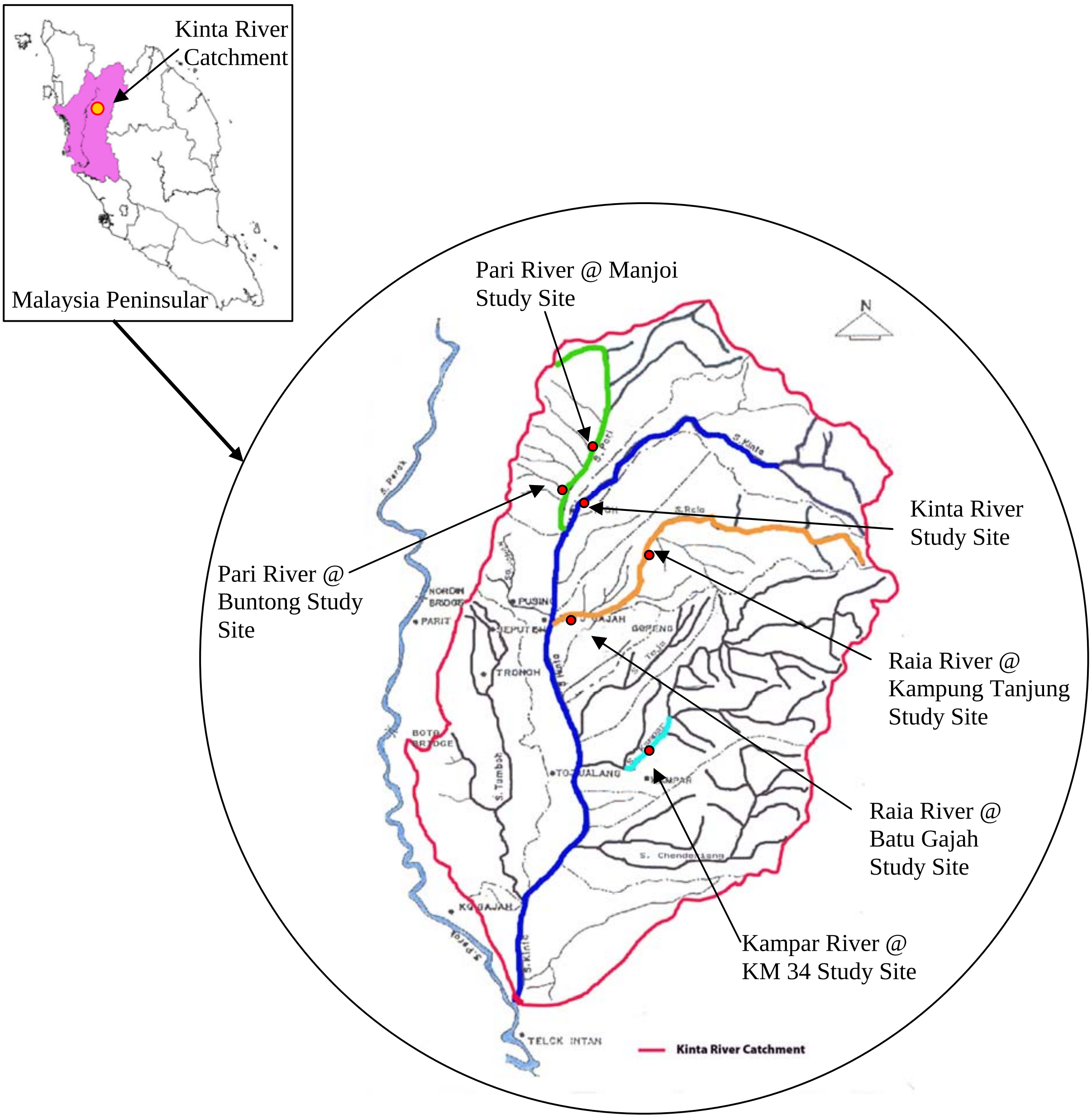


Figure 1 Kinta River Catchment.

(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 Data Collection Program

Field measurements were obtained along the selected cross section at the six study sites at Kinta River Catchment by referring Hydrological Procedure (DID 1976, DID 1979) and recent manuals (Yuqian 1989, USACE 1995, Edwards & Glysson 1999, Lagasse et al. 2001, Richardson et al. 2001). The data collection including flow discharge, suspended load and bed load during May 2000 to October 2002.

3.1 Flow Discharge

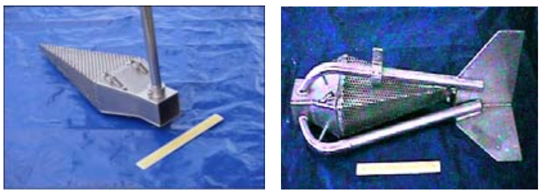
A range of flow discharge measurement covering low and high regime is carried out by using current meter (Figure 3). The procedure of flow discharge measurement is based on Hydrology Procedure No. 15: River Discharge Measurement by Current Meter (DID, 1976).

Swoffer 2100 Model Neyrflux Type 80

Figure 3 Current Meter.

3.2 Bed Load

10-minutes duration bed load sample had been measured by using Helley-Smith sampler (Figure 4) at seven measuring points for each cross section.

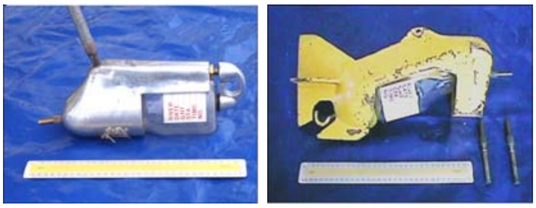


(a) Low Flow (b) High Flow

Figure 4 Helley-Smith Sampler.

3.3 Suspended Load

Suspended load samples have been collected at each study site using DH 48 and DH 59 sampler (Figure 5) with depth integrating technique (DID, 1977). There is three measuring points in suspended load measurement.



(a) Low Flow (b) High Flow

Figure 5 Suspended Load Sampler.

3.4 Total Load

Total load transport rate is estimated by summing bed load and suspended load transport rate. Table 1 shows the summary of the data collection and the total load transport rate against discharge are shown in Figure 6.

4 Sediment Transport Equation Assessment

The analysis for a total of 122 set of data have been obtained for four sediment transport equation including Yang, Engelund & Hansen, Ackers & White and Graf equations. The analysis also included 224 sets of data from Yahaya (1999) and Ariffin (2004) studies for Kerayong River, Kulim River and Langat River catchment (Table 2). Table 3 shows the summary of the sediment transport assessment. The result shows that Yang and Engelund & Hansen equations gives better prediction of measured data. The assessment was based on average size of sediment (d_{50}). It is expected that using fraction size of sediment will give better estimation of measured data.

Figure 7 below shows that the relationship between transport parameter (Φ) and flow parameter (Ψ) for the total 346 data. Comparison with Graf equation shows that the Malaysian sediment transport data consisting of mainly coarse sand (Kerayong River and Kulim River) agrees well with the equation. However, for fine sand, the modified Graf equation seems to suit better.

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)	Bed Load Transport Q_b (kg/s)	Suspended Load Transport Q_t (kg/s)	Total Load Transport Q_j (kg/s)
Kampar River @ KM 34	21	7.98 - 17.94	20.2 - 21.1	0.85 - 1.10	0.40 - 1.25	0.10 - 1.49	0.57 - 2.47
Raia River @ Kampung Tanjung	20	3.60 - 8.46	22.2 - 25.6	0.60 -1.60	0.20 - 1.82	0.07 - 1.39	0.65 - 2.11
Raia River @ Batu Gajah	21	4.44 - 17.44	17.3 - 20.8	0.50 - 0.85	0.25 - 1.37	0.09 - 2.04	0.47 - 2.69
Kinta River	20	3.80 - 9.65	24.6 - 28.0	0.40 - 1.00	0.02 - 1.21	0.21 - 12.31	0.23 - 12.82
Pari River @ Manjoi	20	9.72 - 47.90	20.3	1.70 - 3.00	0.40 - 0.80	0.79 - 16.81	1.25 - 17.62
Pari River @ Buntong	20	9.66 - 17.04	19.3 - 19.5	0.85 -1.20	0.35 - 0.79	0.67 - 4.41	1.03 - 4.89

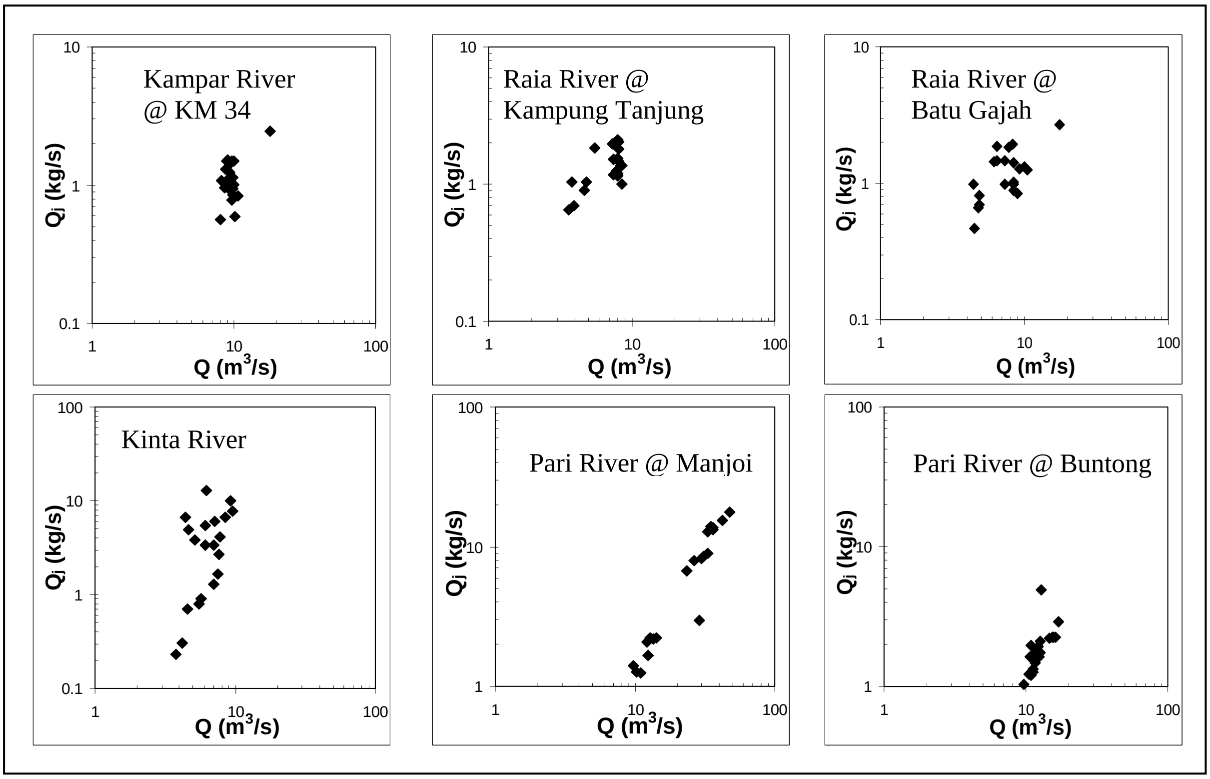


Figure 6 Total Load Transport Rating Curves.

Table 2 Range of Field Data for Yahaya (1999) and Ariffin (2004).

Study Sites	No. of Sample	Discharge, Q (m^3/s)	Width, B (m)	D_{50} (mm)	Bed Load Transport Q_b (kg/s)	Suspended Load Transport Q_t (kg/s)	Total Load Transport Q_j (kg/s)
Kerayong River	27	0.85 - 6.08	18.0	2.00 - 3.10	0.31 - 0.75	0.12 - 15.04	0.47 - 15.78
Kulim River	16	1.39 - 11.14	14.0 - 18.0	3.00 - 4.00	0.07 - 0.34	0.26 - 6.78	0.34 - 7.08
Pari River @ Taman Merdeka	16	5.28 - 24.35	18.0	2.00 - 3.10	0.31 - 0.75	0.12 - 15.04	0.47 - 15.78
Langat River @ Kajang	20	3.75 - 39.56	15.0 - 20.0	0.37 - 2.13	0.02 - 1.29	0.65 - 77.51	0.78 - 77.86
Langat River @ Dengkil	3	33.49 - 87.79	30.0 - 33.0	0.52 - 0.95	0.27 - 0.65	18.69 - 118.30	18.96 - 118.95
Lui River @ Kg Lui	92	0.74 - 17.17	15.0 - 17.0	0.50 - 1.74	0.04 - 1.55	0.05 - 5.77	0.27 - 6.16
Semenyih River @ Kg Sg Rinching	50	2.60 - 8.04	13.5 - 15.0	0.88 - 2.29	0.65 - 3.16	0.24 - 10.77	1.08 - 12.08

Table 3 Summary of Sediment Transport Assessment.

Equation	Discrepancy Ratio (0.5 – 2.0)					
	Present Study		Yahaya (1999) and Ariffin (2004) studies		All Data	
	No. of data	Percentage	No. of data	Percentage	No. of data	Percentage
Yang	**22**	**18.03**	**60**	**26.79**	**82**	**23.70**
Engelund & Hansen	**30**	**24.59**	**46**	**20.54**	**76**	**21.97**
Ackers & White	7	5.74	37	16.51	44	12.72
Graf	10	8.20	36	16.07	46	13.41
Total	**122**	**100**	**224**	**100**	**346**	**100**

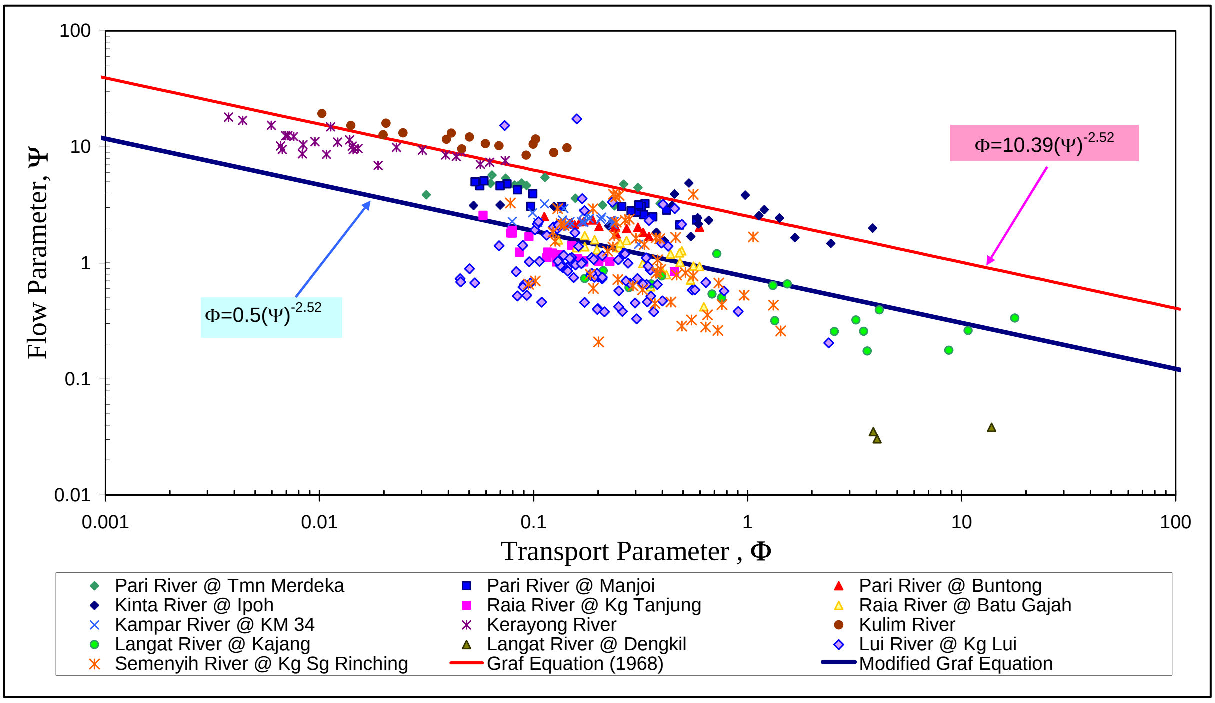


Figure 7 Relationship Between Transport Parameter (Φ) and Flow Parameter (Ψ).

5 Conclusions

Sediment transport is important (Simons & Simons, 1987) for sand-bed river because it will contribute 20 percent of total load. From the results of sediment transport assessment for total load (346 sets of data), it can be concluded that Yang and Engelund & Hansen equations can be used to predict sediment transport rate for sand-bed rivers in Malaysia.

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