

NOTA PENYELIDIKAN/RESEARCH NOTES

VARIATION OF SEDIMENT YIELD OF TROPICAL BASIN: A CASE OF MUDA BASIN, KEDAH, MALAYSIA.

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The data used in this study is based on the sediment output recorded at the hydrological stations at Jambatan Syed Omar and Jeniang in the state of Kedah from 1979-89. The study covers rainfall and other hydrological characteristics related to the sediment discharges of the Muda River and its tributaries. Sediment yield calculation was carried out using the suspended sediment discharge records. However, factors such as land use changes that have a major role in controlling the erosion and sedimentation in the basin are not considered in this paper.

Data yang digunakan dalam kajian ini adalah berdasarkan kepada output endapan yang direkod di stesen hidrologi Jambatan Syed Omar dan Jeniang, Kedah dari tahun 1979-1989. Kajian ini meliputi hujan dan lain-lain ciri-ciri hidrologi yang berkaitan dengan endapan Sungai Muda dan cawangan-cawangannya. Pengiraan hasilan endapan telah dijalankan dengan menggunakan rekod luahan endapan ampaian. Walau bagaimanapun, faktor-faktor lain seperti perubahan gunatanah yang mungkin memainkan peranan penting mengawal hakisan dan pemendapan di dalam lembangan tadahan ini tidak dipertimbangkan di dalam kajian ini.

INTRODUCTION

Globally, soil erosion is one of the main environmental issues of our time. Increases in population, urbanisation, industrial development and other changes in human activities have caused land use changes resulting in erosion problems. The erosion in uplands areas will be manifested in the downstream increase in sediment loads. The increase in sediment loads may in turn cause further problems including reservoir sedimentation and impairment of irrigation and water supply schemes. Presently, sediment studies has attracted global attention. Many papers concerning the impacts of human activities on hydrological behaviour such as surface runoff, sediment discharges and water qualities of catchment areas have been published. In a developing country like Malaysia, urbanisation and industrial development are almost inevitable and sediment studies have been conducted and reported (Abdul Rahim, 1988, 1989; Salleh, Abdul Rahim and Mushrifah, 1983; Abdul Rahim and Zulkifli, 1986; Lai and Rentap, 1986; Baharudin, 1988; Goh, 1983; Greer *et. al.*, 1989; Wan Ruslan Ismail, 1991).

In tropical countries like Malaysia human efforts in disturbing the environment, coupled with intense rainfall, will accelerate the process of surface erosion. As the rate of surface runoff intensifies the resulting sediment loads will increase and thus increase the sediment yield. The intensities of rainfall which vary from time to time are bound to be reflected in the pattern of sediment discharges.

This paper describes the pattern of distribution of sediment discharge with respect to seasonal changes according to rainfall distribution. The climate variability of the area will be discussed first.

SITE DESCRIPTIONS

The Muda River Basin

1. Drainage

The Muda river basin stretches across the state of Kedah into the state of Pulau Pinang. Among all the river basins in the region, it has the largest catchment area of 4300km² including the Tembus river basin. The main stream originates in the northern mountain area of the state of Kedah and flows down towards the west coast below the confluence of the Muda river and the Ketil river. In the northern mountain area mentioned above there is the Muda Dam which stores water which is conveyed to the Pedu Dam.

In addition to the principal tributary of the Ketil river there are tributaries of the Chepir and the Sedim rivers as shown in Fig.1. The Ketil river has the largest subcatchment area in the basin (884km² including the catchment area of the secondary tributary of the Kupang river)(J.I.C.A, 1984).

2. General Geology

The Muda river basin is located in the southern and southeastern part of Kedah State. The basin is bordered in the north and in the east by ridges of the Main Range with the height ranges from elevation 500m to more than 1000m. The southern watershed is a warped ridge, descending from Elevation 1,000m in its eastern end to the coastal alluvial plain. In the west a ridge with 200m to 600m of ground height divides the Muda basin from the Kedah river basin, and its southwestern extension is a chain of low hills which divides the small Merbok river basin and the Muda river basin (J.I.C.A., 1984).

The Muda river basin is largely occupied by intrusive granites of Mesozoic era, which compose the mountainous area in the eastern part of the basin and stretch

Figure 1: The Muda River Basin in the state of Kedah.

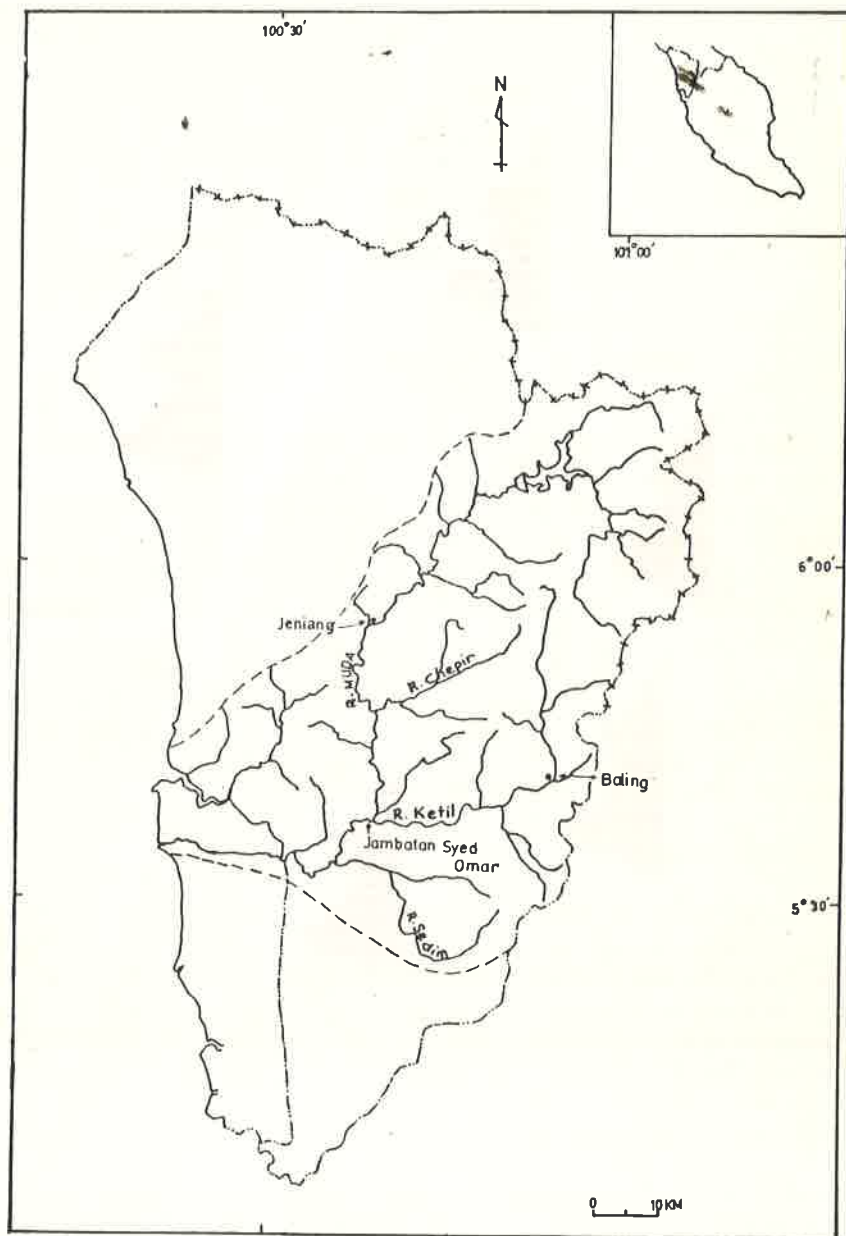


Fig. 2 : Rainfall Characteristics of the basin.

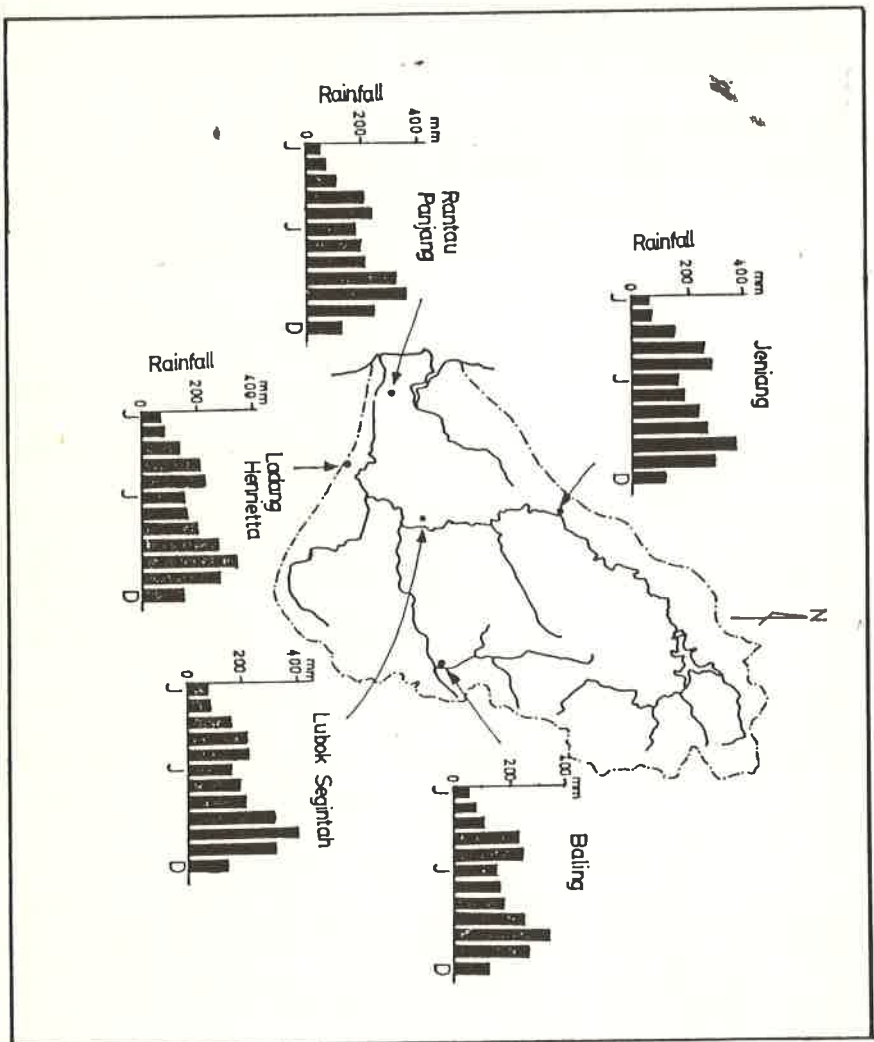
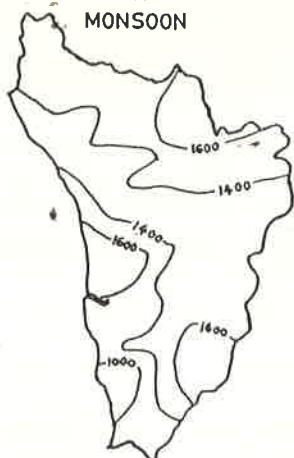


Figure 3: Rainfall analysis.

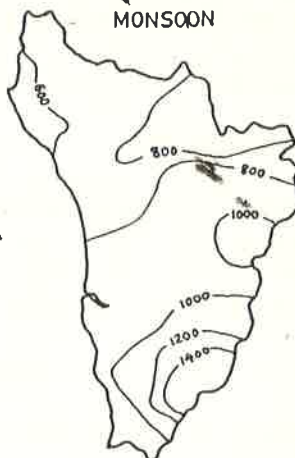
SOUTHWEST
MONSOON

NORTHEAST
MONSOON

Mean Rainfall



A



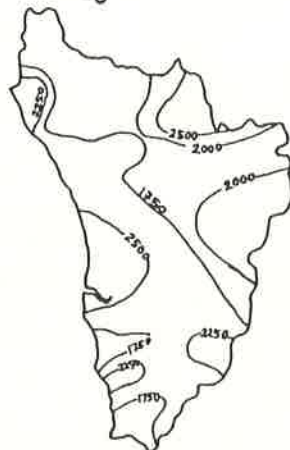
Coefficient of
Variation



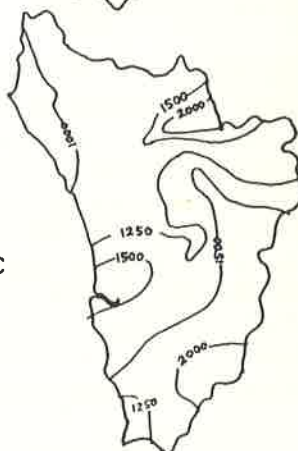
B



Probability



C



west to the middle reach of the Muda river and up to mount Perak (El. 865 m). Quarternary plain with approximately 20 km of width is developed in the coastal zone near the river mouth, 20 km north of Butterworth (J.I.C.A, 1984).

3. Present Land Use

The 20 km coastal plain of the Muda river is mostly used for paddy cultivation. Undulating land in the middle of the basin is largely developed for rubber plantation. Some horticultural land and paddy field exist in the riverine areas, especially along the Kupang river.

4. Soil

In the Perlis, Kedah and Pulau Pinang region, the soil extending over hilly and rolling lands are derived mainly from the weathering of primary rocks such as granite, feldspar and mica, and sedimentary and metamorphic rocks such as sandstones, shale and limestones.

The soil on terraces along steep and narrow valleys and of undulating plains are rather coarsely textured and well drained. Coupled with the seasonal fluctuation in river flow these soils are not well suited for intensive agricultural use, especially for irrigated rice cultivation.

In the northern part of the west coast, the riverine plain soils are of river alluvium with heavy silty clayey texture and poorly drained. These soils are frequently overlaying marine alluvium in areas closer to the coast and have slightly better nutrient holding capacity than the hilly terrace soils (J.I.C.A, 1984:3).

5. General Climatology

The Muda river basin (Fig.1), unlike any other places in West Malaysia, being located in the north, experience a rather different monsoonal effect compared with the east coast and other west coast region. This is due to the 'sheltering effect' of the central mountain ranges running from north to south in Peninsular Malaysia and the Sumatera Island. The climate of the basin is of maritime nature and its exposure to the monsoonal effect, even though being sheltered, has given rise to an equatorial climate characterised by high and uniform temperature, high humidity and abundant rainfall. Temperature variation throughout the year is absent where annual variation is not more than 2.2°C (Chan,1987). Rainfalls are high (ca 81 per cent) occurring during the wet month (April to Nov). The dry months are from December to March.

MATERIALS AND METHODS

1. Rainfall

The rainfall data used in this study are selected from 55 stations all over the State of Kedah, Perlis and Pulau Pinang for the period 1971 to 1985. The rainfall records were used to calculate the mean, standard deviation, coefficient of variation and probability of rainfall.

2. Streamflow and Sediment Discharge

Streamflow records used in this study were obtained from the Hydrological Data: Streamflow and River Suspended Sediment Records 1975-80 (D.I.D, 1985) and 1980-85 (D.I.D, 1988). In addition to these, the latest information on discharge were computed from stage records at Jambatan Syed Omar (3330km²) and Jeniang (1710km²), obtained from the Drainage and Irrigation Department (D.I.D) Kedah (Personel Comm.). Discharge rating curve and sediment rating curve were used to calculate the streamflow and sediment discharge from stage records. The sediment rating curve equation relating the sediment discharge and river discharge used in this study is $Q_s = 0.06Q^{2.0547}$ where Q_s is sediment discharge in tonnes per day and Q is the discharge in cubic meter per second (cumecs).

RESULTS AND DISCUSSION

1. Rainfall

Generally the mean annual rainfall over the basin varies between 2000mm in the north east to about 3400mm in the south west. Annual input for the entire basin ranges from 2250mm to 3420mm.

The rainfall characteristics of the basin are as shown in Fig. 2. It can be seen that the rainfall has two peaked distributions, one in April and May and another in October and November. The minimum rainfall occur in January. These two peaks of rainfall are reflected in the discharge of the basin (Fig. 4). Mean seasonal rainfall distribution is as shown in Fig. 3(a). The means for Northeast (N.E.) monsoon (range 600 - 1600mm) are lower than the Southwest (S.W.) monsoon period (range 800 - 2000mm). Mean range for the basin is 1400 - 1600mm for S.W., and only 800 - 1000mm for N.E. monsoon.

Table 3: Areas of bank erosion along Muda River

Ekor Kuching.
Kampung Sementul and Kg. Seberang Tok Soh.
Pinang Tunggal.
Permatang Langsat, Lahar Tlang
and Kg. Matang Kedondong.
Tanjung Putus and Kg. Jawa.
Lubok Pusing.
Kg. Permatang Kapas.
Tanjung Rambai and Bumbong Lima.
Guar Kepar.
Kg. Kota Aur, Kg. Sireh and Kg. Sentul.
Permatang Bendahari and Pekan Kota.
Pulau Mertajam.

■ Source: D.I.D, Kedah (1987).

Mean River Discharge Jambatan Syed Omar

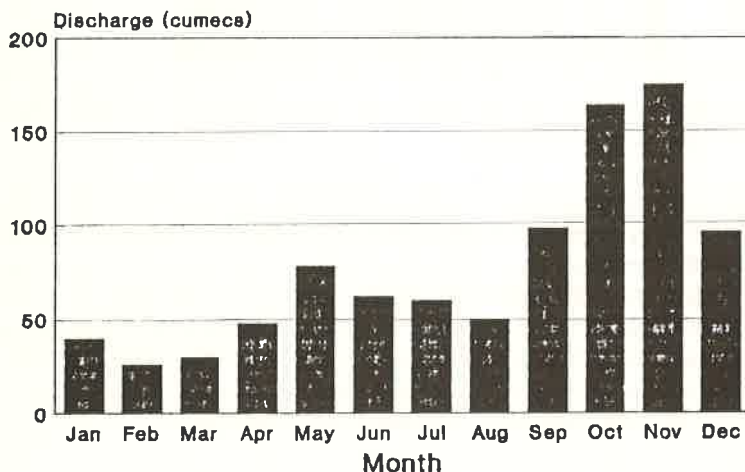


Figure 4: Mean river discharge at Jambatan Syed Omar.

JAMBATAN SYED OMAR

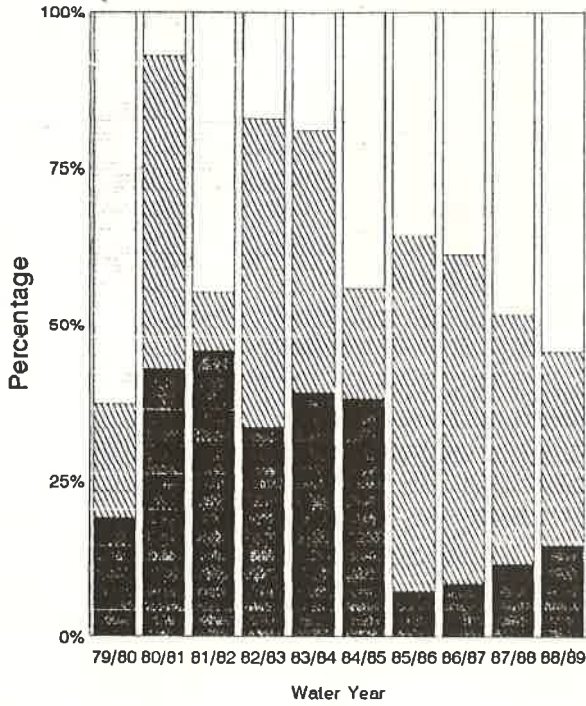


Figure 5: Seasonal sediment discharge recorded at Jambatan Syed Omar.

JENIANG

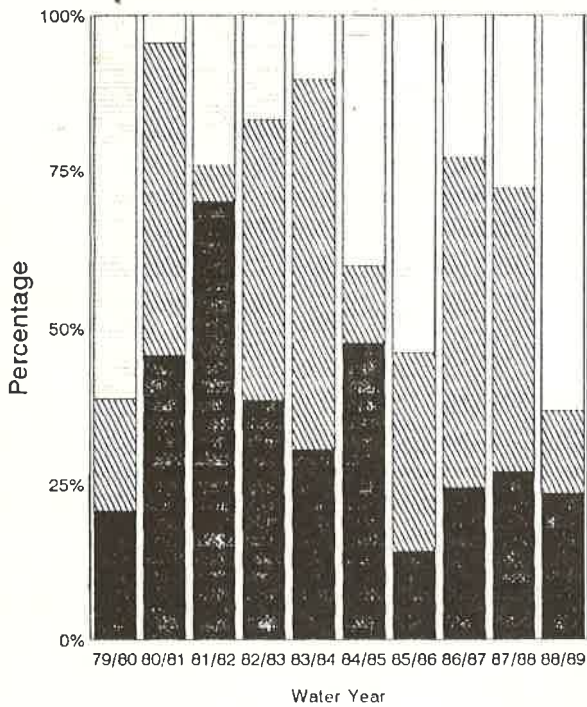


Figure 6: Seasonal sediment discharge recorded at Jeniang.

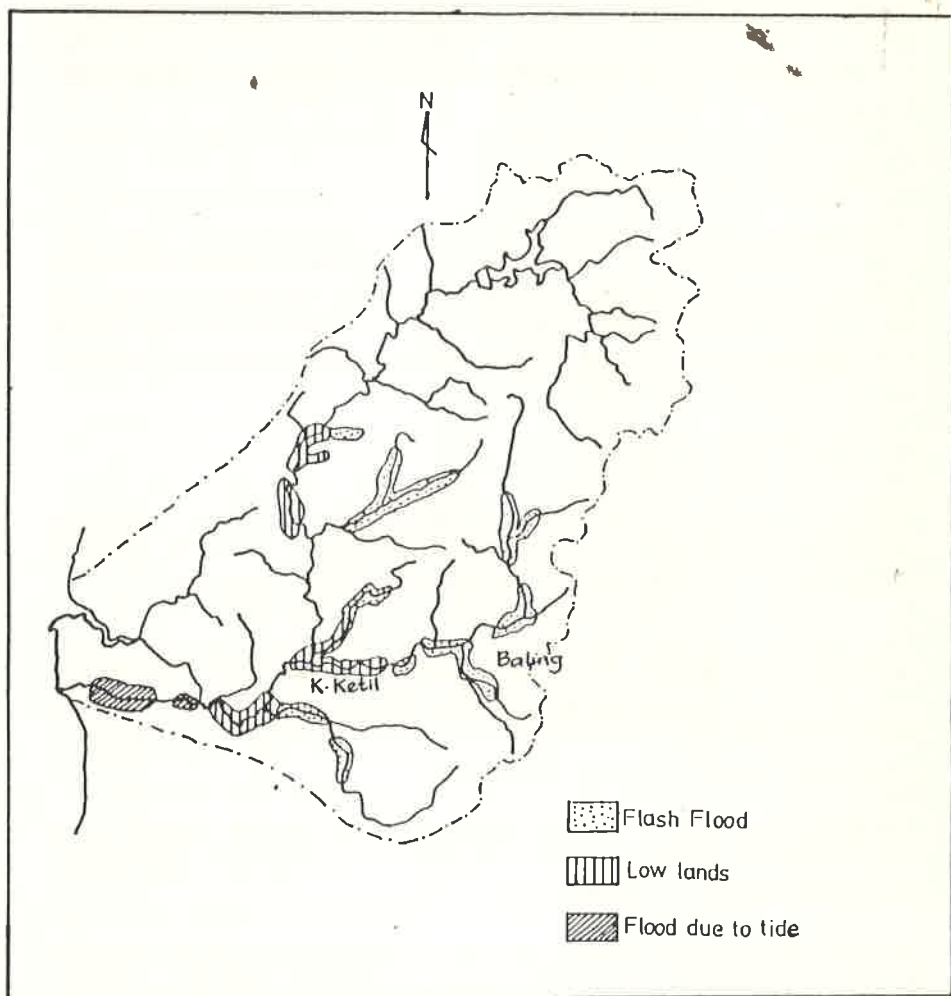


Fig. 7 : Flood Affected Areas in the basin.

The coefficient of variation (C.V.) of rainfall for the state was also calculated. The C.V. shows how much deviation (per cent) of rainfall from the mean. The C.V. was found to be higher in the N.E. monsoon period (20 - 35 per cent) compared to only 10 - 20 per cent for S.W. period (Fig. 3(b), suggesting that higher variability of rainfall in the N.E. period. This fact is further supported by the low value of probability in the N.E. compared to the S.W. monsoon (Fig. 3(c)). Generally we can consider that the rainfall variability is higher in the Muda Basin.

2. Streamflow and River Discharge

The streamflow pattern at both stations resembles that observed at many west coast stations (Fig. 4). The streamflow pattern generally reflect the rainfall pattern with bi-modal distribution. There are basically two peaks in a year. The smaller peak occurs during the months of April-May (Intermonsoon and onset of S.W. monsoon); and the larger peak occurring during the months of Oct-Nov (Intermonsoon and onset of N.E. monsoon).

3. Sediment discharge and sediment yield

Sediment discharge is a measure of the amount of sediment carried in suspension or suspended load expressed in tonnes per day or per year. The sediment discharges were calculated from the suspended sediment concentration.

The sediment yield is the amount of sediment discharged per unit area of drainage basin at gauging station and is usually expressed in tonnes/km²/year. Sediment yield of a drainage basin is the resultant of the combined processes of erosion, transportation and deposition (denudation) operating in that basin. Its magnitude reflects the sediment delivery ratio.

The percentage seasonal sediment discharges at both gauging stations are as shown in Fig. 5 and 6 respectively. The mean annual load for Jambatan Syed Omar was around 3.7×10^5 tonnes/year.

About 80 per cent of the annual load is usually transported during the period of wet months of April to November. Maximum monthly load are commonly associated with October (ca 26 per cent of the annual load), whilst minimum monthly loads are transported during March (ca. 0.8 per cent). The maximum annual suspended sediment load for the above period is 5.5×10^5 tonnes (1985/86).

The seasonal sediment yields are shown in Table 1 for Jeniang and Jambatan Syed Omar respectively. The contribution of Northeast monsoon and intermonsoon periods is very significant. Nearly 60 - 85 per cent of annual yield is due to the contribution from the wet months of the Intermonsoon and N.E. monsoon periods. The mean annual yield of Muda river is c.a. 112 and 42 tonnes/km²/year at Jambatan Syed Omar and Jeniang respectively. The mean annual yield at Jambatan Syed Omar is slightly higher than that quoted by Soong *et. al.*, (1980) and Sham Sani (1987) which was about 98 tonnes/km²/year (Table 2) and a much lower value was quoted by Wan Ruslan (1989) which was only 83 tonnes/km²/year. The increase in the average yield in this study could have been assisted by the 1988 floods. On the other hand, even one such major flood event would not have contributed so much sediments. Therefore other factors such as logging activities and other human influences might have caused such dramatic increases in the sediment yield. Studies on the effect of logging activities on sediment yield were reported elsewhere. Baharuddin (1986), for example, reported that after logging, the suspended sediment increased by nearly 70-97 per cent in two watersheds in Berembun Forest. Logging cause the forest floor to be disturbed and compacted as in the case where heavy machinery were used. These disturbances causes an increase in the surface runoff and sediment load. The stream discharge from logged over forest could carry as much as 8-17 times higher sediment load than it was before logging (Chong, 1985). The sediment yield reported in this study although seems to be quite high, it is still considered to be low by the World standards (Walling, 1986; Walling and Webb, 1987; Al Ansari *et al.*, 1988; Holeman, 1968).

4. Flood and Erosion of River Bank in Muda River.

Flood is one of the major problems encountered in the Muda River Basin. The siltation of the river channel was responsible for flooding in several places along the Ketil and Muda river. Areas such as Sik, Baling and Kuala Ketil were identified as frequently experiencing flood (Fig. 7). The frequency of flooding is two to five times per year (D.I.D., 1987). In turn, flood could also lead to bank erosion along the Muda river. The floods in the basin are categorised as flash flood, flooding of low lands and flood due to tidal influence.

The river bank erosion is another major problem faced in the Muda River basin. There are several places along the Muda River that are severely experiencing bank erosion whereby a lot of agricultural and kampong land has been affected (Table 3). The sand mining activities were responsible for the widespread river bank erosion beside the naturally bank erosion during flood (D.I.D., 1987).

Table 1: Sediment Yield at Jeniang and Jambatan Syed Omar.

SEDIMENT YIELD AT JENIANG (ton/sq.km/year)

Year	Total	Monsoon Period				Intermonsoon Period		
		Southwest	%	Northeast	%	April	%	October
'79/80	28.6	5.9	20.6	3.2	18.2	0.1	0.3	17.4
'80/81	18.4	8.4	45.7	9.2	49.8	0.5	2.7	0.3
'81/82	180.6	12.6	7.0	1.1	0.6	0.5	0.3	3.8
'82/83	25.6	9.9	38.5	11.4	44.6	0.0	0.1	4.3
'83/84	19.9	6.1	30.7	11.7	59.0	0.4	2.0	1.7
'84/85	11.0	5.2	47.4	1.3	12.3	0.3	3.1	4.1
'85/86	22.6	3.2	14.1	7.2	32.0	0.3	1.3	11.9
'86/87	20.4	5.0	24.5	10.8	52.7	0.3	1.6	4.3
'87/88	16.6	4.5	27.0	7.5	45.1	0.3	1.6	4.4
'88/89	80.5	18.9	23.5	10.9	13.5	3.7	4.6	47.0
Mean	42.4	7.97	27.9	7.63	32.8	0.64	1.7	9.92
Std. Dev.	49.6	4.5	12.4	3.8	19.2	1.0	1.3	13.3

SEDIMENT YIELD AT JAMBATAN SYED OMAR

(Ton/Sq.km/year)

Year	Total	Monsoon Period				Intermonsoon Period		
		Southwest	%	Northeast	%	April	%	October
'79/80	144.4	23.6	16.4	42.7	29.6	0.8	0.53	77.4
'80/81	112.3	48.0	42.8	56.4	50.2	5.7	5.05	2.2
'81/82	69.8	32.0	45.8	6.4	9.14	26.0	37.3	28.8
'82/83	117.3	39.2	33.4	58.2	49.6	0.3	0.25	19.7
'83/84	116.5	45.4	39.0	49.1	42.1	12.7	10.9	9.4
'84/85	62.8	23.9	38.0	11.1	17.7	0.4	0.63	27.4
'85/86	166.0	11.9	7.2	94.4	56.9	1.3	0.78	58.4
'86/87	113.9	9.7	8.3	60.9	52.6	0.4	0.34	44.9
'87/88	101.7	11.7	11.5	40.7	40.0	1.7	1.65	47.7
'88/89	112.0	16.1	14.4	34.8	31.1	4.0	3.59	57.0
Mean	111.9	26.2	25.7	45.5	37.9	5.3	6.1	37.3
Std. Dev.	28.9	13.6	14.6	24.0	14.9	7.8	10.9	22.6

CONCLUSION

The sediment data of a river is very important in determining the rate of denudation for the river basin which in turn is very useful for the planning and management of the basin. In Malāysia, like any other developing countries, sedimentation data are scarce but there is an indication that the specific annual sediment yield is in the range of 10 tonnes/km² (low flow situation) to maximum (high flow situation) value of 400 tonnes/km² in Peninsular Malaysia and about 30 - 230 tonnes/km² in Sabah (J.I.C.A., 1982:2). The average sediment yield of Muda river basin measured at Jambatan Syed Omar was found to be about 112 tonnes/km²/year for the period 1979-89 and about 42 tonnes/km²/year at Jeniang. The sediment load was largely transported out during the wet months of April to November ammounting to c.a. 80 per cent of the total load every year. The maximum load carried away by the river was in October (the wettest month for the basin), i.e. about 28 per cent at Jeniang and 33 per cent at Jambatan Syed Omar (Percentage of the annual load). The relatively high sediment yield of Muda River has caused siltation which in turn leads to flooding and bank erosion in the basin.

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