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Assessment of Total Suspended Sediment and Bed Sediment Grains in Upstream Areas of Lata Berangin, Terengganu

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***Abstract*—The amount of suspended sediment yield and the size of sediment grains an indicator of hydrological cycle, especially in the river. The sediment transportation process is one of the measurements of water resources management. Equilibrium of the river depends on the flow rate of water and by several factors such as frequency of rainfall, climate changes and land use activities that changes then effected to the river flow. Sedimentation problems occur in reservoirs, rivers, lakes, flood plains and offshore. This study was carried out in the upstream area, Lata Berangin, Hulu Keruak, Besut, Terengganu. This study was implemented to prove the sedimentation problem, especially the formation of total suspended sediment (TSS) and the bed sediment grain size. There are three important parameters were quantified in this study such as the distribution of sediment grain size (phi), TSS (mg/L) and the river discharge values (Q) (m³/s). The technique of analysis of primary data obtained which determine the bed sediment grain size according with the procedure of Gerald and Kenneth and the phi (ϕ) value in this study using the scale Udden-Wentworth that included median, mean, standard deviation, skewness, kurtosis and the Gravimetric Method used to analyze the concentration TSS is the Gravimetric Method. From the result, the highest TSS up to 6.0 mg/L which is categorized under the class I, based on the National Water Quality Standard. Overall, the estimated daily-suspended sediment load values up to 1.1649 tonne/day at Station 2. Then, from the statistics for the median, mean, standard deviation, skewness and kurtosis showed that the size of sediment falls between phi -0.30φ to phi -1.00 φ which classified as very coarse and the majority of the sediment texture and a very leptokurtic, leptokurtic texture showed sedimentation production is not so high. Overall, the sedimentation problem in Lata Berangin, Hulu Keruak still in stable level. Most of this upstream area still not developed as land use activities around the river basin.**

***Keywords*— sediment transport, grain size, Udden-Wentworth, leptokurtic, skewness.**

I. INTRODUCTION

Sediment is a source of nature, environmental and geomorphological resource. Sediment consists of rocks, mud, minerals and the remains of plants and animals [1], [2]. Sediments can be classified into various shapes and size. It can be as small as a grain of sand or as large as a boulder. The sediment solid can be defined as the organic and inorganic materials, which is moved from one place to another place through the erosion process and deposited in a new location. The erosion can move the sediment through by water, ice or wind. Sediment is rocks, mud, minerals and the remains of plants and animals [2], [3]. The small size of sediment such as sand and silt or large as boulder, which are found at upriver and then the fine-grained normally found in estuaries [1]-[3]. Sediment that is light enough to be carried by water without touching the streambed is called suspended sediment and is visible as cloudy or milky areas of water. Over millions of years, layers of sediment may build up and harden into sedimentary rock. Some of the many forms of sedimentary rock include sandstone, rock salt and coal [4], [5]. Many rivers in Malaysia are regulated for land use activities such as residential development, domestic, agricultural, industrial field and urbanization are among the major pollution sources influencing the in the equilibrium of the rivers. The sedimentary content and the quality of water were influencing the condition of the river. There are three processes, erosion, transport and deposition that are interacting along the river from the upstream to downstream of the river. Then, the frequency and intensity of rainfall in the Terengganu River influenced the water level flow and the rates of the erosion process. The positive relationship between the rate of the side and riverbank erosion proposed to increase the sediment production. The velocity of water an important role in the erosion activity and sediment production, the velocity depends on the intensity of rainfall. Generally, the high rate of speed and volume of water, the strong erosion rates [4]-[6].

The speed of water flows is the main factor that affected the capacity to transport the sediment and the sediment movement. Thus, the processes of deposition of sediment depend on the river discharge and the speed of the river flow. When the higher discharge value and higher the water velocity, the higher amount of sediment load deposited. The secondary data distribution of rainfall in Terengganu from Department of Irrigation and Drainage (DID) showed the transportation process is initiated on the land surface when raindrops in sheet erosion which effected to the sediment movement [7]. Rainfall intensity is a very important factor, there are relationship between rainfall intensity and water erosion causes increased soil particle detachment [5]-[8]. The higher rainfall intensity also caused higher rates in infiltration excess runoff, a much greater transport total suspended sediment and suspended sediment load [9].

There is a positive relationship between river discharge, the rate of the flow and the capacity of sediment transport [9]-[15]. These factors will affect the hydrological, biodiversity and ecosystem. Increased in the velocity and volume of water will also increase the rate of the erosion. This situation will increase the amount of suspended sediments, water turbidity the river and the river became shallower. It gives a negative impact on the benthic ecosystem, the flora and fauna in the area around this river [16] and reducing the water quality level. The river discharge rate was vital in the aspect of flood controls, stabilization or development of the river.

The distribution of rainfall, the river discharge, flow rate and amount sediment production were interdependencies between each other. The distribution showed the rainfall intensity around Terengganu. The figure below proves within in the 10 years (2001-2010), the trends of the monthly rainfall data in Terengganu, Malaysia based on seasonal rainfall indices. The distribution indicates that the Northeast Monsoon had the greatest impact on the Eastern part of the Peninsula such as Terengganu, Pahang and Kelantan particularly in characterizing the rainfall pattern of the northwest region. During this season, the Eastern region indices tested are higher than in other regions of the Peninsula. The trends showed the higher intensity of rainfall in Terengganu on October until March every year. The distributions showed the sediment production lowest in April and May every year, followed by flow rate, river discharge and rainfall respectively (Fig. 1). From this study, the researcher will analyze and make the comparison the sedimentation problems during the monsoon season and normal season.

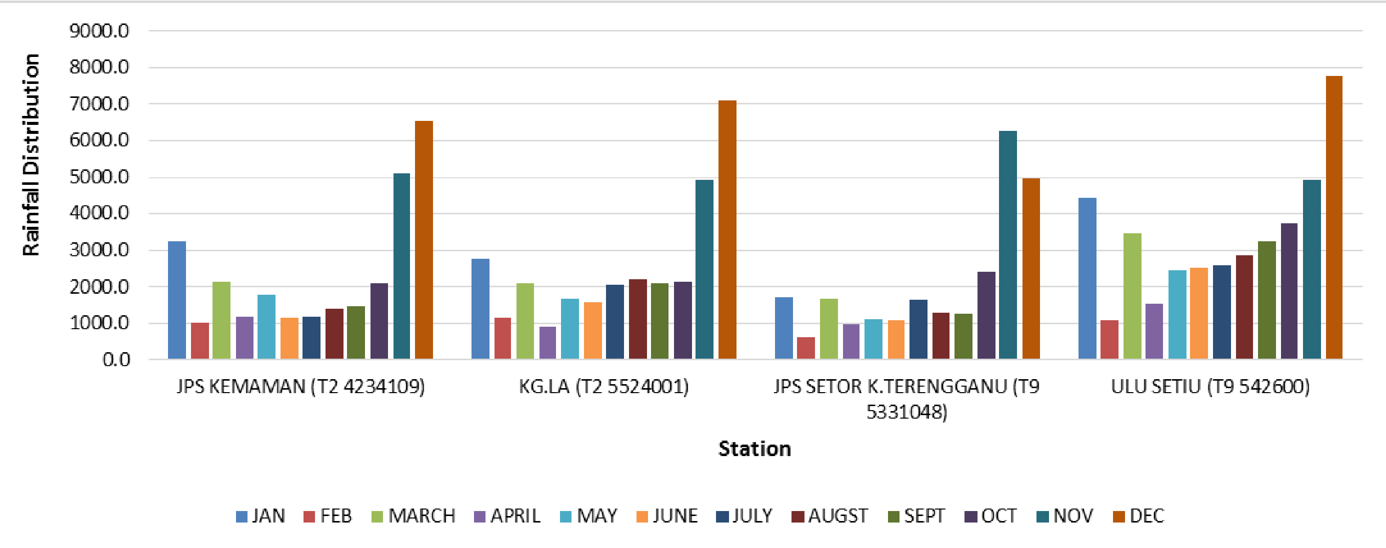


Fig. 1 The distribution of rainfall in Terengganu, Jan-Dec on 2001-2010

II. Methodology

A. *Area of Study*

Lata Berangin, Hulu Keruak, Besut, Terengganu selected as research location. This study involves four main sampling stations that have been determined using DGPS which located in the upstream of Besut River, Terengganu. Station 1 and Station 2 are located at the upstream, Station 3 is located in the middle while 4 stations located in the downstream (Table I and Fig. 1). Lata Berangin is a virgin forest and from the observation, the land is not fully used for development and land use activities. The primary data used in this research and the results obtained from the fieldwork and analysis in the laboratory. The method has been used is the analysis of particle size and texture of the deposited bottom sediment and riverbanks to classify the type of sediment and the sediment yield production found in Lata Berangin.

TABLE I
LOCATION OF SAMPLING STATIONS AT THE LATA BERANGIN, HULU KERUAK, BESUT, TERENGGANU

Station	Longitude	Latitude	Location
Station 1	102° 26'44.8"E	5°25'52.5"N	Mid-stream
Station 2	102° 26'37.2"E	5°25'55.8"N	Upstream
Station 3	102° 27'47.4"E	5°26'56.6"N	Upstream
Station 4	102° 27'29.4"E	5°26'29.4"N	Downstream

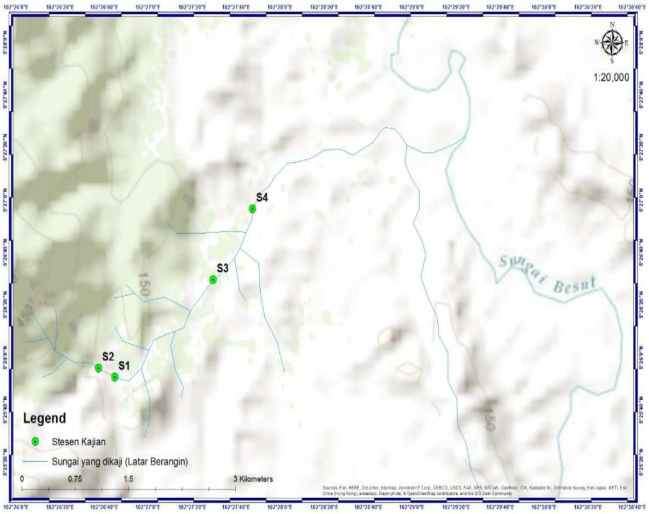


Fig. 2 Location of sampling stations at the Lata Berangin, Hulu Keruak, Besut Terengganu

The water samples were obtained from each station and were kept in the 500ml bottles to find the total suspended sediments (TSS) concentration. Sediment samples were collected using sediment scoops and sediment grab to classify the sediment properties. The samples collected were analyzed in the laboratory. The Gravimetric method was used to analysis the TSS measured in mg/L. 250 ml water sample was needed for each study area (each station). Firstly, weighing the membrane filters using electronic weighing. Then, a membrane filter was placed onto a filtration apparatus connected to a vacuum pump and clipped in place. The 250ml water sample lowly poured into the filtration jar. The membrane filter was removed and allowed to dry in the drying jar. Next, the membrane filter was weighing. Readings were taken and calculated using the following formula:

$$TSS = \frac{\{(\text{weight of membrane filter} + \text{dry residue}) - \text{weight of membrane filter}\}(mg) \times 1000}{\text{Volume of filtered water}(mL)}$$
$$= mg\ L^{-1} / 1000 / 1000 / 1000$$
$$= \text{tonne}\ L^{-1} \quad (1)$$

where the discharge value (Q) is the product of velocity and cross section area (A). The cross section area is derived from the product of depth (d) and width (w), the cross section area is trapezium or triangular shaped and the value is half the product (2) (3), which are due to the imprecision of the current meter, variability of the river flow velocity over the cross section and uncertainty in the estimation of the cross section geometry.

Cross section area (A) (refer Fig. 3)

$$A = dw\,(m) \text{ or } A = \tfrac{1}{2}\, dw(m) \sum A1 + A2 + A3 + A4 \quad (2)$$

Discharge value (Q)

$$Q = vA \text{ or } Q = ½vA$$
$$Q = m^3/sec \quad (3)$$

To obtain the unit L/day, the following formula (3).

$$Q = m/sec \times 86400\ sec/day \times 1000\ l/m$$
$$= L/day \quad (4)$$

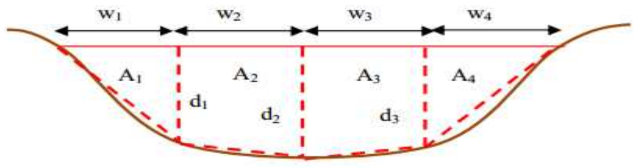
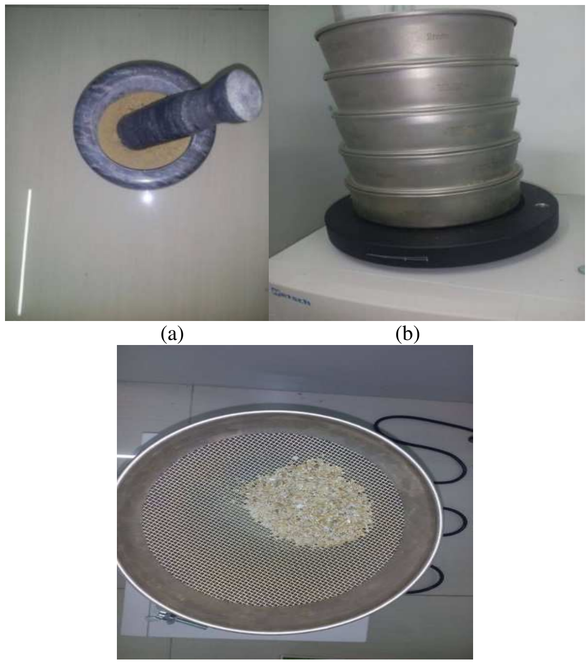


Fig. 3 The theoretical of discharge measurement by cross-section of the river

The first step to analyze the sediment samples are the drying process, the sediment was dried at room temperature. Afterward, the sediment will be crushed using a mortar pestle. Then, the sample weighed as much as 100 g using the electronic weighing. It is sieved for 15 minutes using mechanical shakers. The sizes of trays used in this study are 2 mm, 0.25 mm, 0.125 mm, 0.63 mm and pan. The technique of analysis used follow the procedure, the scale of size of sediment followed Udden-Wenthworth. All the samples would be classified by size. Then, the samples which have been alienated would be weighed using the electronic weighing [17]-[20].



(a) (b)

(c)

Fig. 4 a) Mortal pestle b) Mechanical shakers c) The sediment was sieved

Based on the method [17]-[18], the arithmetic ordinate graph used the weight of the sample. On the x-axis is a scale unit of micrometer (um) and the y-axis is the cumulative percentage scale (0 to 100%) by a linear scale. The Phi's value of sample size is determined by the schedule grades size of sedimentary particles. A few the value of ϕ determined to calculate the statistical values for median, min (M), standard deviation (D), skewness (S) and kurtosis based on the specific equation as shown in Table II. Table III, IV, V and VI were used to determine the distribution size of sediment of mean value as indicator to compare the flow force, the level of uniformity deposition process of standard deviation value, the size of sediment or sensitivity environmental sedimentation classify on the value of skewness and the kurtosis value used to determine the texture of sediment. In Table III, the mean value proved the coarse size sediment will need high flow energy than the fine grain size. For Table IV, the value of standard deviation described the uniformity of sediment deposition, the low standard deviation showed the selection is good and vice versa. In Table V, the size sediment showed by the value of skewness. Basically, the positive value for river sand which deposited of fine grains while the negative value for beach sand showed of coarse sediment which easily separated [19]-[20]. For Table VI, the kurtosis value explained about the texture of sediment or physical condition details of sedimentary fragments. A leptokurtic shaped curve that showed good texture and platykurtic shape showed bad texture.

TABLE II
THE VALUE OF Φ DETERMINED TO CALCULATE THE STATISTICAL VALUES

Percentage	5 ϕ	16 ϕ	25 ϕ	50 ϕ	75 ϕ	84 ϕ	95 ϕ
Phi Value	-1.95	-1.85	-1.73	-1.35	-0.33	1.00	3.68

The statistic value of median, min (M), standard deviation (D), skewness (S) and kurtosis were determined based on the specific equation

$$\text{Median} = ø50 \quad (5)$$
$$\text{Mean (M)} = ø16 + ø50 + ø84/3 \quad (6)$$

TABLE IIII
THE TYPE OF SEDIMENT GRAINS

Distribution Size (Mean)	Phi Value (ϕ)
Rock	-12 to -8
Stone	-8 to -6
Pebble	-6 to -2
Sand	-2 to -1
Very Rough Grain	-1 to 0.0
Rough Grain	0.0 to 1.0
Medium Grain	1.0 to 2.0
Fine Grain	2.0 to 3.0
Very Fine Grain	3.0 to 4.0
Rough Silt	4.0 to 5.0
Medium Silt	5.0 to 6.0
Fine Silt	6.0to 7.0

Standard deviation

$$\text{(D)} = ø84 - ø16/4 + ø95 - ø5/6.6 \quad (7)$$

TABLE IIIV
THE DESCRIPTION OF LEVEL UNIFORMITY OF DEPOSITED (STANDARD DEVIATION)

Uniformity	Phi Value (ϕ)
Very well sorted	< 0.35
Well sorted	0.35 to 0.50
Moderately well sorted	0.50 to 0.71
Moderately sorted	0.71 to 1.0
Poorly sorted	1.0 to 2.0
Very poorly sorted	2.0 to 4.0
Extremely poorly sorted	> 4.0

$$\text{Skewness (S)} = ø84 + ø16 - 2(ø50)/2(ø84 - ø16) + ø95 + ø5 - 2(ø50)/2(ø95 - ø5) \quad (8)$$

TABLE V
THE DESCRIPTION OF LEVEL UNIFORMITY OF DEPOSITED (STANDARD DEVIATION)

Size	Phi Value (ϕ)
Very Fine	+ 1.00 to +0.30
Fine	+0.30 to +0.10
Medium	+0.10 to -0.10
Rough	-0.10 to -0.30
Very Rough	-0.30 to -1.00

TABLE VI
THE DESCRIPTION TEXTURE OF SEDIMENT (KURTOSIS)

Texture	Phi Value (ϕ)
Very Platykurtic	< 0.67
Platykurtic	0.67 to 0.90
Mesokurtic	0.90 to 1.11
Leptokurtic	1.11 to 1.50
Very Leptokurtic	1.50 to 3.00
Extremely Leptokurtic	>3.00

III. RESULTS AND DISCUSSION

The sedimentation study in Lata Berangin, Hulu Keruak is still on the stable level. The concentration of TSS and the properties of sediment grains showed the sedimentation production not really higher. When the water flow in a basin increased, the total suspended sediment will also increase because the higher flow contains the strong energy to move the higher concentrated the suspended sediment load compared to the low flow. The high water flow also increased the rate of erosion. TSS to determine whether the status of water quality clean, moderately polluted or contaminated. TSS is of an indicator to classify the river in Class I, II, III, IV or Class V based on National Water Quality Standards (NWQS) every year.

Basically, the normal phenomenon the concentration TSS in the downstream higher than at upstream because of the land use activities around the river basin and the velocity and force of water higher at upstream than at downstream. Therefore, the concentration of TSS does not only depend on the value of river discharge but others geomorphology factors.

Fig. 5 showed total suspended sediment concentration and river discharge value in the Lata Berangin, Hulu Keruak, Terengganu. The highest amount of TSS at Station 2, 6 mg/L the minimum level amount of suspended sediment at Station 4, 4 mg/L. The highest of river discharge value (Q) at the station 2, 3.18275 m^3/s. This situation is normal reading for a river, the water velocity in the elevated upstream is higher than the downstream. Relatively, there are natural correlations between the river discharge and total suspended sediment, river discharge rate is one of a factor affected mobility or the concentration of TSS, the higher the velocity, the higher the amount of sediment production [20].

Normally, increased the value river discharge will increase the production of total sediment suspended and sediment load. However, the frequency and intensity of rainfall, land use activities around the basin, erosion and other factors will affect the TSS and sediment load production. In Fig. 6 showed a correlation between river discharge (Q) and TSS values in Lata Berangin, Hulu Keruak Terengganu River. There are significant relations of R^2 = 0.5813. This correlation showed a low positive relationship between Q and TSS, which increase in Q caused an increase in TSS. But, this result proved that the Q not as main factor the increased of TSS. From this research, the production of TSS not only depends on the Q but also depends on the others geomorphology factors.

The deposition of mud and certain other materials over time will cause big problems in water quality, shallow and increasing the potential for flooding. Daily suspended sediment yield was calculated to estimate the TSS tonne per day. The highest daily suspended sediment load was caused by highest discharge value and the highest suspended yield, the highest value of estimated TSS (tonne/day) or suspended sediment load at Station 2, 1.1649 tonne/day and the lowest value is 0.2099 tonne/day at Station 3 (Table VII). However, Lata Berangin is one of river basin which not covered by development. But, the sedimentation still can be exist if without the strategic conservation and preservation to stabilize the flow system.

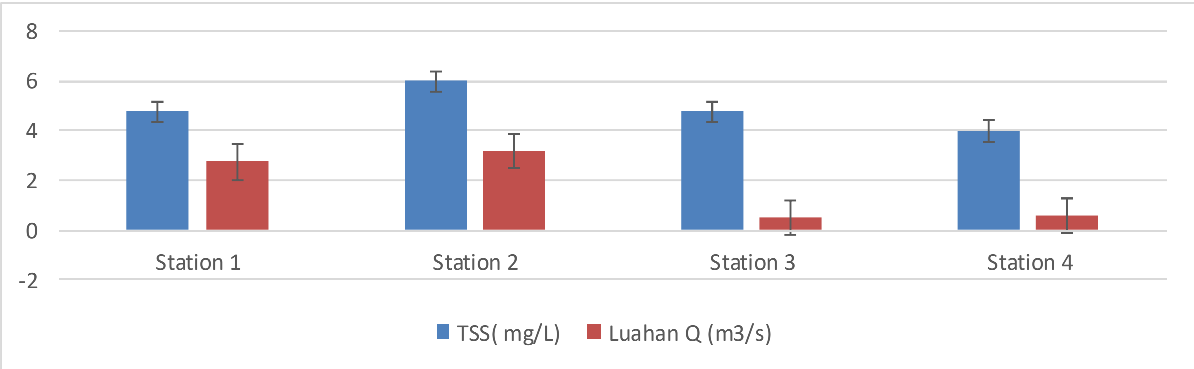


Fig. 5 Total suspended sediment concentration and river discharge value in the Lata Berangin, Hulu Keruak, Terengganu

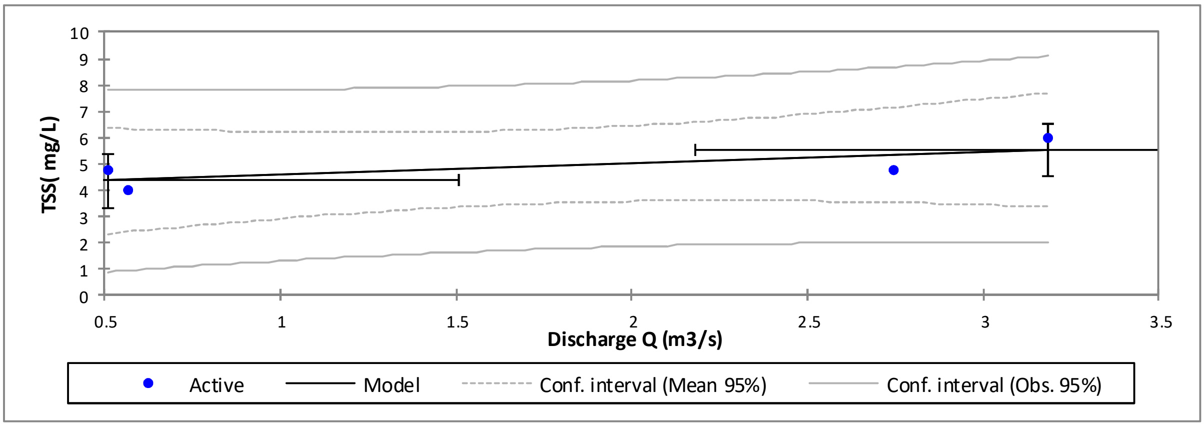


Fig. 6 Relationship between TSS and Q in the Lata Berangin, Hulu Keruak, Terengganu

TABLE VII
SUSPENDED SEDIMENT LOAD IN THE LATA BERANGIN, HULU KERUAK, TERENGGANU

Station	TSS (mg/L)	Q (m^3/s)	Estimated Q (L/day)	Estimated TSS Tonne Per Day (Tonne/Day)
Station 1	4.8	2.74615	237,267,360	1.1389
Station 2	6.0	3.18275	274,989,600	1.1649
Station 3	4.8	0.50632	43,746,048	0.2099
Station 4	4	0.5667	48,962,880	0.1959
Average	4.9	1.75048	151,241,472	0.6774

Based on this study, Table VIII shows the distribution of sediment particle properties in Lata Berangin, Hulu keruak. The highest value of median is phi 1.739 at Station 4 (right), while the lowest value of median is phi 1.559 at Station 4 (left). The value of mean showed the particle type of sediment at each station around the Lata Berangin. Mostly, the types of the sediment grains are medium grains. Station 4 (center) showed the highest mean, phi 1.687 and the minimum value of mean at Station 4 (left), phi 1.003 which is kind of medium grains. The value of mean along the Lata Berangin is dominated by the medium grains with a value of phi 1.0 to phi 2.0. The standard deviation is measured to determine the degree of uniformity of deposition during the process of transport and deposition of particles. In addition, the standard deviation showed a moderate level of deposition uniformity around the all stations which value phi 0.5 to phi 1.0. The level of uniformity size of sediment size in Lata Berangin is still on the stable level.

The analysis of skewness showed the size of sediment, the size of the sediment obtained in the study, the majority of sediment is a very rough sediment grains. 90% of the total size of the sediment obtained from sampling stations worth between phi -0.30 to phi -1.00, which dominated by the very rough size of sediment grains. The highest size of grain, phi -0.286 at Station 4 (left), while the lowest size of the grain is phi -2.364 phi at Station 4 (center). Basically, the area of river in Malaysia showed positive skewness because mostly the fine grains were deposited after the river receded due to rain while the sand of beach showed a negative skew value for the fine grains which to be easily separated [19]-[23]. However, from the results of this study showed there mostly are negative skewness which classify as very rough skewed. This proves that many frough sediment grain sizes available around the Lata Berangin.

The kurtosis act as an indication of the level of sediment texture. The level of sediment texture can be identified from a curved shape either wide or narrow edges. Kurtosis said arch-shaped leptokurtic is textured well as the selection in the middle is better than the selection of the left and right edges, and curved shaped platykurtic is bad texture as the selection of the side is better than the election of the central part [24]-[27]. Mostly, the sediment grains in the Lata Berangin are good texture included Very Leptokurtic texture is 50% of the total sediment grains, while 30% are the kurtosis texture of Extremely Leptokurtic and 20% are Leptokurtic texture. From this result proved the good texture sediment grains have the well uniformity of sediment sorted. According to [9], the higher rate of discharge would indicate the size of the coarser sediments, which negative phi value [20]-[22]. There was a strong correlation between the size or skewness of sediment grains and discharge of the value $R^2 = 0.9899$, the discharge conditions in this study area have and caused on the size of the sediment grains (Fig. 7).

TABLE VIII
SEDIMENT GRAIN PROPERTIES IN THE LATA BERANGIN, HULU KERUAK, TERENGGANU, APRIL 2016

Station	Median (50ø)	Mean (Type of Sediment Grains)	Standard Deviation (Uniformity)	Skewness (Size of Sediment Grains)	Kurtosis
Station 1 (LEFT)	1.681	1.387 (MG)	0.747 (MS)	-1.166 (VR)	2.929 (VL)
Station 1 (CENTRE)	1.664	1.317 (MG)	0.757 (MS)	-1.147 (VR)	2.398 (VL)
Station 1 (RIGHT)	1.643	1.241(MG)	0.807 (MS)	-0.841 (VR)	1.872 (L)
Station 2	1.698	1.465 (MG)	0.645 (MWS)	-1.809 (VR)	4.393 (EL)
Station 3 (LEFT)	1.707	1.502 (MG)	0.742 (MS)	-0.972 (VR)	4.095 (EL)
Station 3 (CENTRE)	1.643	1.24 (MG)	0.802 (MS)	-0.852 (VR)	1.942 (VL)
Station 3 (RIGHT)	1.72	1.573 (MG)	0.571 (MWS)	-2.039 (VR)	7.025 (EL)
Station 4 (LEFT)	1.559	1.003 (MG)	0.866 (MS)	-0.286 (R)	1.113 (L)
Station 4 (CENTRE)	1.591	1.687 (MG)	0.405 (WS)	-2.364 (VR)	1.813 (VL)
Station 4 (RIGHT)	1.739	1.092 (MG)	0.876 (MS)	-0.32 (VR)	1.597 (VL)

*MG = Medium Grain, MS = Moderately Sorted, MWS = Moderately Well Sorted, WS = Well Sorted, VR = Very Rough, R = Rough, VL = Very Leptokurtic, EL= Extremely Leptokurtic, L= Leptokurti

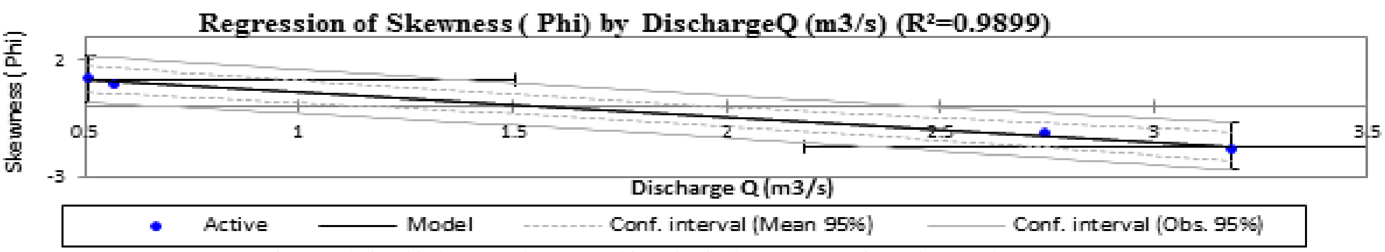


Fig. 7 Relationship between skewness (Phi) and Q in the Lata Berangin, Hulu Keruak, Terengganu

IV. Conclusions

Overall, the study showed that the suspended sediment and the sedimentation problem of the 4 stations in the Lata Berangin, Hulu Keruak, Terengganu and detected the main causes of this problem happened. Therefore, the prevention and the step towards need to do with the authorities and the communities as the responsibility to these environmental issues. This research can be to enlighten the public about the importance of the environment. The increasing the sedimentation could lead to increase the turbidity and the odors of water. The values of river discharge (Q) are the primary factor that affected the sediment mobility. The increased rate of water flow could cause the suspended sediment yields. The suspended sediment yield was related to the incidence of rainfall that which effected the increasing value of river discharge.

Sedimentation problem in Lata Berangin, Hulu Keruak increase progressively and it is possible this problem will reach a critical point in the future if this issue is not addressed sooner. The authorities and communities need to take responsibility and be more sensitive to these issues. From this research proved the sedimentation problem is not serious because Lata Berangin, Hulu Keruak is one of unexplored forest.

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