Effect of Sg. Lembing Morphology due to Sedimentation and Extreme Flood Event

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Abstract

A study on river morphology was conducted at Sg. Lembing, Kuantan, Pahang. The major contribution to the depositional process in the river is the sediment which is composed by granular materials that have variety size and type. Excess sediment could cause the river level increase that can cause changes of the river morphology. This study focused on changes of river morphology by determines the point of the river that has major changes. Three sampling Stations have been chosen based on the river changes between in year 2010 to 2015 which had been analyzing using Google Earth software. The locations of study area are in upstream (Station 1), mid-stream (Station 2) and downstream (Station 3). Sampling data are collected in two day which is on 16 March 2016 and 23 March 2016. Sediment particles in every station were classified based from United State Army Corps Engineer [1] table. The data from Department of Irrigation and Drainage and Malaysian Meteorological Department are used for analysed rainfall pattern. As the conclusion, sediment sizes at Sg. Lembing are between 2.360mm to 0.425mm. The minimum and maximum total yearly rainfall data is 1443mm and 3775.5mm at 2008 and 2011 respectively.

Keywords: Sg. Lembing, Rainfall pattern, River morphology, Sediment classification

Abstrak

Satu kajian mengenai morfologi sungai telah dijalankan di Sg. Lembing, Kuantan, Pahang. Sumbangan utama kepada proses pengenapan di dalam sungai adalah sedimen yang terdiri dari bahan-bahan berbutir yang mempunyai pelbagai saiz dan jenis. Sedimen yang berlebihan boleh menyebabkan peningkatan paras sungai yang boleh menyebabkan perubahan morfologi sungai. Kajian ini memberi tumpuan kepada perubahan morfologi sungai dengan menetukan titik sungai yang mempunya perubahan besar. Tiga stesen pensampelan telah dipilih berdasarkan perubahan sungai di antara tahun 2010 sehingga 2015 yang telah dianalisa dengan menggunakan perisian Google Earth. Lokasi kajian adalah di hulu (Stesen 1), pertengahan aliran (Stesen 2) dan hiliran (Stesen 3). Data pensampelan dikumpulkan dalam dua hari iaitu pada 16 Mac 2016 dan 23 Mac 2016. Partikal sedimen di setiap stesen diklasifikasikan berdasarkan Jadual United State Corps Army Engineer [1]. Data daripada Jabatan Pengairan dan Saliran dan Jabatan Meteorologi digunakan untuk menganalisa corak hujan. Sebagai kesimpulan, saiz sedimen di Sg. Lembing adalah antara 2.360mm sehingga 0.425mm. Jumlah data hujan tahunan minimum dan maksimum adalah 1443mm dan 3775.5mm masing-masing pada 2008 dan 2011.

Kata kunci: Sg. Lembing, corak hujan, morfologi sungai, klasifikasi sedimen

1.0 INTRODUCTION

Rivers are the most important freshwater resource for mankind. Most commonly rivers flow on the surface but there are many examples of underground rivers where the flow is contained within chambers, caves or caverns. River is very useful and has various functions in human life such as for domestics, economics, connection for one place to others place and many more. The main function of the river is to flow the water to the water storage or sea. River also brings the sediment from upstream or from erosion process. Sediments may affect the characteristics and the rate of the river. As example, the depth of river become shallow if the sedimentation occurred. It also will make the quantity of aquatic life will reduced [2] .

Sediment is the nonpoint source pollutants come from a number of sources and washed into our waterways by surface runoff. When land disturbing activities occur, soil particles are transported by surface water movement. Soil particles transported by water are often deposited in streams, lakes and wetlands that can changes the cross section; increase the bed load also changes the morphology itself. The process of sediment deposition is also dependent on river discharge and speed of river flow. As such, the higher value of water velocity would result in higher amount of sediment.

Erosion of soil from the catchments involves the process of detachment of soil from the soil surface and its transport by rainfall and runoff. Water is a very dangerous agent than the wind. Water soluble and will not only run but also erode the nutrients and soil grains break away [3]. The overland flow exerts shear stress on the surface thereby inducing both detachment and transportation of soil particles. Deposition of detached material takes place when the transport capacity of flow is smaller than the quantity of material being transported.

Sedimentation is the process of letting the suspended material to settle by gravity. The sediment size can be small, such as sand, small pebbles and silt, or large such as boulders, which are normally found upriver [2]. Sediments found in estuaries are mostly fine-grained, such as sand and silt. Sedimentation accomplished by decreasing the velocity of the water, which is treated to a point below. So the particle will not remain in the suspension. If the velocity no longer supports the particle, it will be remove by the gravity.

Erosion and sedimentation are linked to each other and embody the processes of erosion, transportation and deposition mechanism of sediments. In nature, there are two major types of erosion, example by water and wind. For Malaysian environment water is the most significant erosion due to high mean of annual rainfall, storm frequency and density [4]. Sediments which reach streams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels, reduce the depth and capacity of the channels and silt reservoirs. This may cause hydrological deterioration and can lead to severe flooding.

The pressures of urban development have large scale in Kuantan town impacts to the natural environment and in particular aquatic resources and their natural corridors. Changes to the land use can decrease permeability, increase fine sediment inputs, impact on water quality and increase runoff. These changes create an unbalance in the natural processes and lead to increased flood events, reduce base flows, decrease habitat diversity and channel erosion.

Several major floods occurred in the last few decades in Kuantan, not only causing extensive damage and inconvenience to the community or the economic, but also the river morphology itself. The sediment will reduce the function of the river and will cause flooding and brings along the sediments from upstream to downstream when receives heavy rainfall during monsoon time.

There are three main objectives for this study which are:

i. to study the river morphology and identify the area that contributed high sedimentation to the Sg. Lembing catchment.
ii. to identify the types and characteristics of sediment at Sg. Lembing catchment area.
iii. to determine the factor that affect transportation of sediment within Sg. Lembing catchment area.

The study was conducted at Sg. Lembing, Kuantan, Pahang. It was concentrate on the types of sediment of 3 sample location where the river morphology change. Additional sources of rainfall data are obtained from Malaysian Department of Irrigation and Drainage to analyse the rainfall pattern. The changes of the river cross section due to the sedimentation and flood event were determined.

2.0 METHODOLOGY

Three sampling point representing the length of Sg. Lembing which is about 2km has been selected; Station 1 (S1) upstream Sg. Lembing, Station 2 (S2) mid-stream Sg. Lembing and Station 3 (S3) downstream Sg. Lembing. Sediment sample were collected by using the shovel. The samples collected were analyzed in the laboratory.

The sieving method was done by spreading sediments on a tray and dry with 105 ˚ C for about 24 hours. The soil sample was divided into 500 grams samples and sieved about 15 minutes with a mechanical shaker. The sizes of sieve tray used in this research were 10.0mm, 5.00mm, 2.00mm, 1.00mm, 0.425mm, and 63μm. Each type of the sediment represents the different size that characterized from the United State Army Corps Engineer [1] table as reference of sediment particles classification.

Parameters, such as the flow velocity, width and depth of the river were determined in-situ. All the data obtained from laboratory and in-situ measurement are important in computing the stream discharge. In this study, the flow measurement can be measure by using Mean Section Method. Other than the stream data, the rainfall data from Department of Irrigation and Drainage is collected. The data is collected to observe the pattern of the rainfall. After all, the data was analyzed.

3.0 RESULTS AND DISCUSSION

River geometric give effects on the river's flow rate where steeper, wider and deeper as goes down from upper stream to downstream. In the meantime, higher flow rate tends to sweep and erode the soil more and much more at the area with less vegetal cover. Also, high flow rate is able to carry large sediment discharge. Smaller size of sediment is easy to be carried out along the river instead of larger size of sediment.

Sediment deposition on floodplains is normally largest where there is an exchange of water between the main channel and the floodplain, commonly at bend [5]. After all, the relationships between sediment grain sizes, rainfall pattern, river flow rate, Q are discussed.

Flow rate or stream discharge, Q for each Station was calculated by using mean section method is presented in Table 1, Table 2 and Table 3 and sieve analysis data for each Station as in Figure 1, Figure 2 and Figure 3. Besides that, rainfall data within year 2008 to 2015 is also presented in Figure 4.

Table 1 Flow rate and cross section data for Station 1 [a]

Station	Depth (m)	Width (m)	Velocity (m/s)	Average velocity	Average Depth	Flow rate $= w_1d_1v_1$ (m^3/s)
1a	0	0	0			
				0.193	0.145	0.114
1b	0.310	4.080	0.385			
				0.436	0.335	1.192
1c	0.380	8.160	0.487			
				0.417	0.345	1.760
1d	0.290	12.240	0.347			
				0.174	0.155	0.440
1e	0	16.320	0			

Table 2 Flow rate and cross section data for Station 2[a]

Station	Depth (m)	Width (m)	Velocity (m/s)	Average velocity	Average Depth	Flow rate $= w_1d_1v_1$ (m^3/s)
2a	0	0	0			
				0.178	0.083	0.062
2b	0.165	4.175	0.355			
				0.497	0.3303	1.257
2c	0.440	8.350	0.638			
				0.492	0.365	2.249
2d	0.290	12.525	0.346			
				0.173	0.145	0.419
2e	0	16.700	0			

Table 3 Flow rate and cross section data for Station 3 [a]

Station	Depth (m)	Width (m)	Velocity (m/s)	Average velocity	Average Depth	Flow rate = $w_1d_1v_1$ (m^3/s)
3a	0	0	0			
				0.167	0.088	0.070
3b	0.175	4.785	0.334			
				0.377	0.213	0.768
3c	0.250	9.570	0.420			
				0.439	0.340	2.143
3d	0.430	14.355	0.457			
				0.229	0.215	0.942
3e	0	19.140	0			

3.1 Flow Rate, Q

The flow rate is obtained from data velocity of the river and the cross section area of every Station. The flow rate result is collected on 13/3/2016. Table 1 until Table 3 shows the cross section and flow rate data for Station 1, Station 2 and Station 3.

3.2 Sediment Grain Size

The finding of this study, for grain size sediment it shows that sediment in river (bed load) and sediment besides the river at all Station are most retained at 0.425mm followed by 10.00mm and 2.00mm. Bed load is the particulate material that moves through the channel fully supported by the channel bed itself [6]. According to [1], the most sediment can be classified as medium sand, medium coarse gravel and fine gravel.

Figure 1 until Figure 3 shows the percentage of particle size distribution from Station 1 to Station 3. The sediment collection is done on 13 March 2016. The result was obtained from the sieve analysis to get the percentage of mass retained at every sieve size used.

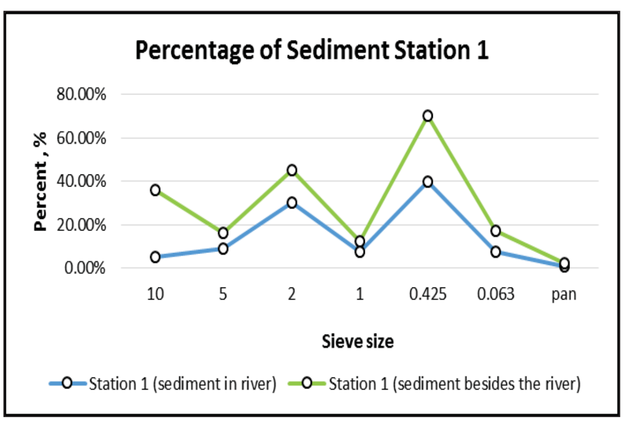

Figure 1 Percentage of Sediment at Station 1

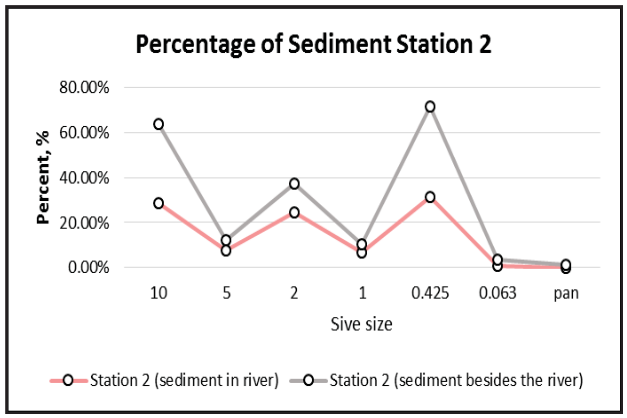

Figure 2 Percentage of Sediment at Station 2

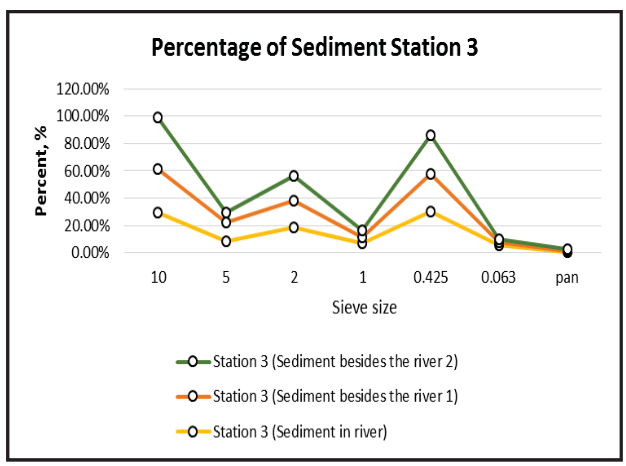

Figure 3 Percentage of Sediment at Station 3

3.3 Analysis Rainfall

Factors influencing sediment transportation was covered by acquiring the flow rate of the river. Total of rainfall genuinely affects the flow rate. From Figure 5, the year receives the least number of rainfalls is in 2008 where amount of 1443mm was recorded. In contrast, the wettest month is in year 2011, records 3775.5mm.

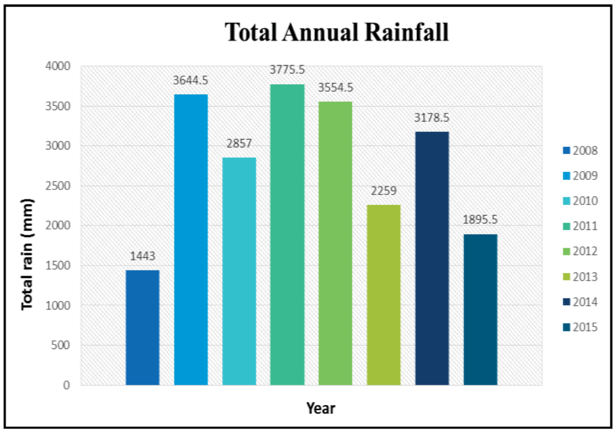

Figure 5 Total Annual Rainfall (2008-2015)

Rainfall in the river catchment area are the primary sources of water discharge, the local water level are also determined in the state of the river bed. Sudden changes in velocity can result in deposition by streams. Within a stream the velocity varies with position and if sediment gets move to the lower velocity part of the stream the sediment will come out of suspension and be deposited.

For example, if the discharge is suddenly increases, as it might be during a flood, the stream will overtop its banks and flow onto the floodplain where the velocity will then suddenly decrease. This results in deposition of such features as levees and floods.

3.4 River Morphology

Water and sediment transport through the Sg. Lembing increase with time due to the reduction of river capacity that resulted from reclamation and sedimentation along the river.

River bank erosion, river bed degradation, river buffer zone encroachment and deterioration of river water quality cause a serious and regular hazard in urban settlements at the area. The powerful water currents wear away at the edges of these settlements during the wet periods and sometimes entire settlements established near the bank are washed away. Figure 6 shows the channel planform modification along Sg. Lembing.

The changes in the channel can be observed in many locations along the river. From these results of cross section changes, it's shown that steep slope in Sg. Lembing has induced higher discharge, and it was associated with the spatial variation in sediment transport and sediment size. The changes in river bed profile may be attributed to the erosion or deposition along the banks or the channel width.

a) Year 2010 ***b) Year 2015***

Figure 6 ***The channel platforms modification along Sg. Lembing in year 2010 and year 2015***

Station 1 is located at the upstream with coordinate N 03 ° 54.329' E 103 ° 01.821' which is nearby Kg. Kolong Pahat. This area is famous and became a centre for tourist rent a chalet or resort that ore provided by the villagers. This section has a width of stream of 16.32 m, meanwhile width of sediment besides of the stream is 40.1 m. The depth of the stream is between 0.2 m to 0.4 m. Figure 7 below shows the morphology changes of river at Station 1, Sg. Lembing in year 2010 and 2016.

Station 2 is located at the upstream with coordinate N 03 ° 54.647' E 103 ° 01.756' which is in front of the Muzium Sg. Lembing. This section has a width of stream of 16.70 m, meanwhile width of sediment besides of the stream is 26.40 m. The depth of the stream is between 0.1 m to 0.5 m. Figure 8 below shows the morphology changes of river at Station 2, Sg. Lembing in year 2010 and 2016.

Station 3 is located at the upstream with coordinate N 03 ° 54.986' E 103 ° 01.995' which is nearby the food court. This section has a width of stream of 19.14 m, meanwhile width of sediment besides of the stream is 116 m and 27.70 m. The depth of the stream is between 0.1 m to 0.5 m. Figure 9 below shows the morphology changes of river at Station 3, Sg. Lembing in year 2010 and 2016.

a) Year 2010 ***b) Year 2015***

Figure 7 ***The changes of the river at Station 1 in year 2010 and 2015***

a) Year 2010 *b) Year 2015*

Figure 8 The changes of the river at Station 2 in year 2010 and 2015

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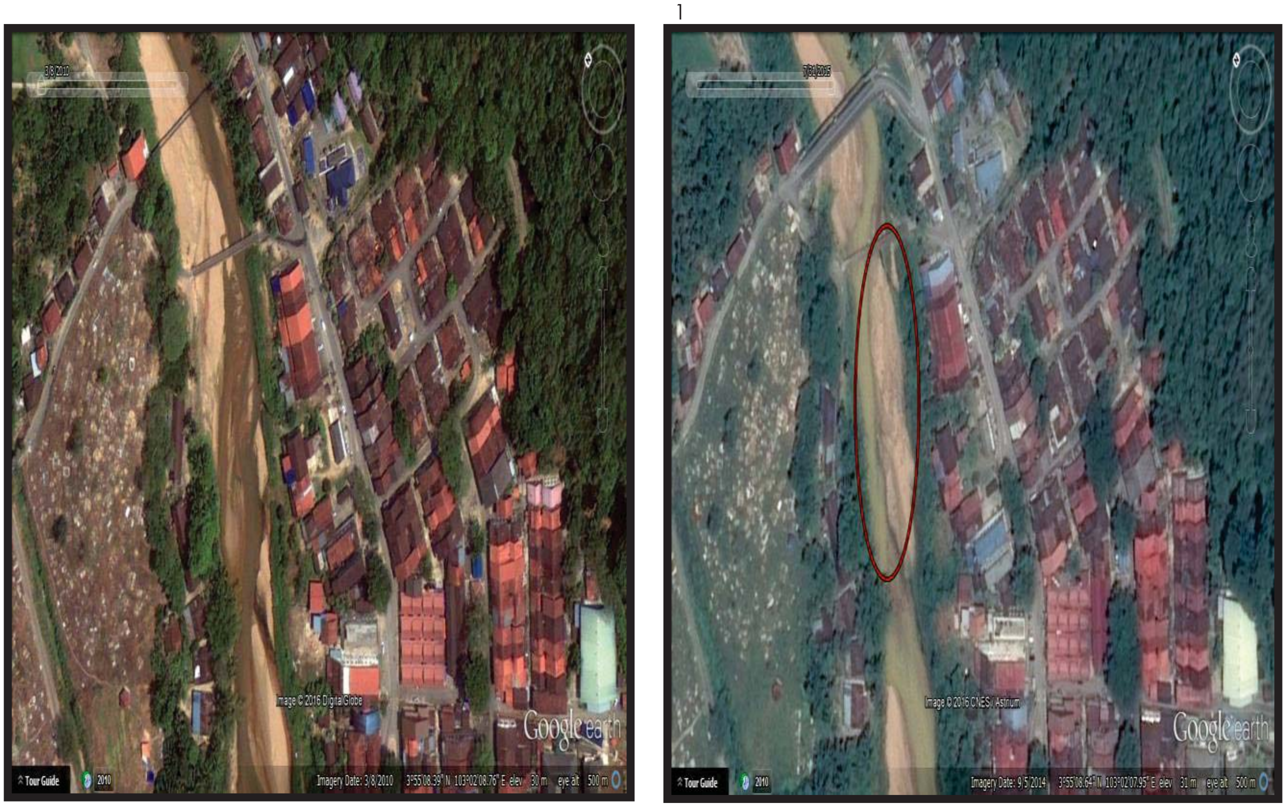

a) Year 2010 *b) Year 2015*

Figure 9 The changes of the river at Station 3 in year 2010 and 2015

4.0 CONCLUSION

Sedimentation and flooding can give an effect to river morphology. The flood problem that happens every year in Sg. Lembing gives the big impact to the river system. During floods sediment is transported in the main channel. The sediment is carried onto the floodplain either by diffusion or convection and, as the flow velocities on the floodplain are generally low, it is deposited. The rate of sediment deposition normally reduces rapidly as one move away from the main channel. Sediment deposition on floodplains is normally largest where there is an exchange of water between the main channel and the floodplain, commonly at bend [5].

In order to carry out the analysis of sedimentation pattern at Sg. Lembing, samples are collected from the study area and sieve analysis graph is used to determine the size of sediment while the types of sediment is determine by reference using USACE table.

From the study, it can be concluded that the sediment and flood give an impacts to the flow or river morphology. The relationship between the flow and the types of sediment deposited and also rainfall distribution can be shown by the graph. The types of sediment at Sg. Lembing are different from upstream to the downstream. Most of the types of sediments at the area are coarse gravel, fine gravel and medium sand. At Sg. Lembing, the types of sediment can be found at the area are 7 types according U.S.Army Corps of Engineer (USACE) size classification., the percentage of coarse gravel that have size between 32-16 mm is high among the other types. The medium sand recorded second high which is 0.50-0.25 mm followed by fine gravel which has size between 8-4 mm. The percentage other types of sediment is below than 10%.

At Sg. Lembing, the area that has the highest velocity is Station 2 that consisted of larger sediments. Most of the types of the sediments at the area are coarse gravel, fine gravel. The other types of sediments are only few at the area because has been wash into the downstream that had a lower velocity.

At Station 1, the velocity at this area is the lowest among other station at the study area. There are still larger sediment like coarse gravel and fine gravel, but increasing of the finer particles such as medium sand can be found at this station.

It shows that, the types of the sediment will flow with the velocity and discharge of the river. The larger sediment will move when there are high velocities while the finer types will settled at the area when flow cannot transport the sediment anymore.

This study had identified the area that contributed high sedimentation to the Sg. Lembing catchment. Also, this study had gained sediment information at Sg. Lembing. The sediment grain size and factors influencing sediment transport are determined. The relationships between size of sediment, rainfall, flow rate, cross section of the river are correlation with each other that can changes the river morphology itself.

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