Research Journal of Applied Sciences 11 (10): 964-969, 2016
ISSN: 1815-932X

River Hydro Morphology Characteristic Influenced by Seasonal Changes: A Case Study in Galas River, Kelantan

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Abstract: Hydro morphology is the field that deals with the structure, evolution and dynamic morphology of hydrological systems over time. Hydrological systems evolve due to variety of both natural and anthropogenic influences such as changes in land and water use caused by urbanization, agriculture, climate change, modifications to water infrastructure and water use. Natural functioning river ecosystems for each environmental driver have a natural range of variability that depends on the geomorphic character of catchment, climatic regime and local factors. The purpose of this study is to elucidate river hydro morphology characteristic in different season of Galas River, Kelantan. Three different types of season were collected to get full hydrological regime properties for complete water year cycle. Results show that, in low flow period, a shallow and narrow channel was observed compare to high flow period which record has a deeper and wider channel. Hence, a liner relationship between discharge against sampling station is $R^2 = 0.9152$ for the high flow and the low flow is $R^2 = 0.7522$. In conclusion, the results indicate that factors influence the channel morphology changes in different season was significant due to the discharge, erosion, sedimentation and enlargement.

Key words: Hydromorphology, seasonal changes, river profiling, channel morphology, galas river

INTRODUCTION

River morphology is one of important challenge for people who involve in any effort of river engineering analysis. It requires a proper understanding of river's morphology features and river's response towards changes (Chang, 2008). River morphology reflects the shape of river channel changes over time. According to Rosgen (1996) the morphology of a river able to influence numbers of processes and environmental conditions, including the composition and erodibility of river's bed and the availability of size and composition of the sediment pass through the channel. Matsuda (2004) stated that three main elements in channel processes are sedimentation, erosion and transpiration. Barbara (2003) classified the river channel as a system that allows water, sediment and solute to flow out into the sea. Additionally, the changes of channel were influenced by specific elements such as discharge, water surface slope, velocity, depth and width of the channel. The factors of these elements occur either from natural factor or human factor.

As known, rivers play many vital roles for human civilization especially for domestic uses, transportation, agriculture, plantation irrigation and etc. Moreover, based on the (DoE, 2009; Ambak and Zakaria, 2010), gold and sand mining as well as legal and illegal logging activities can be found along the Galas River. For information, based on Tan Peck (Yen and Rohasliney, 2013 at the early of 1990s, the Galas River became turbid because of high suspended solids and siltation. As a demand of water resources is escalating for public uses, maintenances and quality of the water must be under control and protected (Yen and Hashim, 2013).

MATERIALS AND METHODS

Study area: Kelantan is one of the largest states in Peninsular of Malaysia which consist of ten districts. Out of then, two districts are included in this research, encompasses the district of Kuala Krai and GuaMusang which been identified located inside the catchment of Galas River. Galas River is one the main tributary of Kelantan River. It has two tributaries which include Galas River and Lebir River. In terms of supply, Galas River is one of the prominent water body systems that contribute to the Kelantan River. The length of Galas River is 178 km and the catchment area is 7,770 km^2. Seven sampling stationswere selected based on several characteristic

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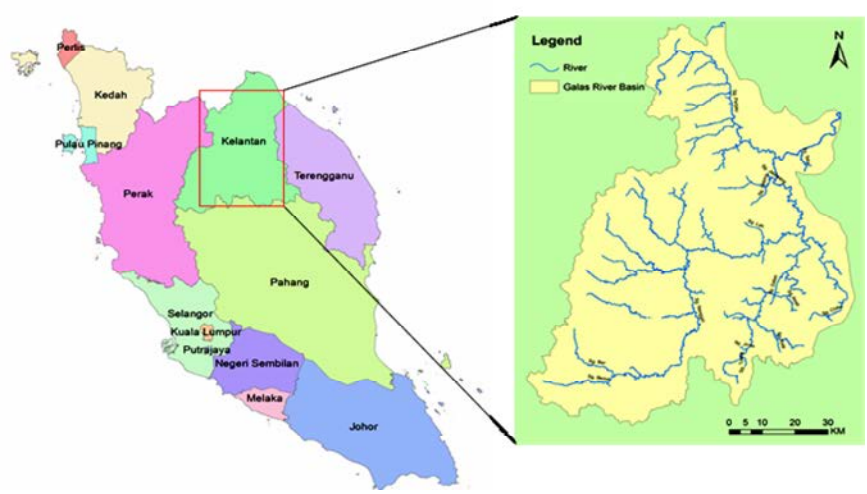

Fig. 1: Kelantan map

which are less obstacles river flow condition and river's straightness. Specifically, the identified stations selected were from areas of Ulu Pulai, GuaMusang, Kg. Terah, LimauKasturi, Kg. BertamBaru, Dabongand Kuala Geris (Fig. 1).

In Galas River, rainfall over the area varies between 0 mm to 1750mm. Dry season occurs between March to May while wet season occurs between October to January. The estimated runoff in this area is 500 m^3 sec^{-1}. (Basarudin and Adnan, 2014). Occasionally, the river often overflows its bank especially between the month of November to early of January due to northeast monsoon season. Three different times of sampling had been conducted in all seven stations represent the different season classified as low, normal and high flow. The sampling design for each station in each season was made consistent to avoid bias results. The first set of sampling began in the third week of May, specifically on May 15th until May 18th 2014. Second sampling was conducted on August 15th to August 17th 2014 while the third sampling on October 16th until October 19th 2014. Bridge and boating method using for river cross section measurement.

Measurements of cross section for this study were determined by using two methods which are bridge and boating method (Autrey, 2001). Both methods are included in this study for several reasons. These two methods were to use within different station because from upstream to downstream of the river has different depth. Besides that, it need to ensure that the reach should be straight and uniform for a long enough distance to provide uniform flow through the measuring section. Velocity reading taken at river's meander part would differ from the velocity recorded at non-meander part of the river as no loop and straight river path will increase the flow of water. Bedside, streambed should be stable, free from any obstacle and protruding obstructions that can disturb or influence the water velocity for every sampling station.In order to perform river morphological analysis, particular sampling stations must first be identified according to desirable criteria. Once the sampling point has been identified, the width of river was measured. A measuring tape was strung at right angles across the river. The measurement taken cross over the bridge could also aid the process of cross sectional measurement. Next, the interval between subsections were designed as no subsection's discharge must be no more than 10 percent of the total discharge of that particular cross section. Area of each cell was calculated from the width and depth of each subsection's cell. River's depth measurements were taken by using staff gauge and handheld depth sounder, while river's velocity was measured by using current meter. The current meter is more user friendly because its capability to measure the water velocity at different depth. Data inputs of velocity (v) and area (A) were computed to calculate the value of river discharge (Q). The Velocity-Area Method:

$$\text{Discharge} = \text{Area} \times \text{water velocity} \quad (1)$$

RESULTS

Longitudinal profile and cross sectional profile are two graphical data capable in displaying changes of river's gradient and the relationship of height of the river above sea level at various points as the water flow from its source. By referring to the past study, morphological studies or profiling studies isimportant in purpose to

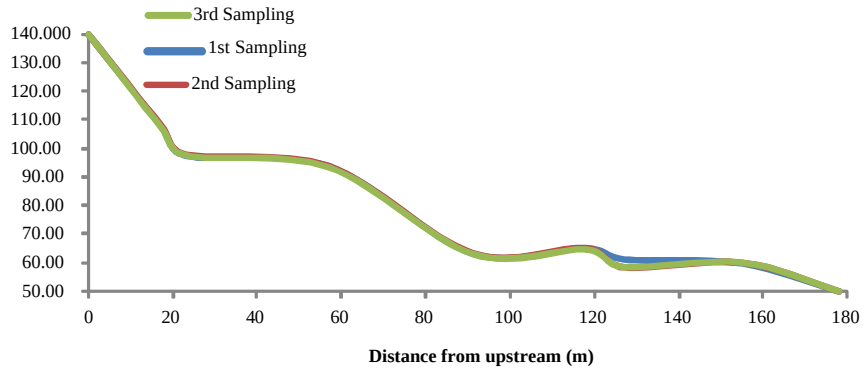

Fig. 2: Longitudinal profile

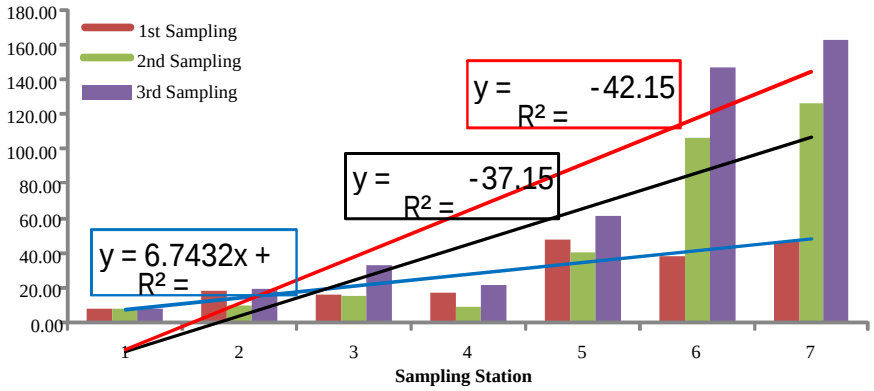

Fig. 3: Flow discharges for sampling station in different season

relate any type of phenomena to the longitudinal profile of riverbased on the problem occurs (Radoane *et al*, 2003). According to the Fig. 2, it summarize for river's longitudinal profile from the sevensampling stations from the downstream to the upstream along the Galas River. The river water travelling from upper to lower part use energy that causing erosion leading to sediment's transporting and depositing. This kinetic energy is produced when water is gravitationally flows down the slope. In context of this study, the upstream of this river is Ulu Pulai has 110 m from mean sea level while Kuala Geris as downstream part only has elevation by 61 m. These two stations have a part of different hydrological characteristic specifically in terms of cross section and flow velocity. The river channel in upstream has 'V' shape compared to downstream has 'U'. The changing of river's morphology from 'V' shape to 'U' shape is influence by several factors such as reduced in kinetic energy, wider in width and shallower in depth as the channel will be flowing out to the sea.

As comparison the linear relationship exist between the discharge and the sampling station for the third sampling as described by the equation y = 49.597x - 79.583 with R^2 = 0.9152. For the linear relationship in first sampling as explain by the equation y = 24.38x -26.527 with R^2 = 0.7522. According to the results addressed in Fig. 3, it is concluded that the total discharge during high flow (third sampling) was higher than the low flow (first sampling) for every single reach of sampling sites.

DISCUSSION

The change of river morphology depends on some influencing factors for it to occur. Amongst these influencing factors are the natural factors and human factors such as seasonal changes, erosion, sedimentation, enlargement and transportation. These factors below have been identified as relevant ancillary data or supporting data required to support this study to carried out. According to the Fig. 4, in different season produce various pattern of river channel morphology. In this study, it was explain details the main reason make changes on river morphology in Galas River. Therefore, in certain sampling sites was additional reason that contributes the changes.

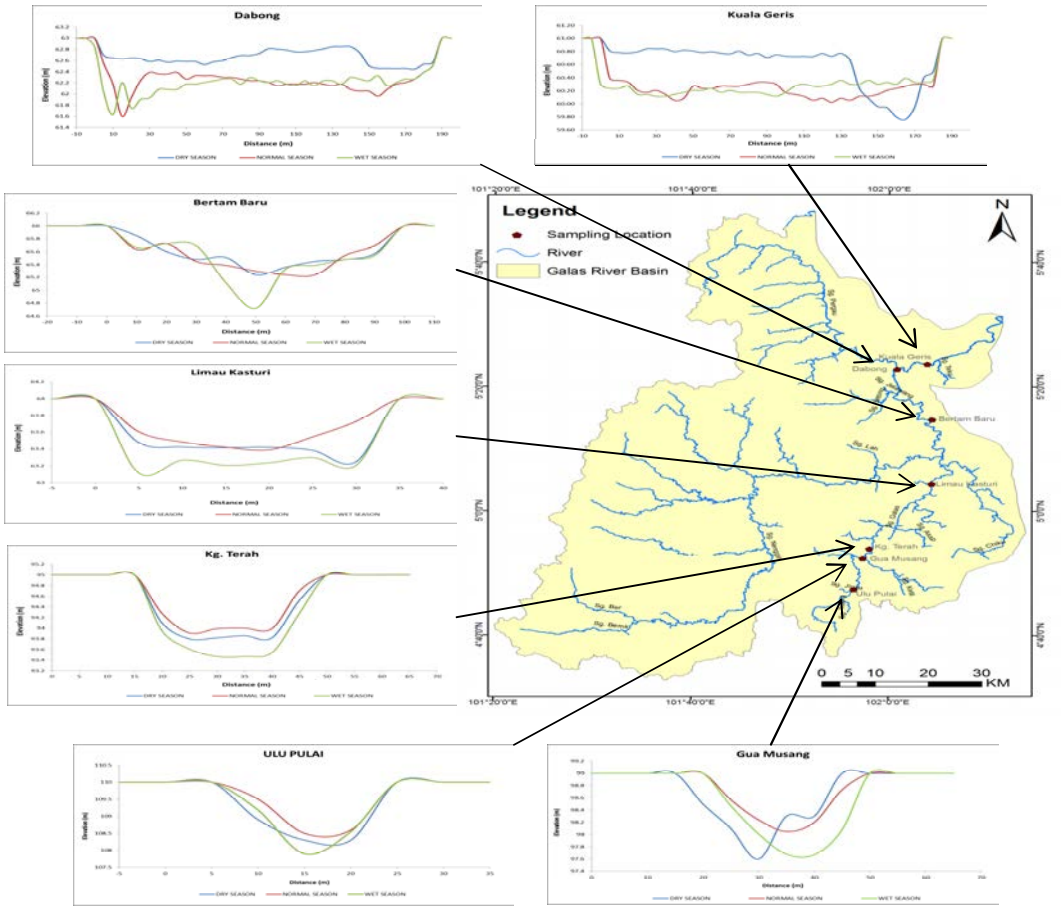

Fig. 4: River channel morphology for each sampling sites

Seasonal changes factor: Seasonal changes is a marked by changes in weather that occur in division of year. From this study, it was selected three season in hydrology term such as low, medium flow and high flow. In low flow season (first sampling) river channel was shallow compared with other season. Thus, hydrologic properties such as water level and streamflow was recorded at that time literally decrease and low respectively compared to other season. So that, the decrease in water level promoting slower river's velocity gives enough time for sediment to settle in particular part of river and cause the river remains shallower in comparison to other season. As compared, high flow dictates the increased amount of river discharge, elevating its kinetic energy and make erosions. The river flow become faster which causing sediments no enough time to settle and the river channeldeeper. From the result, natural corrosion of riverbank is higher during high flow season compared to the low flow and normal flow. Based on Fig. 4, sampling sites that most affected high flow event was Kuala Geris and Dabong. The discharges were continuing increase when heavy rainfall occur and exceed the optimum capacity for the river.

Erosion factor: The energy in a river causes erosion that make the bed and banks can be eroded either making it wider, deeper or longer. River erosion processes claimed its effects in causing river morphology changes at sampling site specifically in Dabong and Kuala Geris. Theoretically, erosion can be described as the detachment of minerals and soils particles transported by water, wind, gravity and also by human activities (Galay, 1983). Nevertheless, any increase in velocity and volume of surface run-offs will be increase the rate of erosion as increasingly large quantities of soil will be swept down theslopes. This situation makes the amount of suspended sediments and water become turbid in stream channel, thus reducing the water quality (Kamarudin *et al*., 2009) For instance, rainfall droplets could be more erosive compared to water flow over the surface. There are several types of erosion has been identified which are natural

erosion and accelerated erosion.Galas River was more affected by accelerated erosion triggered by human activities especially near to river bank and occurs in a very fast duration. Furthermore, the significant erosive agents was identified from the sampling site was boating activity. Galas River is one of water route that is being frequently used by fishermen and boat guider for daily activities especially in Dabong and Kuala Geris. Moreover, the accelerated erosion was detaches and transport soils came from agriculture, construction site and surface mining.

Enlargement factor: An enlargement of channels can cause by the combined processes of incision, bank erosion and direct modification of construction activities. Therefore, increases of discharge amount due to watershed changes that become the river channel wider than natural channel. It will happen especially after the flood event. It was proven by previous study that said the enlargement pattern of river width from upstream to downstream in order to cater the increase amount of water capacity (Jamil *et al*., 2012). In this study, the river morphology shows that the width in left bank ang the right bank becomes wider from upstream to downstream as the proven in previous study. For instance, Ulu Pulai possess 'V' type of channel compared to Kuala Gris possess 'U' type channel.

Sedimentation factor: Sedimentation is one of the factors that contribute to the channel changes in this study. This phenomenon can be described as a process by which eroded particles of rock are transported by water from upstream to downstream.Normally, the sedimentation was caused by the human activities such as logging, agriculture and improper development. In this study, three out of seven stations were dramatically undergoing rapid sedimentation. Those three stations were LimauKasturi, Dabongand Kuala Geris. Based on Fig. 4, the channel of those mentioned stations during low flow recorded the amount of sedimentation. The most affected station is Kuala Geris. This area is located at the downstream in Galas River tributaries.

Transportation factor: Transportation is the process that carried out the sediment load or suspended load. Naturally, the load was transfer from upstream to downstream which means from Ulu Pulai to Kuala Geris. It can see sedimentation problem was occurring in area of Dabong and Kuala Geris. Additionally, the higher the water velocity, the more capacity a river has for transporting sediment load. There are three different processes in transporting sediment load such as corrosion, suspension and traction. Corrosion is the process in which stream water corrodes rocks and brings them invisibly into solution such fine materials as clay, silt, fine sand and materials lighter than water are transported in the water or on the water surface without contact with the river bed. For the suspension process when materials carried in suspension are the suspended loads and creates the turbidity of stream water. Gravel of largerdiameter slides or rolls and sand hops or bounds on a river bed was called as traction process. Sediment load carried by traction is known as bed load. The main process of transportation involved in this study area was traction.

CONCLUSION

According the result obtain, it can conclude thatthere is significant different between seasonal fluctuations and their effects towards the river channel morphology changes. The river channel morphology in different season creates different characteristic river channel morphology. These different river channelsadditional from the enhance process of erosion, scouring and sediment loading that occur in Galas River. Low flow recorded a shallowand narrow channel section compared to the high flow event has a deeper and wider channel. Additionally, the different of river channel cause from human activities along Galas River such as logging, agricultural and human settlement. All these activities, contributed to increment of sediment loading volume and erosion in study area. Thus, the result and data provided from this study can help local authorities to take action in overcome the problem in Galas River especially sediment load and erosion problem. The local authorities should control the development of river and enhance the sustainable environmental management along the Galas River.

ACKNOWLEDGEMENT

The study was funded by the Grant of GP-IPM 9402600 that provided from the fund of University Putra Malaysia. Special thanks to the local people in the study area that give co-operations to do this study. Cordial appreciation goes to staff from the Faculty of Environmental Studies, UPM.

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