STUDY OF MORPHOLOGICAL CHANGES IN BRAIDED RIVER REACH

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ABSTRACT

Temporal variability of flows and sediments and bank erosion is fundamental to understand river dynamics. The temporal variability of sediment load and effective discharge class is one of essential information which is require to improve the barrage and canal operations for flow diversion into the canals. Similarly, bank erosion causes substantial land loss along the river banks due to erosion. Moreover, understanding for the impact of flood events on bank erosion are also lacking for sand bed braided river reaches. Similarly, quantitative relationship between branch channel movement and river bank erosion also have not attained significant attention.

The river reach just starting from downstream of the Marala barrage to the 7 km downstream was selected to study the bank erosion. The reach is braided with small unstable sand bars and few semi-stable islands and river flows in multiple channels during low flows. The major proportion of the flows in the Chenab River occurs during monsoon season, which brings lot of sediments from the catchment. Thus, sediments in the river flows not only cause changes in the morphology of river but also diversion of highly sediment laden flows into the canals which creates sedimentation issues. Therefore, firstly, sediment rating curve, variation of sediment load and effective discharge for different temporal scales were examined. Secondly, the changes in the river were assessed and the relationships of river bank erosion with branch channels movement and floods magnitudes (during different flow regimes) were developed. Thirdly, two dimensional (2D) hydrodynamic numerical model was simulated for the flows/floods of 2010 and the results were coupled with the excess shear stress approach to predict the bank erosion and identify the river bank locations more vulnerable to erosion.

The temporal changes of sediment load were assessed through double mass curves. Based on these changes, sediment rating curves for each evaluation period i.e., Evaluation Period-1 (EP-1) ranging from 2000 to 2004 and Evaluation Period-2 (EP-2) ranging from 2005 to 2011, were developed. Therefore, sediment data was analyzed for each evaluation period. The base line period is selected from 1997 to 2000 and the changes in sediment load are analyzed for both evaluation periods. Eleven flood events were selected to assess the bank erosion. The impact of floods on river bank erosion and channel evolution was analyzed under low and high flow conditions. Flood induced changes, for river's external banks and channel evolution were assessed by processing Landsat ETM+ images in Arc GIS tool and their inter-relationship is evaluated through regression analysis. The study emphasized on the sediment dynamics and river bank erosion which are the major factors which cause river morphological changes.

Results obtained from double mass curve of flows and sediments revealed that sediment load increased by 8% during evaluation period-1, while decreased by 22% during evaluation period-2 in the river. The results suggest that monsoon floods are mainly responsible for sediment loading in the river; supported by the finding that effective discharge (1700–2100 m^3/s) is almost twice the mean annual river discharge (918 m^3/s). Over the 15-years study period, the discharge classes between 900 and 2900 m^3/s are mainly responsible for major proportion (76%) of the total sediment load in the river. The sediment load increased during the evaluation period-1 and decreased during evaluation period-2.

The river banks experiences erosion that caused the widening of the river section. The average annual bank erosion rate is 34.3 m/y which is much higher on a global scale. The river reach has widened about 6% during the study period due to bank erosion, especially along the right bank. The results revealed that the major morphological changes were triggered by the flood events occurred during the high flow or Monsoon season (July-September), whereas the flood events of relatively similar magnitude occur during low flow season (October-March) did not induce such changes. Mostly, the erosion remained limited to the middle segment of the reach, where the branch channel remains along the bank. Data analysis showed a strong correlation between the mean high flows and total bank erosion indicating that Monsoon seasonal flows and floods are responsible for bank erosion. The present study further identifies the river bank locations highly susceptible to erosion for the selected reach and similar approach can be used for other river reaches by developing the relationship between bank erosion and branch channels progression towards outer banks for the braided reaches of sand bed rivers. However, it is also concluded that the presence of sand bars along the river banks reduces erosion and weakens this relationship.

The calibration of predicted bank erosion by excess shear stress approach with the image analysis results showed that the erodibility coefficient, originally developed by Hanson and Simon (2001), under predicted the bank erosion for the selected reach. Therefore, the relationship was modified for the estimation of erodibility coefficient. Similarly, two dimensional hydrodynamic modeling provided the good agreement in identifying the bank locations more vulnerable to erosion. Findings of the present study can help in developing better understanding about the temporal changes in sediment load, bank erosion process and constitute a key element to inform and improve river bank protection works for the study reach.