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RIVER RESPONSE IN THE SELECTED REACH OF JAMUNA RIVER DUE TO DREDGING

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Abstract

Dredging in a river is certainly a human intervention need to be analyzed for better planning and decision processes. In this study, an attempt has been made to analyze the river responses due to dredging on a selected reach of the Jamuna River by preparing a morphological model of this river. The study reaches covers from 30 km upstream of Bangabandhu Bridge to 20 km downstream of this bridge. Various important hydraulic structures are situated around this area like East Guide Bund and West Guide Bund of Bangabandhu Bridge, Sirajganj Hard Point and Bhuapur Hard Point. Among all, Sirajganj Hard Point area has been focused here as a prime concern. To setup these morphological models, MIKE 21C, an advanced two-dimensional mathematical modeling software developed by DHI, has been applied and numbers of simulations have been conducted for different dredging conditions to fulfill the study objectives. From analysis, it has been found that with the increasing of dredging depth, dimensionless velocity increases along the dredged channel and decreases along the bank. Moreover, the bed materials along the bank stay at the threshold point of erosion during average flood year of the Jamuna River while at higher dredging depth condition, the velocity along bank decreases in such an amount so that it becomes lower than the critical velocity and the bank becomes non erosive zone. Due to dredging, bed scour near Sirajganj Hardpoint decreases maximum 33.4% for 7 m of dredging depth and average rate of decreasing of bed scour is 5.5% per meter of dredging depth. However, if dredging executed near Sirajganj Hardpoint, the channel became wider as the dredging depth increases. Finally, a technique has been introduced using the relationship curve between Dimensionless Velocity and Relative Dredging Depth to evaluating optimum dredging depth for planning dredging.

Introduction

Getting idea on river response due to dredging is a complex task. Two-dimensional morphological model can be treated as a useful tool to overcome this complexity. Change in a river due to any interference is a time depending morphological process in nature (Vries 1993). Rivers always try to achieve a stable state of equilibrium throughout it reaches over a period of time. One of the major river in Bangladesh, Jamuna is very dynamic in nature and the sufferings it causes to the people along with damages to national properties; the river has drawn the attention of researchers and planners. Several researchers like Coleman (1969) and Bristow (1987) have carried out comprehensive studies on the Jamuna River. Later in the 1990s, a number of studies were carried out to understand the behavior of the river in relation to the construction of the Jamuna Bridge. Besides that many researchers have conducted numerous experimental works, analytical studies and numerical modeling in the field of river response due to dredging. As example, Lagasse (1986) shape can retard the movement of bed-load sediments through a river system. In this context an attempt has been made to understand the river response due to dredging for a braided river like Jamuna using 2D morphological model.

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Methodology

In connection with this study, a two-dimensional morphological model has been setup in the selected reach of Jamuna River. To setup this model several related data including bathymetry, banklines, historical water level and discharge, sediment data and other information have been collected from different sources. To evaluate the response due to dredging, a two-dimensional morphological model has been setup using MIKE 21C software. Several steps have been followed to setup the model that includes grid generation, bathymetry preparation, boundary generation, calibration and validation. In this regard, cross-section of Jamuna River of the year 2010 has been used for the model bathymetry. The grid and bathymetry are shown in Figure 1. The upstream discharge boundary at the 30 km u/s from Bangabandhu Bridge (generated by flood routing using the Bahadurabad discharge data) and downstream water level boundary at the 20 km d/s from Bangabandhu Bridge (generated by analyzing the slope and distance) have been set up according to the model area and finally simulations have conducted for average flood event (hydrological year 2005).

The base model has been calibrated and validated against the year of 2010 and 2011, respectively. The calibration plot of water level and the validation plot of a cross-section of Jamuna River near Sirajganj Hardpoint have been shown in Figure 2 and Figure 3. The following parameters have been used for simulation of the 2D morphological model of Jamuna River.

Chezy C = $20h^{0.5}$, Eddy viscosity = 1, Sediment transport equation: Van Rijn
Bank erosion parameter: Slope = 1:10, Erodobility coefficient = 0.04

After setting up the model for Jamuna River, a suitable dredging alignment has been fixed keeping morphological phenomena in mind, also shown in Figure 1. Such an alignment has been fixed so that flow passes through the proper channel and causes no adverse effect in Bangabandhu Bridge as well as its adjacent hydraulic structures. Simulation have been conducted for different options which are made by varying the depth of the dredging section, shown in Table 1. A 15 km long channel has been dredged following the design dredged section near the Sirajganj Hard Point (Figure 1). Bottom width of the dredged section and the side slope of the section is 500 m and 1:3, respectively. Six different options have been carried out by varying the dredging depth from two to seven meter at one meter interval.

Finally, river response in the selected reach of Jamuna due to varying dredging depth have been analyzed by comparing the relative dredging depth with the dimensionless velocity. Moreover, a relation between bank erosion with the dredging depth is also developed.

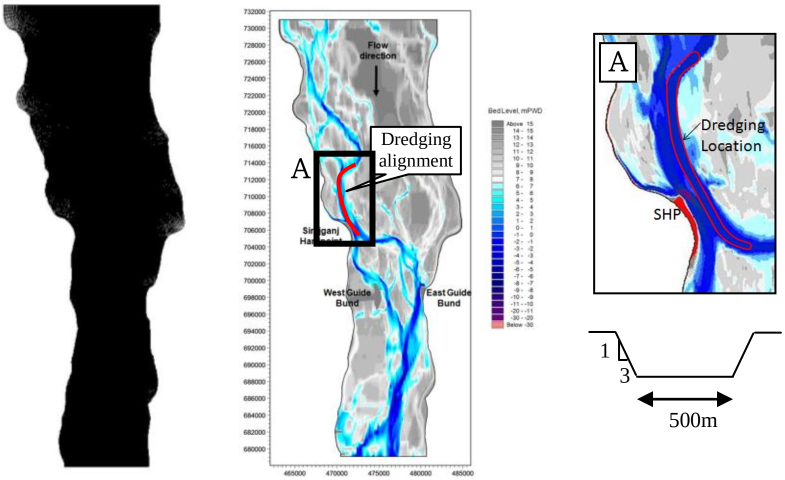

Figure 1. Computational grid, generated bathymetry and design dredge section of the dredging alignment for the study reach of Jamuna River.

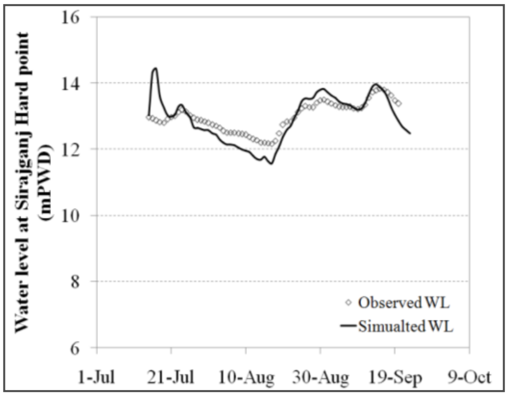

Figure 2. Comparison of model simulated and observed water levels of Jamuna River at Sirajganj

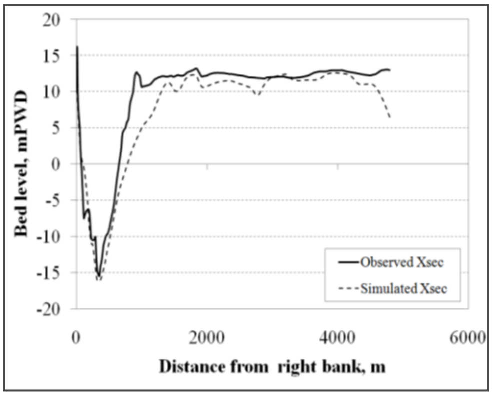

Figure 3. Comparison of model simulated and observed cross-section of Jamuna River near Sirajganj Hardpoint

Table 1. Different option simulations

Options	Dredging width (m)	Dredging depth (m)
Option 1	500	2
Option 2		3
Option 3		4
Option 4		5
Option 5		6
Option 6		7

Results and discussion

The simulated morphological change regarding planform of channel, bed scour are also extracted from the model to understand the relation with dredging.

Channel layout

Plan view of Jamuna River for different dredging depths has been extracted (Figure 4) from model and it is seen that in base condition, the left anabranch near Sirajganj Hardpoint became silted up at the end of monsoon. However, if dredging executed along the dredging alignment, this channel became widened and getting deeper as the dredging depth increases. Here, Option 6 represents the deepest dredging depth among all the options, though dredging width in all options are same. Thus, Option 6 generates deeper channel (Figure 4). Moreover scour depth in front of Sirajganj Hardpoint decreases with the increase of dredging depth.

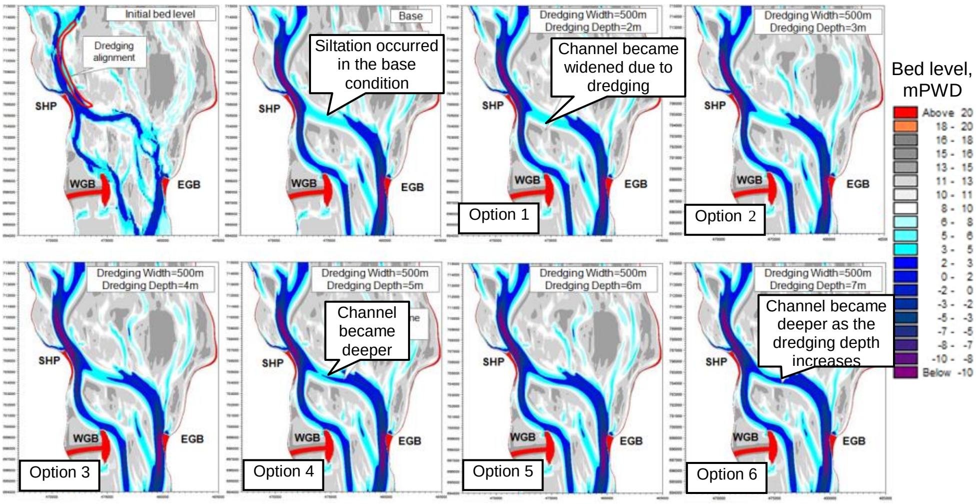

Figure 4. Simulated bed level of Jamuna River for different dredging depth

Bed scour

Cross-section of Jamuna River for different dredging depths also shows that the channel became wider due to dredging (Figure 5). Moreover, scour depth in front of Sirajganj Hardpoint decreases with the increase of dredging depth. Maximum bed scour near Sirajganj Hardpoint decreases 33.4% for 7 m of dredging and on average the rate of decrease of bed scour is 5.5% per meter of dredging depth. The conveyance area also becomes higher as the dredging depth increases. It is worth mentioning here that the dredged channel is silted up more than 30% after the monsoon. So, frequent maintenance dredging would be required.

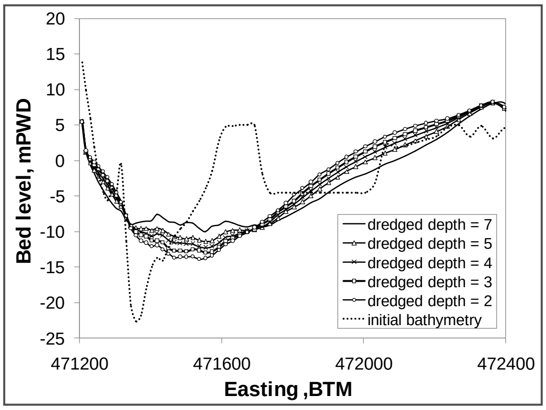

Figure 5. Simulated cross-section in front of Sirajganj Hardpoint for different dredging depth

Relationship between dimensionless velocity and relative dredging depth (for selected reach of Jamuna River)

Velocity and other required parameters are extracted from the simulated model at different locations (at the starting point, middle point and tailing point) along the dredging alignment. It is seen that dimensionless velocity increases with the increase of relative dredging depth along the dredge channel. On the other hand, near the bank location dimensionless velocity decreases with the increasing of relative dredging depth though the rate of decreasing of dimensionless velocity is very low. At the starting point of dredging alignment, numerically 8.8% dimensionless velocity increases at dredged channel location and 1.4% dimensionless velocity decreases near the bank location for 7 m of dredging. These values are more or less similar for the middle position of dredging alignment. At the tailing point, almost 17.3% dimensionless velocity increases along the dredge channel and 15.1% dimensionless velocity decreases near bank location for 7 m of dredging.

The relationship between dimensionless velocities with the relative dredging depth at different locations of Jamuna River are represented in Figure 6. All the plots are showing concave downward shape, the slope of the curve is increasing for along the dredged channel and decreasing for near bank location. Only at the tailing point at near bank location (Figure 6f), the shape of the curve is concave upward.

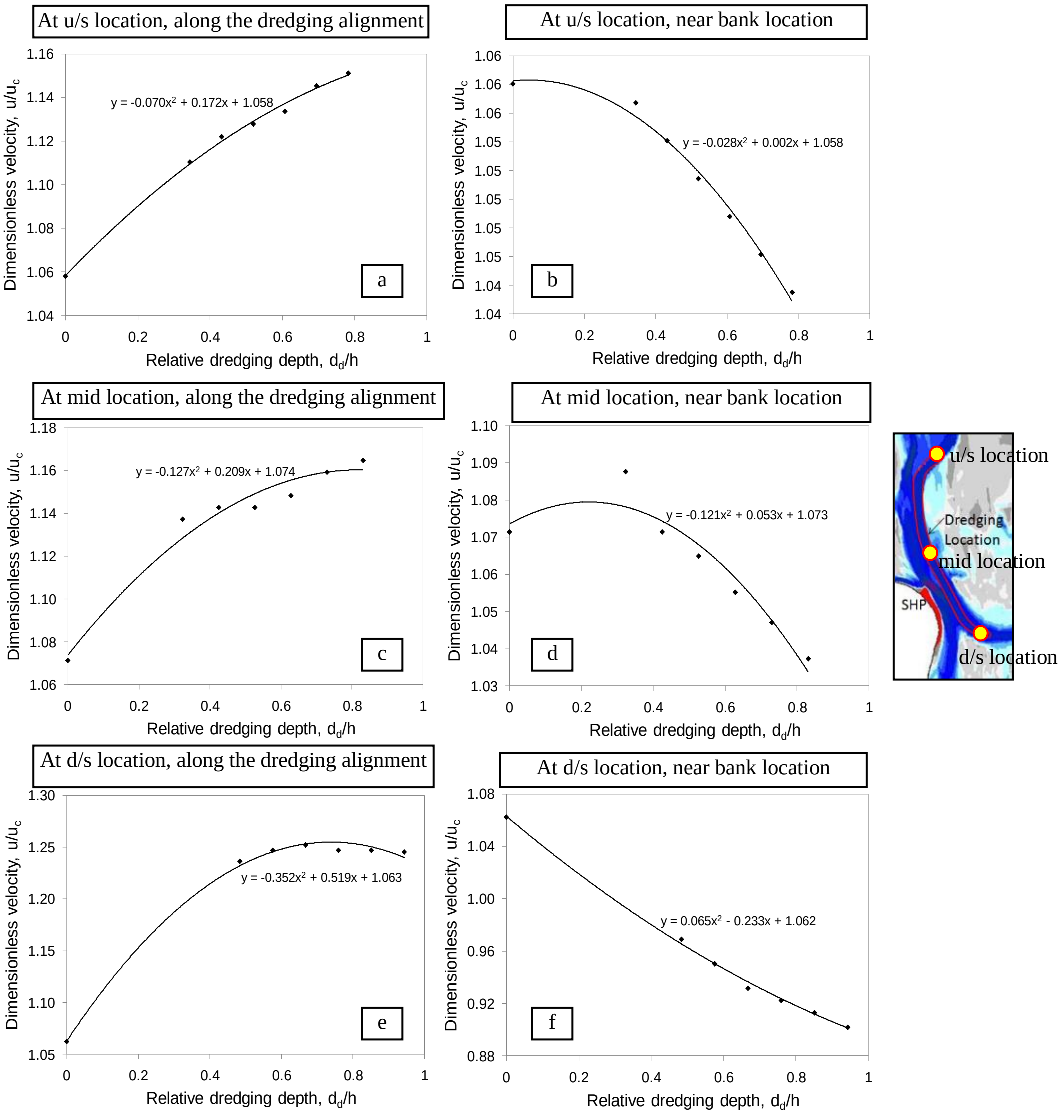

Figure 6. Dimensionless velocity Vs relative dredging depth curve for Jamuna River at different location of dredging alignment

As Jamuna River has the erosion tendency, hence a relationship has been generated between bank erosion with the dredging depth. It is found that model bank erosion decreases with the increase of dredging depth, Figure 7. In some point the bank erosion decreases maximum 50m.

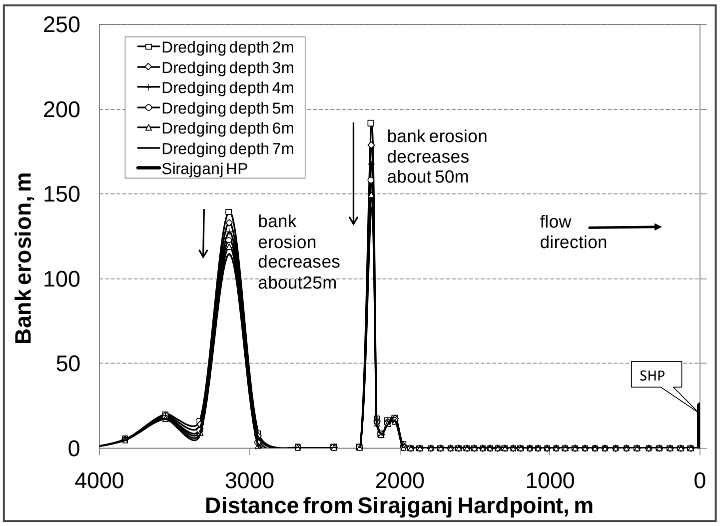

Figure 7. Simulated bank erosion for Jamuna River

In this study, bank erosion is also calculated by Mosselman Equation (FAP 24 1996) at the few kilometers upstream of SHP. It is seen from the calculation that with the increasing of dredging depth bank erosion decreases (Figure 8). So, the Mosselman equation also support the model results. It is worth mentioning here that the coefficient for the Mosselman equation has been fixed by comparing the simulated bank erosion results. In doing so, the time averaged erosion coefficient E_u is considered here as $10.6*10^{-5}$ for Sirajganj (calculating by interpolation). From FAP 24, it is found that the value of E_u is $9.5*10^{-5}$ for Bahadurabad and $7.2*10^{-5}$ for Kamarjani. Both of the locations are 75 km and 100 km upstream from Sirajganj Hardpoint, respectively.

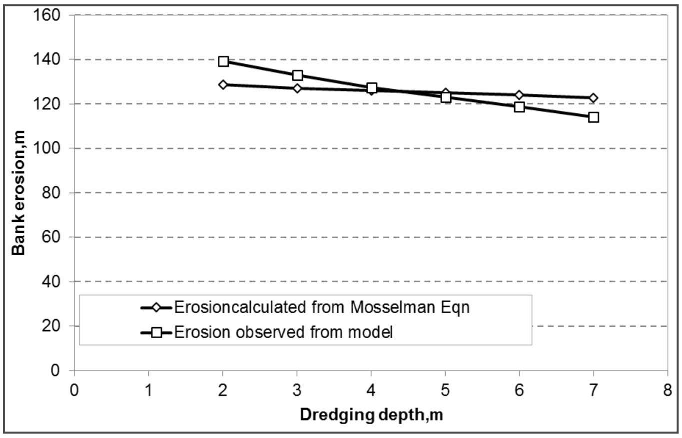

Figure 8. Comparison of simulated and calculated bank erosion

A sample calculation for optimum dredging depth

Dredging is a massive work, huge money and labor is involved in a dredging project. So, an optimum solution is required for allowable bank erosion. In this study, maximum bank erosion is found 140 m near Sirajganj. It is also seen from both the simulated and measured equation that with increasing of dredging depth, the bank erosion decreases. Now, if the maximum bank erosion is allowed 20 m near Sirajganj, the bank velocity is found 0.49 m/s from Mosselman equation (FAP 24 1996). Then the dimensionless velocity at the bank becomes 1.04 m/s. Now from Figure 6d, for dimensionless velocity 1.04, the corresponding relative dredging depth is found 0.82. As the average water depth at dredging location is 8.18 m, so the allowable dredging depth should be 10m near Sirajganj.

Conclusions

These are the conclusions that have been made from this study:

i. On Jamuna River, it has been observed that velocity increases along dredged channel and decreases along bank with increasing dredging depth. Numerically in some point dimensionless velocity increases maximum of 17.3% for 7 m of dredging depth. This is happened due to attracting flow toward dredged channel on increasing dredging depth. On the other hand, along the bank dimensionless velocity decreases maximum of 15.1% for 7 m of dredging depth.

ii. In Jamuna River bed scour near SHP decreases maximum 33.4 % for 7 m of dredging depth and the average rate of decrease of bed scour is 5.5 % per meter of dredging depth.

iii. From plan view analysis it is seen that in base condition, the left anabranch near Sirajganj Hardpoint became silted at the end of monsoon. However, if dredging executed along the dredging alignment, this channel became widened and was getting deeper as the dredging depth increases.

iv. Finally bank erosion is calculated using the model simulated data. It has been found that the bank erosion is decreases with the increasing of dredging depth. Mosselman equation is also used for comparing the bank erosion result found from simulation. A slight deviation is found between the two results due to some valid reasons. To overcome this deviation, a value of time averaged erosion coefficient E_u in Mosselman Equation is suggested for Jamuna River near Sirajganj area which is $10.6*10^{-5}$. Using Mosselman Equation further erosion along the bank could be calculated. Moreover, this bank erosion value and developed relationship curve between the dimensionless velocity and relative dredging depth would be helpful for planning the optimizing dredging depth.

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References

Bristow C.S. 1987. Brahmaputra River: channel migration and deposition, in Ethridge, F.G., Flores, R.M. and Harvey, M.D. (Eds) Recent Development in Fluvial Sedimentology, Soc. Econ. Paleon. and Mineralogists. 39: p-63-74.

Coleman J.M. 1969. Brahmaputra River: channel processes and sedimentation, Sediment. Geol. 3: p-129-239.

FAP 24 1996. Morphological processes in the Jamuna River, Special Report No. 24, River Survey Project, Prepared for Water Resources Planning Organization (WARPO), Dhaka, Bangladesh.

Lagasse P.F. 1986. River Response to Dredging, J. Waterway, Port, Coastl. and Ocean Engg. 112(1): Paper No 20313.

Vries D. 1993. Notes on River Engineering, TU Delft, The Netherland.