Asian Journal of Water, Environment and Pollution, Vol. 12, No. 3 (2015), pp. 65–69.
DOI 10.3233/AJW-150008

Causes of Sedimentation Problem in Bakkhali River Estuary, Cox's Bazar, Bangladesh

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Received June 9, 2014; revised and accepted June 16, 2015

Abstract: Sedimentation problems generally occur at locations where the sediment transporting capacity of the hydraulic system is reduced and it is most often associated with human interference in the physical system. The natural sediment load in Bakkhali estuary is comparatively higher and changes drastically. In the monsoon after a heavy rain large amount of sediment, locally called "charis", is transported and a great amount of sand is carried through its water flash whole round the year. But the construction of the rubber dam in Bakkhali River due to the conservation of fresh water from upstream and to prevent saline water intrusion from the downstream causes the siltation in the upper region of the Bakkhali River. Again the river is getting narrower day by day due to the dumping of garbage by local people and the encroachment on both sides of the river by erecting illegal structures by land grabbers. So, these entire human interference factors restrict the normal flow velocity as well as the natural transportation of sediment load through the estuary. As a result the deposition intensity in the Bakkhali estuary decreases which may affect the process and characteristics of estuary evolution.

Key words: Sedimentation problem, Bakkhali estuary, rubber dam, encroachment.

Introduction

An estuary is a semi-enclosed coastal body of which has free connection to the open sea, extending into the river as far as the limit of tidal influence and within which sea water is measurably diluted with fresh water derived from the land discharge (Nichols and Biggs, 1985). According to the sedimentologists, estuary is the seaward portion of a drowned river valley which receives sediment from both fluvial and marine sources. It may be affected by tide, wave and river processes. Bakkhali river estuary is one of the important estuaries in Bangladesh located at Cox's Bazar, at the south-eastern coast of Bay of Bengal. Here the natural sediment load is higher due to the easily erodible semi-consolidated sediment from the tertiary hills along the catchment area of the Bakkhali River.

Though sedimentation is a natural process but the problem occurs with human interferences in the hydraulic system and the sediment transport capacity of the system is reduced due to the decrease of the steady and oscillatory flow velocities and related turbulent motions. Examples are: the expansion of the flow depth and width due to natural variations or artificial measures such as dredging, the presence of vortex or eddy zones, flow separation zones, dead water zones and lee zones of structures. Expansions of the navigational depth will reduce velocities inducing shoaling. Similarly, the expansion of the width of turning and mooring basins inside a harbour area will reduce velocities stimulating shoaling conditions (Van Rijn, 2005).

Due to high demand of water during the dry season for agricultural production, a bulk of water is being

withdrawn from the Bakkhali River by the local people for irrigation of agricultural fields for production of rice and cereals. They have been practicing this since 1952 by building an earthen dam across the river, which later on was permanently replaced with a 'rubber dam' for the fulfillment of the local demand in 1995 (Sustainable Water Management, Cox's Bazar, 2008).

Again a massive land grabbing along the bank of the Bakkhali River for last few years is going on. People built house, businessman establish their business and local people dump their garbage to a great extent (Jinnat, 2013). So the Bakkhali river estuary experiences a huge human interference which accelerates the sedimentation problem of this estuary.

Study Area

The study area is the Bakkhali river estuary at Cox's Bazar. It is at the southern region of Bangladesh (Figure 1). The approximate geographical location of this estuary is between 20º 85′ 40″-20° 46′ 92″ N and 91° 96′ 60″-92° 34′ 37″ E (Abu Hena et al., 2013). It originates in the Arakan Mountains, flows north and then turns to the west flowing past Ramu and Cox's Bazar towns, finally falling into the Bay of Bengal after meeting with several tributaries.

Characteristics of Bakkhali River Estuary

The estuary is approximately 0.5 km wide and more than 10 m deep at its midpoint. Tidal data was collected from Bangladesh Inland Water Transport Authority (BIWTA) of the Bakkhali River of the year 1990 and 2001-02 and found that it has a semidiurnal tidal regime (Sustainable Water Management, Cox's Bazar, 2008). The estuary is directly influenced by this semidiurnal tides and the tidal range is varied between 0.07 m and 4.42 m during neap and spring tide respectively (Belaluzzaman, 1995).

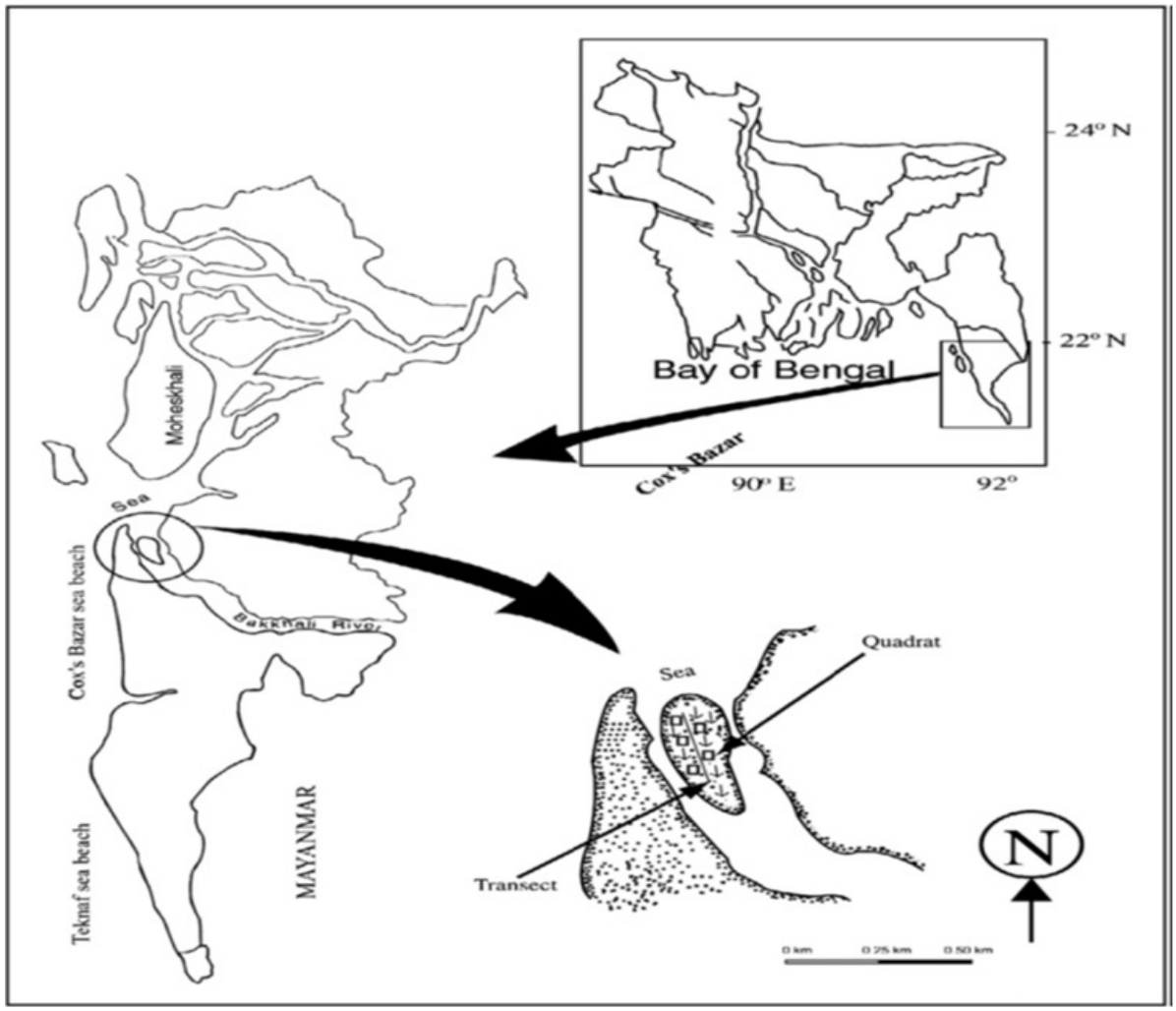

Figure 1: Study area location showing the Bakkhali River Estuary at Cox's Bazar.

The average tidal range is about 2.0 m. The estuary zone is heavily influenced by monsoonal wind and also characterized by long intertidal mudflats (Abu Hena et al., 2012). Normally, 80% to 90% of the annual rainfall occurs during the monsoon months of June to September (Sustainable Water Management, Cox's Bazar, 2008).

Sedimentation Process in an Estuary

Estuary sediments are usually derived from the river watershed and the continental shelf and both the landward transport of sediments by tidal currents and river inflow supply sediment to an estuary. The contributing sources for the sediments are erosion within the estuary, biological activity and eolian transport. Here the sedimentation pattern is controlled by the interactions between the available sediments, bottom topography and flow hydrodynamics. If the rate of sedimentation and energy available for transportation are not in balance, either trapping or by-passing can occur. Sediment cycling may occur through three combinations:

1. The sediment may transport through the estuary and discharge to the shelf by force or by river flooding or by strong wave, tidal and circulatory mixing. Sediments may be deposited temporarily in the estuary and then moved out of it in progressive steps with each flood or storm.
2. The sediment can be partially trapped in a closed circulation system with some escaping and some released by extreme flooding or storm wave conditions.
3. The sediment settles deposits and accumulates in low energy parts of the estuary where it will not be removed by flooding or storm waves.

Suspended load are removed both by flood and ebb flow. There is net inland transport of suspended sediment with deposition on tidal flats and marshes. Sand deposits are present sporadically; otherwise monotonous sequence of silts and clays. Shell and plant fragments are common components which are usually lenticular layers developed by concentration and reworking of the sands by currents (Nichols and Biggs, 1985).

Sedimentation Problem in an Estuary

Sedimentation problems generally occur due to the decrease of sediment transporting capacity because of reducing the steady and oscillatory flow velocities and related turbulent motions of the hydraulic system. Sedimentation problems are most often associated with human interference in the physical system such as the construction of artificial structures or the dredging of sediment from the bed to increase the flow depth or width. Erosion often occurs in places where sediment cannot be supplied by nature in sufficient quantities because it is trapped in another part of the system. The trapping can be due to natural causes or due to manmade changes in the system. Natural navigation channels in estuaries often suffer from the generation of bars/shoals at the transition of flood dominated and ebb dominated channels (Van Rijn, 2005). Factors enhancing sedimentation are:

- Deep and wide channel
- Orientation almost normal to the flow
- Strong flows and large waves passing the channel
- Fine sediment (fine sand and mud)
- Alignment through shoaling areas

The influences of reservoir regulation and water and soil conservation programmes carried out in the upper and middle reaches of a river may change the conditions of inflow and sediment load to the estuary, and thus affect the characteristics of estuary. Then various engineering measures should be taken in the estuary thus to guarantee the safety of the estuary and to maintain a relatively stable flow path for a long period of time (Li and Wang, 2003).

Table 1: Sedimentation problems in estuaries and coastal seas

Channel sedimentation	*Basin sedimentation*	*Shoreline sedimentation*
1. Navigation channels	1. Harbour and port basins, docks	1. Up drift area of groynes and breakwaters normal to shore
2. Inlet channels	2. Open settling basins, turning and mooring basins, mining pits	2. Leeside area of offshore breakwaters parallel to shore
3. Entrance channels of harbours, docks and water intakes	3. Water intake basins	
4. Trenches for tunnels, pipelines and cables	4. Flood plains and reservoirs	

Classified by Van Rign.

Sedimentation Pattern of Bakkhali River Estuary

Sediment is a natural component of aquatic systems, derived from physical, chemical and biological input in watersheds (James, 2002). Sedimentation is a basic phenomenon of nature dealing with loose sediments within the transporting cycle from source to sink locations (Van Rijn, 2005). The study area lies within the tertiary hills of eastern folded belt. The hills are made of semi-consolidated sediments, they are easily eroded and sediment load is generally high and the sediment load changes drastically here. In the monsoon after a heavy rain large amount of sediments may be transported; this is locally called "charis". In the dry season the amount of the silt transport varies little. A great amount of sand is carrying through its water flash whole round the year (Sustainable Water Management, Cox's Bazar, 2008).

Rubber Dam along Bakkhali River

Construction of Bakkhali rubber dam was started in February 1995 and completed in May 1995. The dam collapsed in January 2001, and was later reconstructed in 2004-05. The dam conserves fresh water upstream and prevents saline water intrusion from downstream. The dam is inflated in December-January and the retained water is used for irrigation of Boro rice by LLPs up to 12 km upstream of the dam site in dry season (from January to May). The dam is deflated in March-April turning the river back to free flowing. The rubber dam conserves about 80 million m^3 of water (Sustainable Water Management, Cox's Bazar, 2008).

Table 2: Important features of Bakkhali Rubber Dam

Description	*Bakkhali dam*
Length of dam bag	84 m
Height of dam bag	3.5 m
Weight of dam bag	14 ton
Max. retention height	4 m
Cost	36 M Tk.
Construction year	1994-95
Irrigation area	6000 ha
Protective works:	
Upstream	9 m
Downstream	13 m

Causes of Sedimentation Problem in Bakkhali River Estuary

Generally the rate of sedimentation increases in wide channel. Sedimentation process also enhances in case of fine sediment. From the above discussion of the characteristics of Bakkhali river estuary, it is found that it is comparatively wide and the bathymetric condition mostly consists of muddy and sandy particles. Here, sediment load is high and changes drastically. The siltation in the upper region of the Bakkhali dam is so high that it reduces the retention capacity of the dam and also reduces the catchment area. The dam deployment deters the navigation through the channel and restricts water supply to the downstream reaches and upstream-downstream connectivity is cut off. Water conservation by the dam often gives rise to conflict among the upstream and downstream river water users. There are unresolved conflicts in the nearby Eidgaon and Sonaichhari subprojects which influenced the construction of two earthen dams downstream of the Eidgaon dam. In all three rubber dam projects, there are cascaded earthen dams either upstream or downstream of the rubber dam that store water for dry season irrigation. Two more rubber dams in the area, one upstream of the Bakkhali dam, are being planned to be constructed.

These cascaded series of dams will add to the degree of difficulty of ensuring unobstructed flow (Sustainable Water Management, Cox's Bazaar, 2008). Again the river is getting narrower day by day as the land grabbers have encroached on both sides of the river by erecting illegal structures. Land grabbers made shrimp enclosure, built houses, inset occupying the river bank. At least 1000 illegal structures have been set up on the banks of the 50 km long river (Jinnat, 2013). Again a dock yard has been developed along the bank of the river. Local people became used to with throwing rubbish in the river. Dumping of garbage along this river accelerated the siltation.

Generally, in river dominated estuary variation in sediment volume fluctuates with the river flow (Frey and Howard, 1989). The efficiency of sediment trapping within the estuary depends on the capacity of an estuary in relation to rate of sedimentation and energy available for the transportation. In Bakkhali river estuary, these entire human interference factors restrict the natural flow as well as the transportation of sediment load through the estuary. So, the deposition intensity decreases which may affect the process and characteristics of estuary evolution.

Conclusion

The Bakkhali River is now becoming a narrow canal and dying fast. So, its impact on the Bakkhali river estuary

is huge. The sedimentation problem is increasing day by day, as it is caused directly or indirectly by human interference. So necessary measures should be taken to reduce the sedimentation problem of this estuary.

Acknowledgement

I express my gratitude and indebtedness to Dr. Umme Kulsum Navera, Professor, Department of Water Resource Engineering, Bangladesh University of Engineering and Technology (BUET) for her valuable suggestions, advice and strong support during the study.

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