Journal of Modern Science and Technology
Vol. 6. No. 2. June 2018 Issue. Pp.19-31

Comparative Analysis on Flow and Salinity of Rupsha-Passur River System of Bangladesh

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Rupsha-Passur river system, the major river system associating the Gorai river flows through Khulna, Chalna, Batiaghata, Rampal, Dacope and Mongla upazilla. Being tidal in nature saline water intrudes into Rupsha-Passur river from the Bay of Bengal during stronger spring tide but at the following neap tide, salinity is not totally flushed out due to low flow availability at upstream. This study shows a comparison of different flow parameters such as discharge, water level, velocity and salinity concentration between Rupsha and Passur river. Model simulated tidal range showed good agreement with the observed values for Manning's roughness coefficient as 0.01.*Once the flow model is calibrated and validated, the salinity modeling was performed and calibrated using the dispersion coefficient as tuning parameter. Passur River discharge is greater than that of in Rupsha River. This is because Passur is very near to the sea. So during high tide sea water flows into the upstream. During monsoon period the discharge in Passur river is greater than that of in Rupsha river by 186%. In this analysis, water level has been taken into account during high tide only. So there is little variation with water level in Rupsha and Passur. Velocity is increased during monsoon period as there is greater amount of availability of discharge during this season. During monsoon for the present flow the velocity in Passur river will be greater than that of in Rupsha river by 43%. From this model it has been found that in Passur river during the pre-monsoon period the salinity is about 12 ppt for the present flow. During the monsoon period the salinity is about 1.5 ppt for the present flow. In Rupsha river during the pre-monsoon period the salinity is about 2 ppt for the present flow. During the post monsoon period salinity variation is not remarkable. During the Pre-monsoon period the salinity in Rupsha river and Passur river are 7.01375 ppt and 12.012 ppt respectively. During the monsoon period the salinity is about 2.311 ppt and 2.832 ppt in Rupsha and Passur river respectively. During the post monsoon period the salinity is about 2.991 ppt and 6.898 ppt in Rupsha and Passur river respectively. The analyses is expected to support long term assessment that may affect the sundarbans as a result of changes in the flow from upstream because of the water abstraction activity for domestic and irrigation water supply.*

Keywords: Salinity, Flow, Rupsha, Passur, Hydrodynamic.

1. Introduction

Bangladesh is a low-lying, riverine country located in South Asia with a largely marshy jungle coastline of 710 km (441 mi) on the northern littoral of the Bay of Bengal, formed by a delta plain at the confluence of the Ganges (Padma), Brahmaputra (Jamuna), Meghna Rivers and their tributaries (Bangladesh Water Development Board 2011). About 700 rivers including tributaries flow through the country constituting a waterway of total length around 24,140 kilometres (15,000 mi)

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(Bangladesh Water Development Board 2012). Three Major River Systems are prominent in the country: viz, The Ganges-Padma, the Brahmaputra Jamuna and the Surma- Meghna System.

The Ganges is the only source of fresh surface water for a vast area in the greater districts of Rajshahi, Pabna, Kushtia, Jessore, Khulna, Faridpur and Barisal. (Bangladesh Water Development Board 2012). Most rivers in southwestern region (SWR) of Bangladesh depend on water flow from Ganges River. The flow volume declines during the dry-season and it impacts the region. Many of the branch rivers of Ganges River are blocked off from Ganges River due to the water intake at the upstream Indian Farakka Barrage that was built in 1975. Gorai River, a branch of Ganges River, is one of the major sources of freshwater supply to SWR and is the only one remaining branch river. However, in at least these twenty years, its flow volume in the dry-season (December – April) has been declining. It has a serious environmental impact: especially along the coastal areas around the sanctuary forests where the salty water has increasingly been intruding. (Mehzabin 2015).

In the recent years, groundwater based water supply in coastal area is suffering from a number of major problems mainly arsenic contamination, lowering of the water table, salinity and non-availability of suitable aquifers. The Southwest (SW) region of Bangladesh is facing salinity intrusion due to both environmental and anthropogenic issues. In that circumstance, the dominating livelihood agriculture is affected severely including soil and ground water degradation, health problems and long term effect on ecosystem (Khanom 2016).

Study from the Soil Resource Development Institute (SRDI) found that, from 2000 to 2009, saline water intrusion increased up to 15 km north of the coast and in the dry season reached up to 160 km inland, entering into other interior coastal districts as well due to low flow from upstream rivers. In line with that, this article explored local people's experience with salinity intrusion in interior coast of SW region. Along with semi-structured & open ended questionnaire five focus group discussions and eight interviews were conducted to outlines the relationship between food security and salinity intrusion in regards of crop production and examines the impact of salinity on the crop production. The analysis found salinity in both soil and water is favorable for rice cultivation, although yield loss in every year has increased. (Khanom 2016).

Salinity intrusion is one of the concerning problem in the south region in Bangladesh. In this study the comparative analysis of salinity between Rupsha and Passur river has been shown. Here the comparative analysis of flow characteristics between the Rupsha and Passur river has also been disseminated. This study will help us to understand how the salinity concentration changes with the change of flow characteristics. In this study, section one deals with the introduction, section two deals with the study area, section three focuses on Methodology and results and analysis has been discussed in section four.

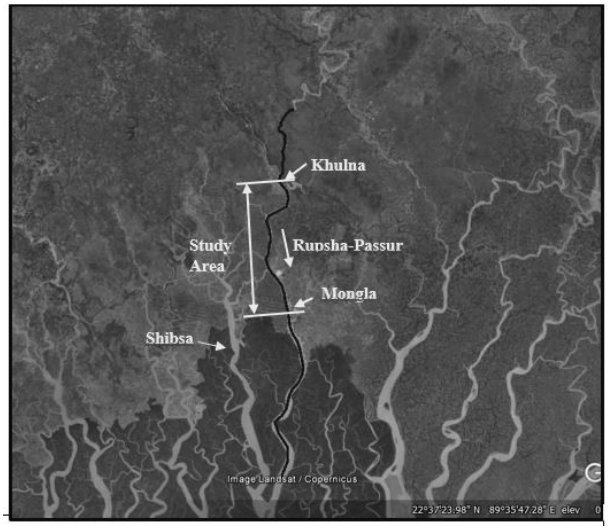
2. Study Area

The Rupsha River is a river in southwestern Bangladesh and a distributary of the Ganges. Rupsha is one of the most famous rivers of Bangladesh. It forms from the confluence of Bhairab and Atrai rivers and flows into the Passur river. Its entire

length is affected by tides. It flows by the side of Khulna connects to the Bay of Bengal through Passur river at Mongla channel. Near Chalna it changes its name to Passur river and flows to the Bay of Bengal. The average width of this river is about 486 meter and the maximum and minimum width is about 650 meter and 322 meter respectively. It is a meandering and perennial river. Passur river is a big river in the Sundarbans area as an extension of Rupsha river. The Bhairab or the Rupsha flows further south and renamed as Passur near Chalna and falls into the Bay of Bengal flowing to the right of Trikona and Dubla islands. South of Mongla upazilla the river flows into the Sundarbans. The maximum flow of the Gorai-Madhumati passes into this river through Nabaganga. The Passur is placed after the Meghna in size in the Deltaic region. The river is joined by Mongla canal at about 32 km south from Chalna. Flowing further south the river meets the Shibsa at about 32 km north from its mouth and debouches into the sea keeping its original name Passur (Bangladesh Water Development Board 2011).

The river is very deep and navigable throughout the year and large marine ships can easily enter Mongla Sea Port through it. The Passur is an important river route through which Khulna-Barisal steamboats and other vessels ply. The total length of Passur is about 104 km. The maximum and minimum width of this river is about 2112 meter and 690 meter respectively. The average width of the river is about 1164 meter. Passur river is a meandering and perennial river and highly affected by tides (Bangladesh Water Development Board 2012)

Figure 1: Location of the Study Area of Rupsha-Passur river



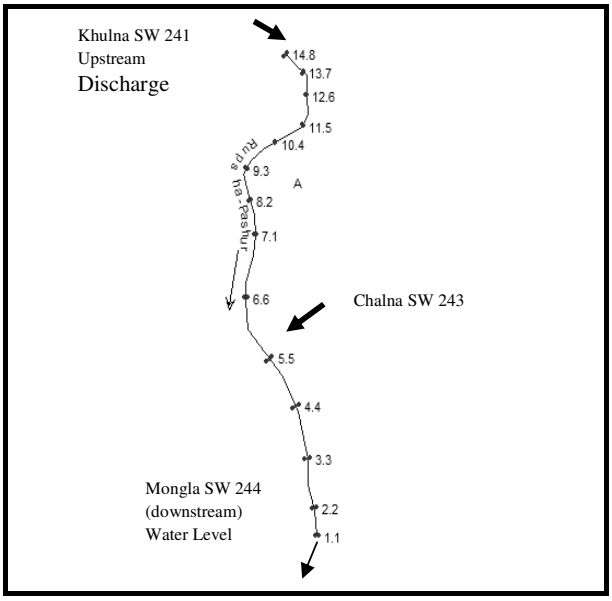
3. Methodology

3.1 Data Collection and Model Setup

For the development of mathematical modeling on flow and salinity analysis of Rupsha-Passur River data on bathymetry, discharge, stage hydrograph and salinity concentration at different station have been collected. Total 14 cross sectional data (8 of Rupsha & 6 of Passur river) of Rupsha-Passur river were collected. The total section of the river is about 70 km long. The reach starts near Khulna and ends at

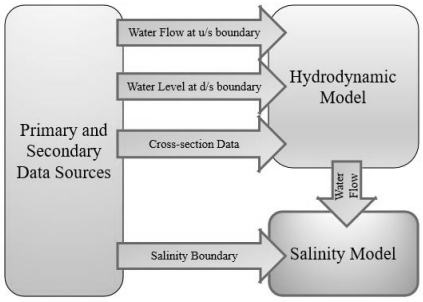
Mongla. Discharge data were collected at Kamarkhali Transit (SW 101). At Kamarkhali Transit discharge are divided into two parts, one part enters into Nabaganga river and another enters into Madhumati river. It has been assumed that 70% of discharge at Kamarkhali Transit enters into Nabaganga river which later flows through the Rupsha-Passur river. Data for January 2014 to December 2014 are available. But daily discharge data is not found. So formation of rating curve is required. Stage hydrograph at the upstream of the river near Khulna (SW 241) and at the downstream of the river near Mongla (SW 244) were collected. This hydrograph contains stage data for the year 2014. Another stage hydrograph is collected near Chalna (SW 243). This data was collected for calibration and validation. As Rupsha-Passur river is a tidal river so there is two high tide and two low tide within a day in the stage hydrograph. salinity concentration data were also collected for the year of 2014. Salinity data were collected near Khulna (SW 241) which is the upstream and at Mongla (SW 244) which is the downstream. Salinity data were also collected at Chalna (SW 243) for calibration.

Figure 2: Rupsha-Passur River System Showing Locations of Boundary Conditions in HEC-RAS



In the Figure 3, the locations of boundary conditions of Rupsha-Passur river system in HEC-RAS has been shown. Near Chalna the river Rupsha changes its name into Passur river.

Figure 3: Flow Chart of Hydrodynamic and Salinity Model with HEC-RAS



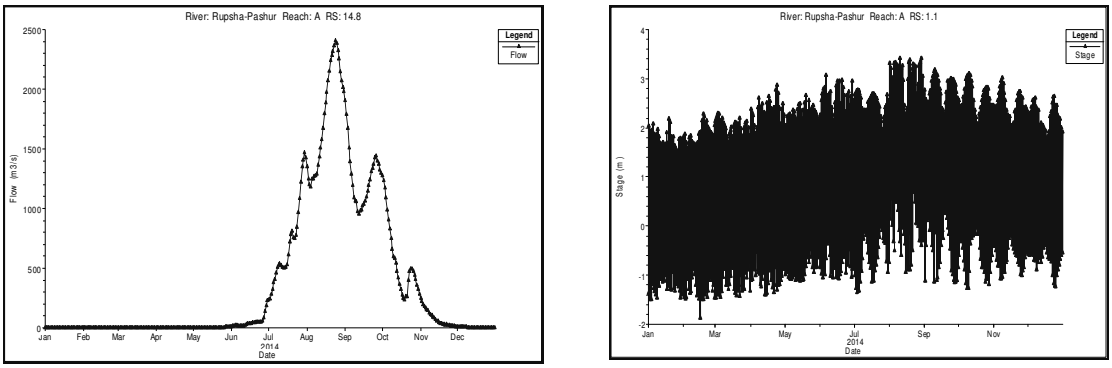
The hydrodynamic and salinity model setup in HEC-RAS has been shown in the Figure 3. After the simulation of hydrodynamic model salinity model has been run.

3.2 Geometric Data Processing

Near Khulna (upstream) discharge data has been input and near Mongla (downstream) stage hydrograph has been input. As the Passur river is affected by tidal effect and the tide is semi-diurnal in character so the stage hydrograph is like as sinusoidal curve.

Figure 4: (a) Flow Hydrograph for 2014 at Khulna and (b) Stage Hydrograph at Mongla.

(a) ***(b)***



3.3 Calibration of Hydrodynamic Model

The data of flow for Rupsha-Passur of April 2014 have been used for calibration of Manning's roughness coefficient, 'n'. Calibration has been done at two stations near Khulna (SW 241) and near Chalna (SW 243) for the month April.

Figure 5: (a) Stage Hydrograph and (b) Regression Analysis for Manning's n= 0.01 Near Khulna (SW 241) for April.

(a) ***(b)***

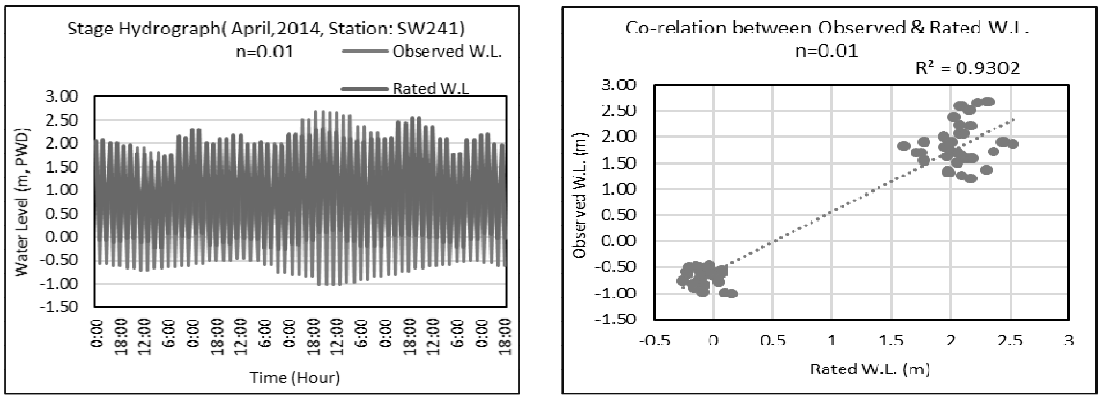
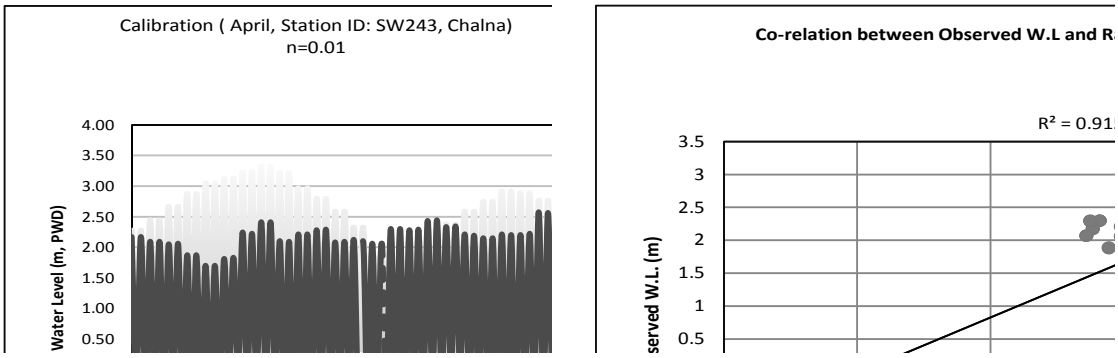


Figure 6: (a) Stage Hydrograph and (b) Regression Analysis for Manning's n= 0.01 Near Chalna (SW 243) for the Month April.

(a) ***(b)***

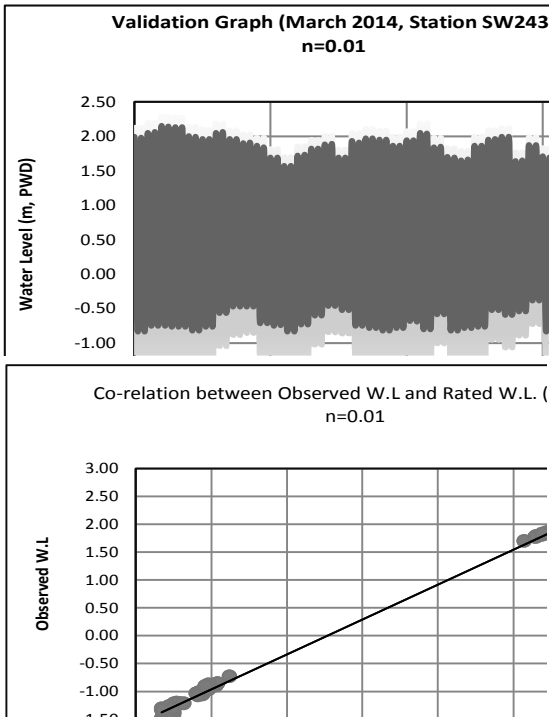


3.4 Validation of Hydrodynamic Model

The best value of R^2 has been found for n=0.01. So data of March 2014 has been used for validation for Manning's n=0.01 near Chalna (SW 243).

Figure 7: (a) Stage Hydrograph and (b) Regression Analysis for Manning's n= 0.01 Near Chalna (SW 243) for the Month March.

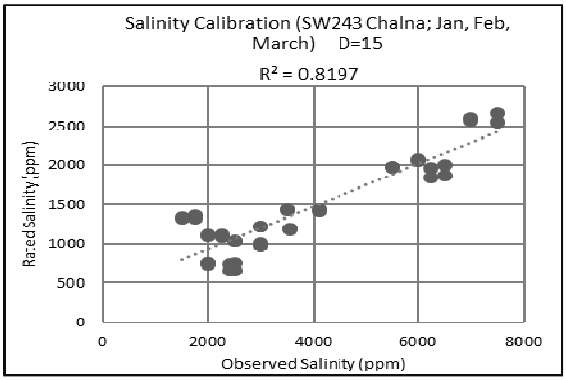
(a) ***(b)***



3.5 Calibration of Dispersion Co-efficient

Calibration of salinity model has been done for different dispersion co-efficient for the month January, February and March near Chalna (SW 243). The best value of R^2 has been found for D=15 m^2/s.

Figure 8: Regression Analysis for D=15 m^2/s



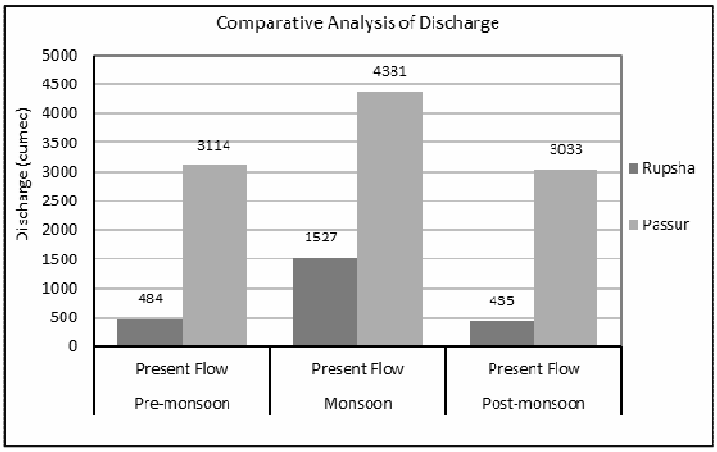
4. Results and Analysis

4.1 Comparative Analysis between Rupsha and Passur River of Hydrodynamic Parameters

4.1.1 Discharge

Discharge is generally high during the monsoon period. But in Passur River discharge is greater than that of in Rupsha River. This is because Passur is very near to the sea. So during high tide sea water flows into the upstream. So the discharge is increased in this region. Again near Chalna a branch of Shibsa river joins with Passur river. So discharge increases. During the pre-monsoon and post-monsoon period the discharge is very low.

Figure 9: Comparative Analysis of Discharge between Rupsha and Passur River

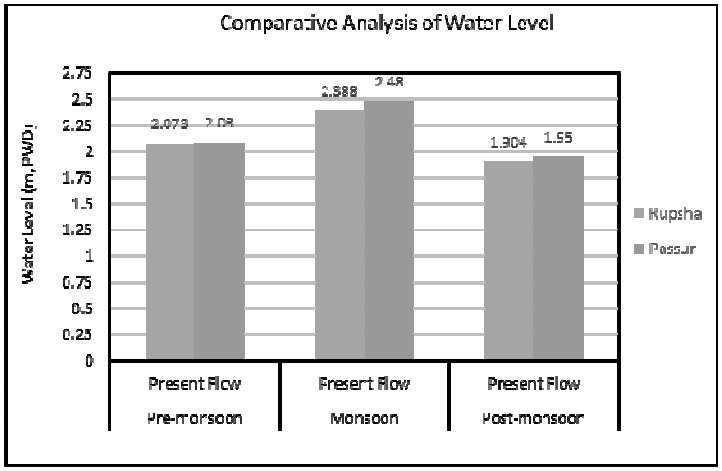


During monsoon period the discharge in Passur river is greater than that of in Rupsha river by 186%.

4.1.2 Water Level

In this analysis, water level has been taken into account during high tide only. So there is little variation with water level in Rupsha and Passur. Water level is high during monsoon period but in pre-monsoon and post-monsoon period water level is lower than monsoon period. During this time water level difference in Rupsha and Passur is very little. Because during these period upstream flow is very little and sea water flow into the upstream during high tide has a great effect.

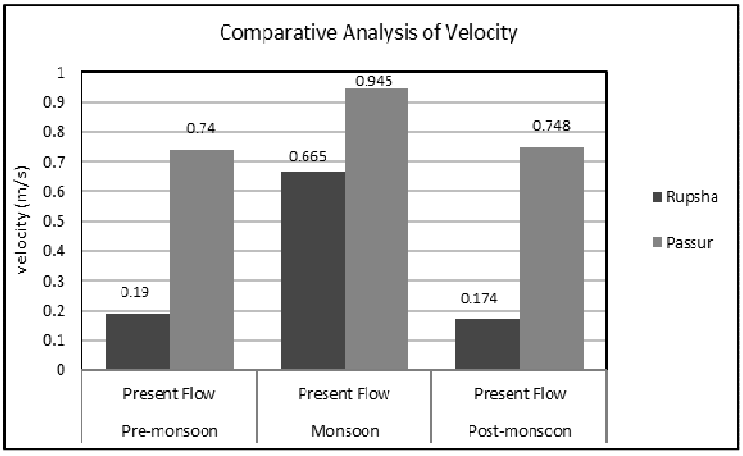
Figure 10: Comparative Analysis of Water level between Rupsha and Passur River



4.1.3 Velocity

Velocity is increased during monsoon period as there is greater amount of availability of discharge during this season. During monsoon for the present flow the velocity in Passur river will be greater than that of in Rupsha river by 43%. During the pre-monsoon period the velocity in Passur river will be about 4 times than the velocity in Rupsha river for the present flow. During the post-monsoon period the velocity in Passur river also will be about 4 times than the velocity in Rupsha river for the present flow. During the pre-monsoon and post-monsoon period the difference of velocity between Rupsha and Passur is very high because during these period in Rupsha river the upstream flow is very low but in Passur river sea water intrusion occurs during high tides which falls into the sea during low tide.

Figure 11: Comparative Analysis of Velocity between Rupsha and Passur River



4.2 Local Flow Field in Rupsha and Passur River

In the Figure 12(a) & (b) the velocity variation in Rupsha river for the maximum and minimum velocities along the cross-section has been shown. During the dry season

the velocity in Rupsha river tends to zero. In the Figure 13(a) & (b) velocity variation in Passur river for the maximum and minimum velocities along the cross section has been shown.

Figure 12: (a) Maximum Velocity and (b) Minimum Velocity in Rupsha River for the Present Flow

(a) ***(b)***

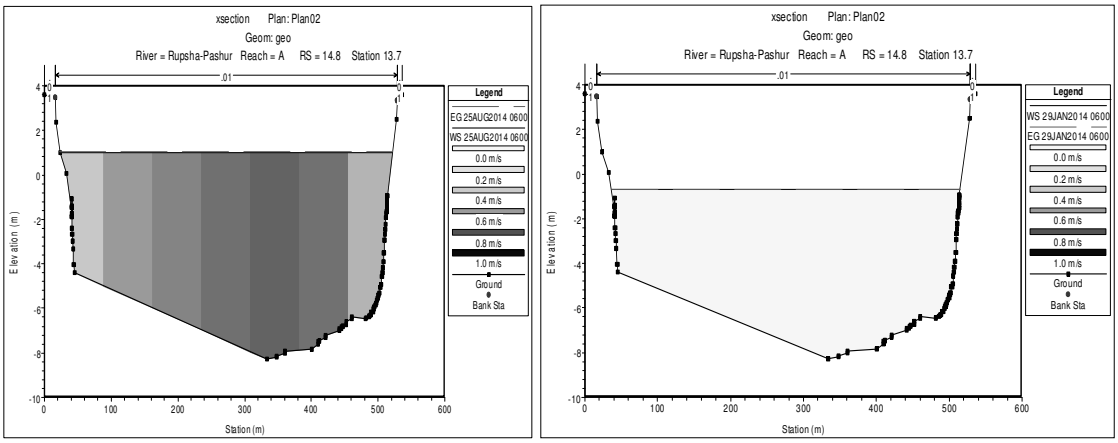
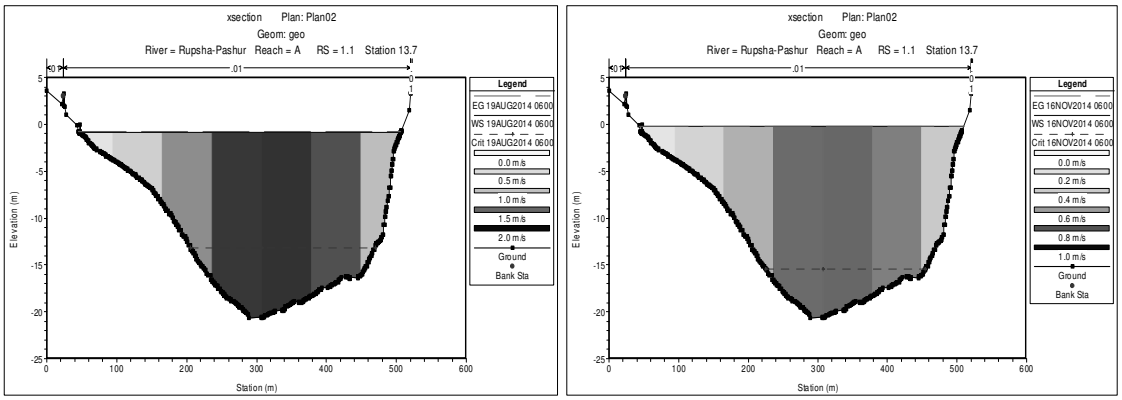


Figure 13: (a) Maximum Velocity and (b) Minimum Velocity in Passur River for the Present Flow

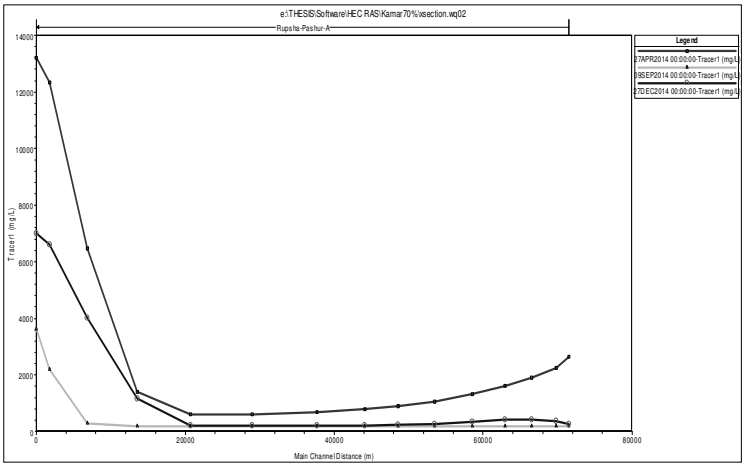
(a) ***(b)***



4.3 Water Quality Analysis

Water quality analysis has been performed to examine the effect of salinity in Rupsha and Passur river during different seasons.

Figure 14: Salinity Simulation for the Present Flow 2014

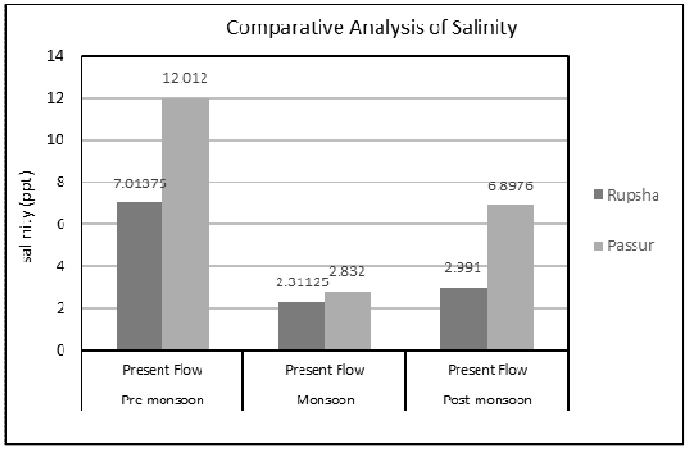


In Passur river during the pre-monsoon period the salinity is about 13 ppt for the present flow. During the monsoon period the salinity is about 3.5 ppt for the present flow and during post-monsoon period the salinity is about 7 ppt. In Rupsha river during the pre-monsoon period the salinity is about 3 ppt for the present flow. During the post monsoon and monsoon period salinity variation is not remarkable.

4.4 Comparative Analysis of Salinity between Rupsha and Passur River

During the Pre-monsoon period the salinity in Rupsha river and Passur river are 7.01375 ppt and 12.012 ppt respectively. So it can be said that the salinity in Passur river is greater than that of in Rupsha river by about 72%. During this period the upstream flow is very less in Rupsha and Passur river. So sea water intrusion occurs much in Passur river basically. So the salinity increases at this time. During the monsoon period the salinity is about 2.311 ppt and 2.832 ppt in Rupsha and Passur river respectively. The salinity in Passur river is greater than that of in Rupsha river by about 23% during this season. During the monsoon period the salinity is about 2.991 ppt and 6.898 ppt in Rupsha and Passur river respectively. The salinity in Passur river is greater than that of in Rupsha river by about 130% during this season.

Figure 15: Comparative Analysis of Salinity Concentration between Rupsha and Passur River



4.5 Limitation of the Study

The main limitation of the study is that only the flow of Rupsha-Passur river is considered here. There are other branch rivers such as Shibsa, Mongla and Kajibacha which have been neglected in this study are sometimes responsible for the intrusion of saline water.

4.6 Recommendation

On the basis of this study, the following recommendations can be made for further studies:

(1) This study is limited to the impact of Rupsha-Passur river discharge only. For better result, its branch channels and other sources of fresh water should be considered.
(2) A more accurate set of data should be used.
(3) Sea level rise should be taken into account to perform this study so that the salinity scenarios can be understood more accurately.

From hydrodynamic and water quality analysis, it was seen that these rivers get very little flow during the pre-monsoon and post-monsoon period. As a result during these periods the salinity remains very high due to increased intrusion of saline water. To prevent the intrusion of saline water the discharge must be increased during pre-monsoon and post-monsoon periods.

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