A STUDY ON RIVER SYSTEM, HYDROLOGY AND SURFACE WATER SALINITY OF SUNDARBANS RIVERS

M. A. Rahman* & S. J. Dipa

Department of Water Resources Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
**Corresponding Author: mataur@wre.buet.ac.bd*

ABSTRACT

Sundarbans, consists of 10,200 sq. km of Mangrove forest, spread over Bangladesh (6000 sq. km) and India (4200 sq. km). Kobadak, Kholpetua, Rupsa, Shibsa, Pashur, Baleshwar, Raimangal, Arpangasia, Sakbaria are the main rivers passing through Sundarbans. The river system is important for ecosystem of Sundarbans which depends on the availability of adequate fresh water. The surface water salinity increases rapidly after construction of Farakka Barrage on the Ganges river at India and withdrawal the Ganges fresh water. Also water level largely affects the surface water salinity. The recent increase in water and soil salinity has upset the natural equilibrium of the delicate ecological balance. So salinity will be a major issue in future. The study aims to assess the present condition of the surface water salinity, water level fluctuation and the spatial and temporal variation of salinity of all rivers through Sundarbans.

Keywords: Surface water salinity; water level; river system; Sundarbans

INRODUCTION

The Sundarbans is the largest mangrove forest in the world and is intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests. It lies at the mouth of the Ganges and is in South West part of Bangladesh, in the district of greater Khulna. The Sundarbans is a part of the world's largest delta formed by the rivers Ganges, Brahmaputra and Meghna (Islam, 2011). The study area encompasses the entire Sundarbans with all river, their tributaries and land. The rivers which almost surrounded Sundarbans are Kobadak, Kholpetua, Rupsa, Shibsa, Pashur, Baleshwar, Raimangal, Arpangasia and Sakbaria. These rivers play an important role to Sundarbans and its ecosystem. The Sundarbans ecosystem depends on the availability of adequate fresh water. With the commissioning of Farakka Barrage, the downstream discharge at Ganges was drastically reduced. The salinity trends in the Sundarbans are not fixed from both soil and water perspective. The recent increase in water and soil salinity has upset the natural equilibrium of the delicate ecological balance required for the healthy growth and existence of the rich flora and fauna (Khan et al., 1994). Consequently, scarcity of water during the dry season (Feb-June) and widespread flowing of excess water in the wet season damages the crops and the ecosystems (Haque and Alam, 1995). The Ganges fresh water withdrawal in the upstream area in India resulted in three types of negative impacts in the downstream catchment. The problems are fresh water reduction, increase of salinity and disturbance of growth and habitat have been identified. The increase of salinity in the Ganges distributaries has also lead to ecological impacts on the world's largest mangrove forest, the Sundarbans (Siddiqi, 2001). Salinity in the river system of southwest coastal region increases steadily from December through February, reaching maximum in the late March and early April (EGIS, 2000). Figure 1 shows the area of Sundarbans and its river systems. This study aims to assess the hydrology and surface water salinity of Sundarbans rivers.

Fig.1: The Sundarbans and its river system

METHODOLOGY

Bathymetry, water level and surface water salinity data of the Sundarbans rivers during 2003 to 2014 were collected from Bangladesh Water Development Board. The inventory of the measuring locations is presented in Table 1, Figure 2 and Figure 3.

Cross-section was plotted in Excel to see variation of rivers cross-section. Water level was analyzed during high tide and low tide and then tidal range was determined. Surface water salinity was analyzed during dry/pre-monsoon period and post-monsoon period for high tide and low tide. Finally variation of surface water salinity with river water level was seen.

ANALYSIS, RESULTS AND DISCUSSIONS

Cross-Sectional variation from 2001 to 2013 of Kobadak River at station RMKBD16 and RMKBD17 are shown in Fig. 4 and Fig. 5. Fig. 4 shows aggrading character of river due to sedimentation. In the year 2001, 2005 and 2008 there was a slow sedimentation process, but in 2013 there developed dune at middle of the channel. Fig. 5 shows degrading character of river due to erosion. In 2001, 2005 and 2008 there was a very slow sedimentation process, but in 2013 there is a depression at middle of the channel.

Table 1: Inventory of measurement station

Nature of Data	River Name	Station Name	StationID
Water Level	Kobadak	Kobadak Forest Office	SW165
	Rupsa-Pasur	Mongla	SW244
	Bhadra	Sutarkhali_Forest Office	SW29
	Gorai-Madhumati	Rayenda	SW107.2
	Betna-Kholpetua	Protapnagaa	SW26
	Sibsa	Nalianala_Hadda	SW259
Salinity	Kobadak	Tahipur	SW161
	Rupsa-Pasur	Mongla	SW244
	Bhadra	Dumuria	SW28
	Gorai-Madhumati	Rayenda	SW107.2
	Rupsa-Pasur	Khulna	SW241
	Sibsa	Nalianala-Hadda	SW259
Cross-Section	Rupsa-Passur		PR16- PR17
	Kobadak		KBD12-KBD14

Fig.2: Location of Water Level Stations

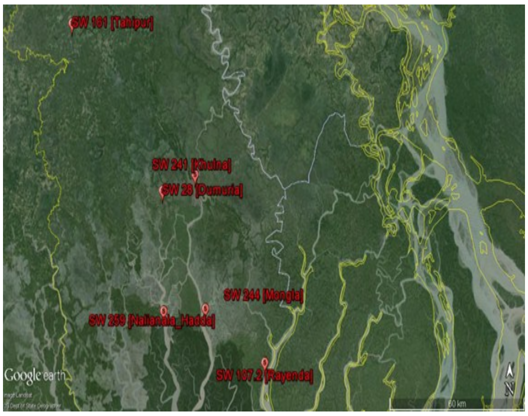

Fig.3: Location of Surface Water Salinity Stations

Water level is analyzed for the period of 2005 to 2014 at Kobadak Forest Office and Mongla, Sutarkhali_Forest Office, Rayenda, Protapnagar and Nalianala-Hadda stations of Sundarbans rivers. Generally, water level is relatively high during monsoon period (July-Oct) and relatively low during pre-monsoon or dry period (March-May). Figure 6 shows the maximum and minimum water level from 2005 to 2014 for Betna-Kholpetua River at Station-SW26. Tidal ranges at the different stations of some rivers passing through Sundarbans are given in Table 2.

In this study surface water salinity of Sundarbans area is assessed by using salinity data as Electrical Conductivity (EC) and as Chloride Ion Concentration (Cl-). Salinity data are analyzed to visualize the changing pattern of surface water salinity over year and also for the period 2003 to 2013. Fig. 7 and Fig. 8 show the variation of surface water salinity as Electrical Conductivity (EC) and concentration of chloride (Cl-) during high tide and low tide for time period 2003 to 2013. These two figures show that salinity is almost same during high tide and low tide. Fig. 9 and Fig. 11 show that surface water salinity as Electrical Conductivity (EC) and as Chloride Ion Concentration (Cl-) during high tide becomes maximum in April-May. The increasing rate of EC is 29.6% in 2002 to 2011 and Cl- is 5.42% in 2008 to 2011 during the month of April-May (pre-monsoon period) which is seen in Fig. 10 and Fig. 12.

Water level largely affects the surface water salinity (Table 3 and Table 4). When water level increases the water salinity decreased or vice versa. Water level is highest during monsoon period at high tide and lowest during dry-period at low tide. Table 5 shows the maximum and minimum water level and their corresponding surface water salinity at various stations during high tide and low tide. Water level and salinity relation of station SW 241 (Fig. 13 and Fig. 14) shows that at high tide maximum water level is 3.41 mPWD while corresponding electrical conductivity is 401 ppm and concentration of chloride is 201ppm and at minimum water level of 0.36 mPWD the corresponding electrical conductivity is 6500 ppm and concentration of chloride is 1774ppm. From the above analysis it can be noticed that at downstream river named Kobadak at station SW165, the tidal range or water level is maximum (1.15-6.68mPWD) than the upstream river named Rupsa-Passur at station SW244 and Bhadra at station SW29 (Table 2). Also for last decade during high tide and low tide, at downstream station (SW165) water level is maximum (4 mPWD) and minimum (-2.58 mPWD) than at upstream station (Table 5). Surface water salinity is maximum at downstream rivers situated at south-west and minimum at upstream rivers situated south-east during low tide. At station SW241 Surface water salinity is maximum (19100 ppm) than station SW161 (601) during low tide and pre monsoon period (Table 5).

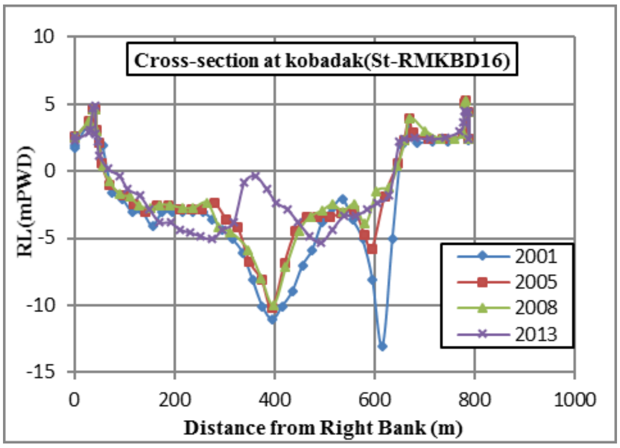

Fig. 4: Cross-Sectional variation of Kobadak River at Station-RMKBD16

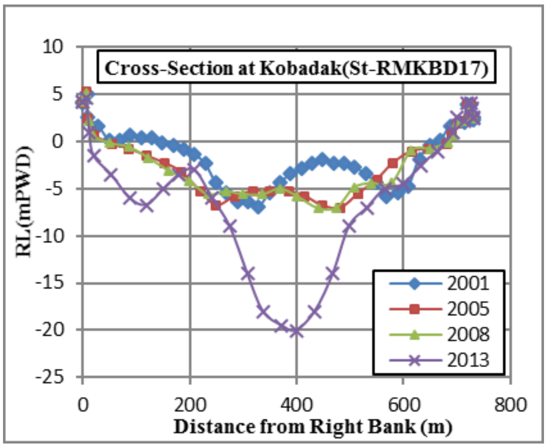

Fig. 5: Cross-Sectional variation of Kobadak River at Station-RMKBD17

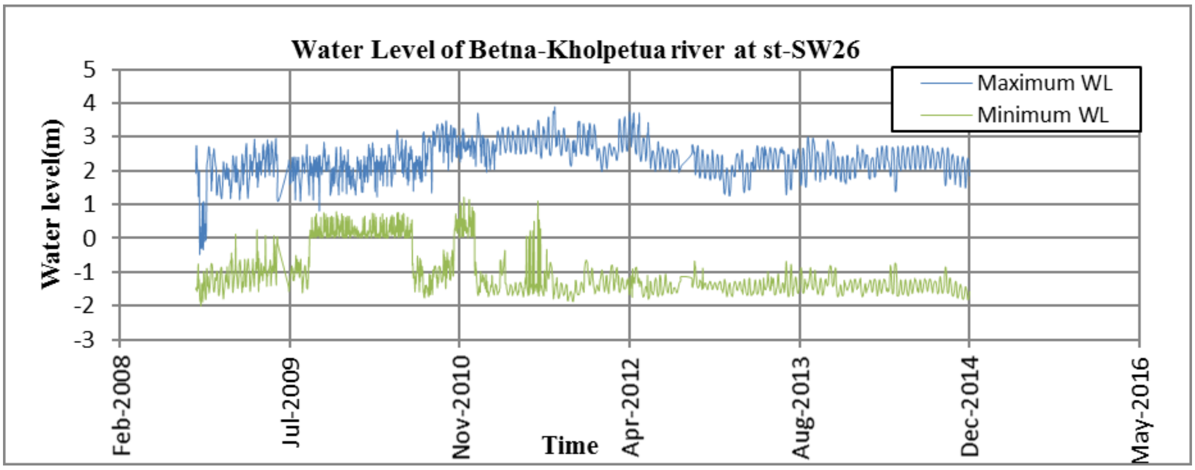

Fig.6: Water Level variation of Betna-Kholpetua River at Station-SW26.

Table 2: Tidal Ranges at different station of different rivers

Station No	Station Name	River name	Tidal Range(m)
SW165	Kobadak Forest Office	Kobadak	1.15-6.38
SW244	Mongla	Rupsa-Pasur	0.54-4.34
SW29	Sutarkhali_Forest Office	Bhadra	1-4.28
SW107.2	Rayenda	Gorai-Madhumati	0.16-3.60
SW26	Protapnagar	Betna-Kholpetua	0.67-5.57
SW259	Nalianala_Hadda	Sibsa	0.45-4.56

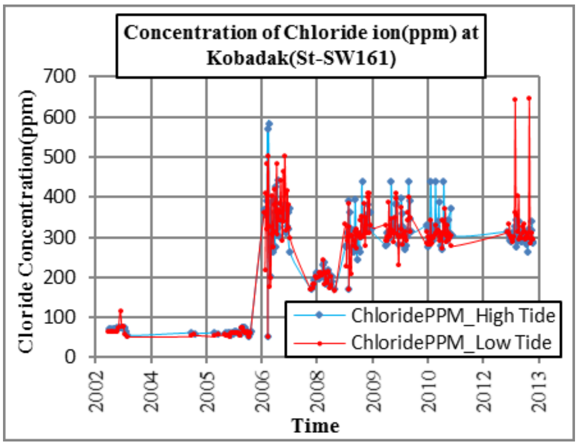

Fig. 7: Surface Water Salinity (Concentration of Cl^-) variation of Kobadak River at Tahipur Station (SW161).

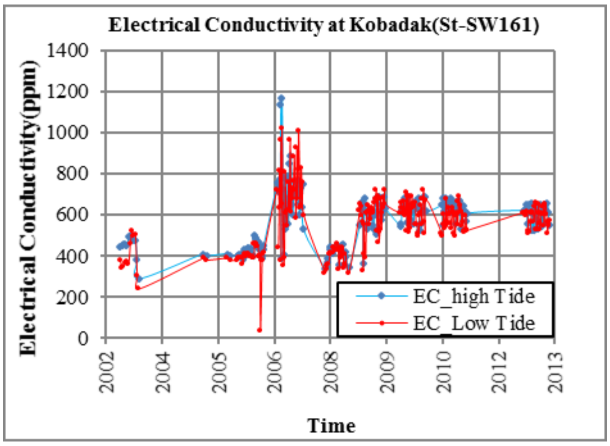

Fig. 8: Surface Water Salinity (EC) variation of Kobadak River at Tahipur Station (SW161).

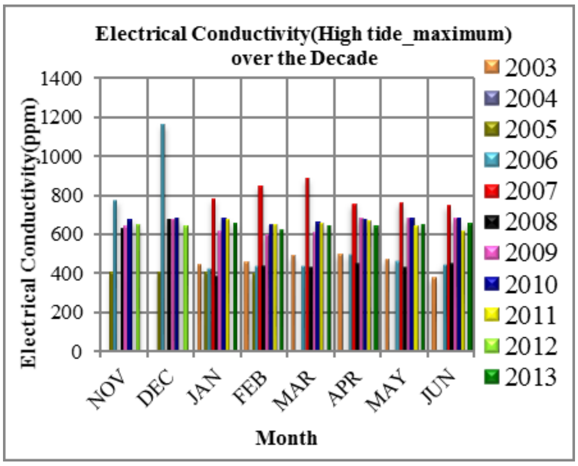

Fig. 9: Variation of Maximum Salinity (EC) during High Tide of Kobadak River at Station-SW161.

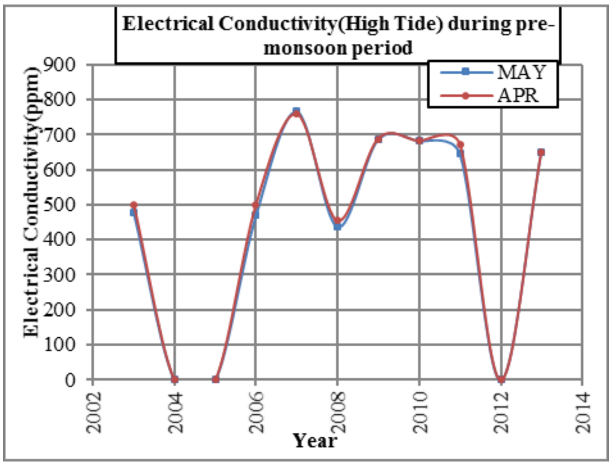

Fig. 10: Maximum Salinity (EC) during High Tide of Kobadak River at Station-SW161 in April-May

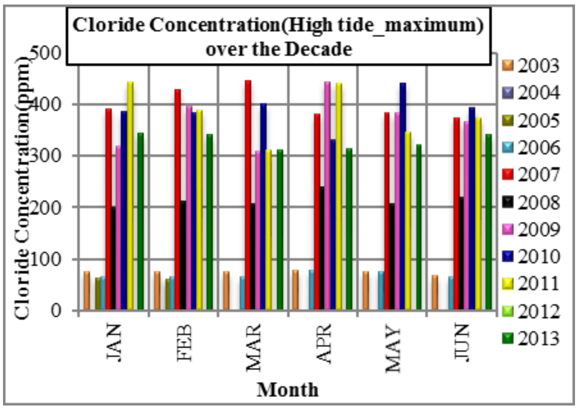

Fig. 11: Variation of Maximum Salinity (Concentration of Cl-) during High Tide of Kobadak River at Station-SW161

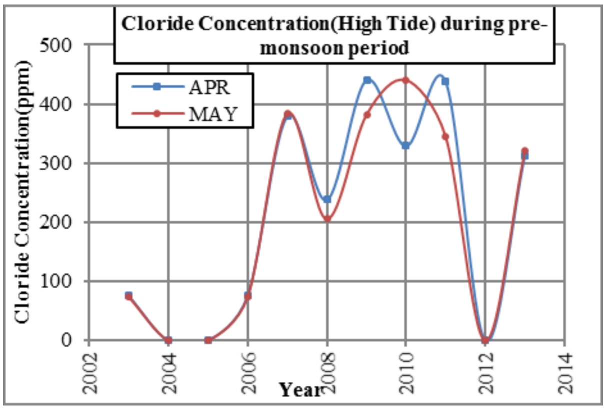

Fig. 12: Maximum Salinity (Concentration of Cl-) during High Tide of Kobadak River at Station-SW161 in April-May

Table 3: Increasing rate of surface water salinity (EC)

Station	Result	Pre-Monsoon High Tide	Post-Monsoon High Tide	Pre-Monsoon Low Tide	Post-Monsoon Low Tide
SW 241	Change	20.44 %	2.90 %	207.10 %	20.83 %
	Years	2004~2007	2004~2006	2005~2007	2004~2006
SW 244	Change	28.34 %	67.50 %	60.69 %	49.40 %
	Years	2003~2013	2004~2013	2003~2013	2005~2012
SW 28	Change	23.98 %	11.11 %	11.50 %	53.49 %
	Years	2003~2006	2004~2005	2008~2013	2004~2012
SW 259	Change	2.94 %	15.18 %	9.09 %	20.67 %
	Years	2007~2009	2006~2010	2007~2010	2004~2009
SW107.2	Change	14.87 %	5.91 %	17.64 %	17.93 %
	Years	2008~2011	2008~2010	2007~2009	2006~2010
SW 161	Change	29.60 %	46.05 %	36.24 %	41.67 %
	Years	2003~2010	2003~2012	2005~2011	2005~2012

Table 4: Increasing rate of surface water salinity (Cl-)

Station	Result	Pre-Monsoon High Tide	Post-Monsoon High Tide	Pre-Monsoon Low Tide	Post-Monsoon Low Tide
SW 241	Change	50.00 %	6.67 %	55.86 %	29.41
	Years	2005~2008	2004~2006	2005~2007	2004~2008
SW 244	Change	60.92 %	20.00 %	10.58 %	41.05 %
	Years	2003~2013	2004~2005	2005~2013	2005~2012
SW 28	Change	16.34 %	58.33 %	16.34 %	37.93 %
	Years	2010~2012	2004~2012	2010~2012	2005~2012
SW 259	Change	3.51 %	9.09 %	3.70 %	9.09 %
	Years	2007~2010	2006~2009	2007~2010	2006~2009
SW107.2	Change	20.24 %	6.29 %	20.00 %	6.28 %
	Years	2008~2011	2008~2010	2008~2011	2008~2010
SW 161	Change	67.80 %	5.42 %	30.00 %	44.74 %
	Years	2008~2011	2008~2012	2003~2013	2005~2012

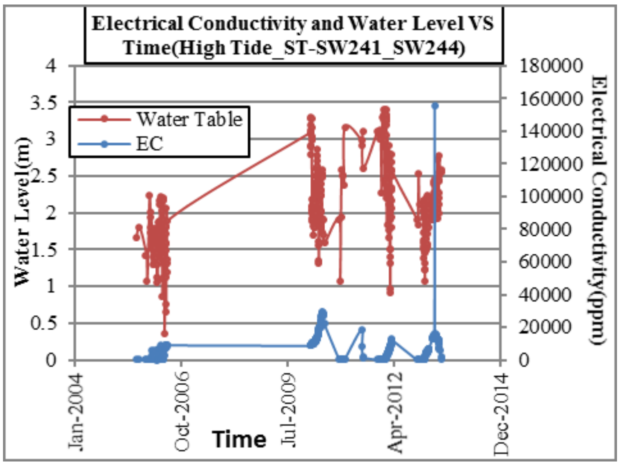

Fig. 13: Variation of Surface water salinity (EC) with water Level from 2005-2013 at station SW241 for High Tide

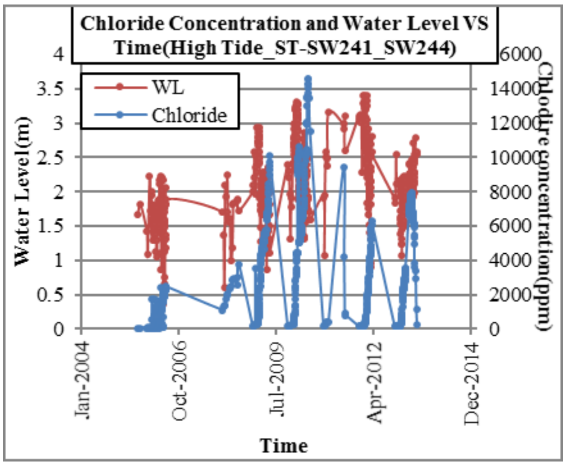

Fig. 14: Variation of Surface water salinity (Cl-) with water Level from 2005-2013 at station SW241 for High Tide

Table 5: Maximum and minimum Water level and their corresponding surface water salinity at various station during high tide and low tide.

Station No	Type	High Tide		Low Tide	
		WLmax(m)	**WLmin(m)**	**WLmax(m)**	**WLmin(m)**
SW241	WL(mPWD)	3.41	0.36	1.13	-1.49
	EC(ppm)	401	6500	6020	19100
	Cl^-(ppm)	201	1774	3010	9550
SW244	WL(mPWD)	3.41	0.36	0.68	-1.49
	EC(ppm)	1890	18000	1670	18000
	Cl^-(ppm)	930	6300	820	9000
SW259	WL(mPWD)	3.2	0.83	0.42	-1.69
	EC(ppm)	34000	4200	11000	5710
	Cl^-(ppm)	17000	4100	5500	2860
SW107.2	WL(mPWD)	3.8	0.55	1.65	0.05
	EC(ppm)	6000	3710	1210	6000
	Cl^-(ppm)	3000	1850	610	3000
SW161	WL(mPWD)	4	-0.5	-0.6	-2.58
	EC(ppm)	557	614	620	601
	Cl^-(ppm)	310	309	331	328
SW28	WL(mPWD)	2.95	1.38	0.85	-1
	EC(ppm)	10000	7470	1850	11000
	Cl^-(ppm)	5000	3730	940	5500

CONCLUSIONS

There are a number of rivers pass through Sundarbans and discharges into Bay of Bengal. Surface water salinity of Sundarbans rivers plays an important role for the existence of Sundarbans ecosystem. Hydrology and surface water salinity of Sundarbans rivers are investigated in this study. Freshwater discharge from the upstream rivers plays vital role in reducing the salinity inside the Sundarbans area during flood tide. Fresh water supplies through Gorai-Madhumati-Nabaganga-Rupsha-Passur river system and Kobadak-Betna-Kholpetua-Shibsha river system mainly influence the salinity inside Sundarbans area, which is very much critical during dry period.

REFERENCES

EGIS.2000. Environmental Baseline of Gorai River Restoration Project – Environment and GIS Support Project for Water Sector Planning, Ministry of Water Resources, Government of Bangladesh and Government of The Netherlands, p.150.

Haque, MA and Alam, SMK.1995. Post Farakka dry Season Surface and Ground Water Conditions in the Ganges and Vicinity, Women for Water Sharing, Academic Publishers, Dhaka, pp 48-64.

Islam, SN and Gnauck, N. 2011. Water salinity investigation in the Sundarbans rivers in Bangladesh, *International Journal of Water*. 6(6):74-91.

Karim, A.1994. Vegetation in Mangrove of the Sundarbans, Volume Two: Bangladesh, IUCN – The World Conservation Union, Bangkok, Thailand.

Khan, MS; Haq, E; Huq, S; Rahman, A A; Rashid, SMA. and Ahmed, H. 1994. Wetlands of Bangladesh. BCAS, Dhaka. Bangladesh.

Siddiqi, NA. 2001. Mangrove of Bangladesh Sundarbans and accretion areas, Mangrove Ecosystems Functions and Management, Springer-Verlag, Berlin, Germany, pp.142–258.