RIVER WATER QUALITY REPORT 2010

পরিবেশ অধিদপ্তর

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MESSAGE

Bangladesh has a large network of rivers, streams and canals with a total length of at least 24,000km and an area of 4,600sq.km. The water ecosystem comprises the tributaries and distributaries of the three major river systems: the Ganges- the Meghna and the Brahmaputra (GMB). The combined total catchments area of these major river systems is about 1.74 million sq. km, of which seven percent lies within Bangladesh.

Rapid urbanization, industrialization, agricultural development, high population growth, upstream withdrawal of water etc have degradation of the river water quality in Bangladesh. It is time for us to conserve and protect our rivers from pollution.

I am pleased to note that this initiative of publishing "River Water Quality Report, 2010" is a good start to notice the state of surface water quality to all corners of concern. I hope this document will bring a clear picture of present status of river water quality in Bangladesh and also highlight the necessary steps to be taken for sustainable management of rivers.

I would like to thank the Natural Resource Management Section specially Dr. Md. Sohrab Ali, Deputy Director (NRM) for his initiative for preparing the first technical report on surface water quality of Bangladesh.

I expect that this document will be useful to the decision makers for conservation of reverine ecosystems of Bangladesh.

Monowar Islam
Director General

PREFACE

This is indeed a great pleasure for us to see the publication of the document: "River Water Quality Report, 2010". This document covers the overall aspect of present status of river water quality in Bangladesh and seems to be a very useful not only to decision makers but also to the academicians and students.

Being a riverine country, Bangladesh has to adopt adequate measures to halt further degradation of our precious water resource. The report offers a clear view of present situation and recommend for the way ahead of us towards conservation and sustainable use of water. It contains statistical analyses of various water quality parameters of different rivers of the country from the period of January to December 2010.

The current status of river water quality in Bangladesh is under serious stress. Population pressure, urbanization, industrialization and encroachment are the main causes of these stresses. Upstream withdrawal of water and siltation are also important responsible factor responsible for degradation of river water.

River water resources have always served as the basis for securing lives and livelihoods for millions of people by providing different ecosystem services in this agrarian country.

The report assesses a set of actions for conservation of river water resources. We strongly believe that implementation of these activities will pave the way to water conservation and sustainable use in various levels of our development agenda.

Md. Jafar Siddique
Director (NRM)

TECHNICAL NOTE

Water is life where quality of water really matters. Since its origin as the "Pollution Control Cell" in 1973, the prime task of the present Department of Environment is to monitor water quality for the conservation planning of water resource and to generate information for policy feedback. The Department of Environment successfully translated its monitoring results in to developing the Environment Policy 1992 followed by the Bangladesh Environment Conservation Act 1995 (BECA) (amendment 2010) and the Environment Conservation Rules 1997 (ECR). To assess surface water quality various parameters are furnished in the rules.

Despite discontinuity of monitoring of surface water quality considering in spatio-temporal context and measurement of fewer parameters, this report would shed some light on water resource quality of the country. We analyzed parameters like P^H, DO, BOD, COD, Turbidity, TDS and Chloride those were measured more or less round the year of 2010. From the analyses seasonality aspect of water quality and impact of industrialization on water quality surfaced up. During the rainy season water quality of most rivers (under the monitoring programme) was good while comparing with the Environmental Quality Standard (EQS) set in the ECR. Water quality of rivers around Dhaka city and the environs, Chittagong and Khulna failed to comply the EQS in the dry season indicating the most probable effect of dense industrialization in those areas followed by increased human pressure on rivers. The difference in pollution level among the sampling points along a single river was also evident. Monitoring and enforcements reports revealed the fact that discharging of industrial untreated wastes was mostly responsible for river water pollution. All the above situations fingering to noncompliance of rules by the industries and thus, need to escalate monitoring and enforcement activities as well as awareness building in all walks of life to achieve sustainable development of reverine ecosystem.

Dr. Md. Sohrab Ali
Deputy Director (NRM)

ACKNOWLEDGEMENT

We would like to thank all divisional offices of the Department of Environment for providing with water quality data. We greatly acknowledge kind support and guidance of Mr Monowar Islam, Director General, Department of Environment for preparation of this report. Also we are expressing our sincere gratitude to the reviewers for their suggestions. Special thanks go to Dr Sultan Ahmed, Director (NRM) at present for critical review of this report.

EXECUTIVE SUMMARY

Rivers are important features of Bangladesh's landscape where hundreds of rivers crisscrossed the landmass and playing role of artery and veins in circulating water. Rivers are mainly used for navigation, irrigation, fisheries, drinking water, and industrialization. Bangladesh's streams and rivers are also the home to a wide variety of aquatic flora and faunal species. The volumes of water they carry vary widely depending on the season, summer rainstorms and upstream diversion of water flow.

The Department of Environment (DoE) has been monitoring surface and ground water quality since 1973. The surface water quality-monitoring programme of DoE includes 63 stations of the 25 rivers in Bangladesh. But divisional offices monitored water quality only at 28 stations of 12 rivers at monthly interval. The monitoring involved making field measurements (only pH at some stations) and collecting water samples for laboratory analyses. Six divisional offices measured 12 parameters (physical and chemical) of collected samples. Depending on continuity of measurements in the spatio-temporal context, we took seven parameters (e.g. pH, Chloride, Turbidity, Total Dissolved Solid (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) for analyses.

Based on the parameters mentioned above water quality of the major rivers e.g. Padma, Meghna, Jumuna, Dhaleshwari, Surma, and Korotoa was within the limit of Environmental Quality Standards (EQS) in 2010 while rivers around greater Dhaka were highly polluted in the first five or four months of 2010 in terms of DO, BOD and COD. Generally no dissolved oxygen was found from January to May at different locations of Buriganga, Balu, Shitalakhya and Turag river. High value of chloride (62 mg/l), TDS (2050 mg/l), BOD (44 mg/l) and COD (150 mg/l) were found at different locations of Buriganga River from January to April in 2010.

Level of chloride, TDS, turbidity was found higher in Moyuri, Rupsha, Pashur and Kakshiali rivers. Highest level of chloride (11,380 mg/l) and TDS (17,750 mg/l) were found in Pashur river. Rupsha river showed highest turbidity (200 NTU). COD>500mg/l was found in Karnaphuli, Bakkhali, Moyuri and Mathavanga river. DO, BOD and COD of Mathavanga river water were beyond the EQS in first four months of 2010.

Lack of continuous monitoring is one of the major problems for river water quality data analyses. Fixing detail inland surface water standard or water quality index is essential to assess water quality of rivers.

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Abbreviations

BOD	-	Biochemical Oxygen Demand
DO	-	Dissolved Oxygen
DoE	-	Department of Environment
COD	-	Chemical Oxygen Demand
ECA	-	Ecologically Critical Area
ECR	-	Environmental Conservation Rules
EQS	-	Environmental Quality Standard
GPS	-	Global Positioning System
NTU	-	Nephelometric Turbidity Unit
SoE	-	State of the Environment
TDS	-	Total Dissolved Solid
WQI	-	Water Quality Index
WCZ	-	Water Control Zone

Chapter 1
Introduction

1.1 Background

Fresh water is a finite resource essential for life where quality really matters. In Bangladesh, there are hundreds of rivers, streams and canals all those serve as sources of fresh water for all forms of lives. They also act as drainage system of waters to the sea. To safeguard human health and to maintain quality of water resources for various uses, the Government has set specific standards for inland surface water under Environmental Conservation Rules (ECR), 1997.

Many watercourses in our country are typically short streams having fast flowing water with rocky substrates, and sluggish flowing lower reaches with silty bottoms. The flows in the rivers could be highly variable, responding rapidly to rainfall and storm water runoff. This is due to steep topography, thin soil overlaying, impermeable strata and upstream withdrawal of water. A significant portion of the river's base flow in the country is abstracted for potable use. This can greatly reduce the river's flow volume, and its natural flushing and purification capacity. To reduce river pollution and maintain sustainable river flow in Bangladesh, effective control and management of pollution at source and regional cooperation are therefore essential.

However, Government of Bangladesh has taken necessary action to protect rivers and use them in a sustainable manner. Government has already declared four rivers (Buriganga, Shitalakhya, Turag and Balu) as Ecologically Critical Area (ECA) to protect from further pollution and return them back to previous pollution free condition. Increased enforcement and freeing encroached river are some other steps taken by Department of Environment. Awareness raising and people's participation is essential ingredient of surface water quality management.

1.2 Major objectives of the report

1. The aim of this report was to provide updated information on the river water quality to help information based decision-making process for sustainable development and management of water resources.
2. Awareness building among the relevant stakeholders.
3. To provide information for research/study in the relevant field.

1.3 Structure of the report

The remaining chapters of this report are arranged as follows:

Chapter 2: This chapter presents an overview of Bangladesh's rivers. These include river system, number of rivers, length, major rivers in the country etc.

Chapter 3: Describe different water quality parameters including (physical and chemical), data collection system, their processing and analyses are depicted in this chapter.

Chapter 4: Chapter four represents river water quality in terms for various physico-chemical parameters. Comparison of water quality with national standard for inland surface water and discussed in this chapter.

Chapter 5: Conclusion and recommendations for actions in areas of policy, research, and enforcement for improving water quality and sustainable management of rivers.

1.4 Limitation of the report

This report has been prepared based on primary data and information collected from six divisional offices of the Department of Environment (DoE) for the period of January to December 2010. The following are the limitations of this report:

- Water quality information on all the selected monitoring sites could not given in this report as samples were not collected from all the sites. Also information on all the parameters as per ECR 1997, for the entire period could not be furnished with this report due to discontinuous sampling and laboratory analyses.
- This report lacks of information on microbiological parameters.
- Supporting data on weather conditions of the sampling locations at the time of sampling could not be provided.

1.5 River water quality monitoring

Monitoring of river water quality is an important task of the Department of Environment. The information obtained from monitoring would provide an insight of the state of surface water quality and riverine ecosystem. It also enables assessment of effectivity of pollution abatement measures and provides a basis for development of strategies of water resources.

The approach of DoE's river water quality monitoring program is to visit regularly a number of fixed sites on the rivers where field measurements are performed and then water samples are collected for further laboratory analyses. In 2010, the monitoring program covered 63 sampling locations of 25 rivers. About 50% of these locations were monitored monthly basis. This report presents the river water quality data collected and analysed by DoE in 2010.

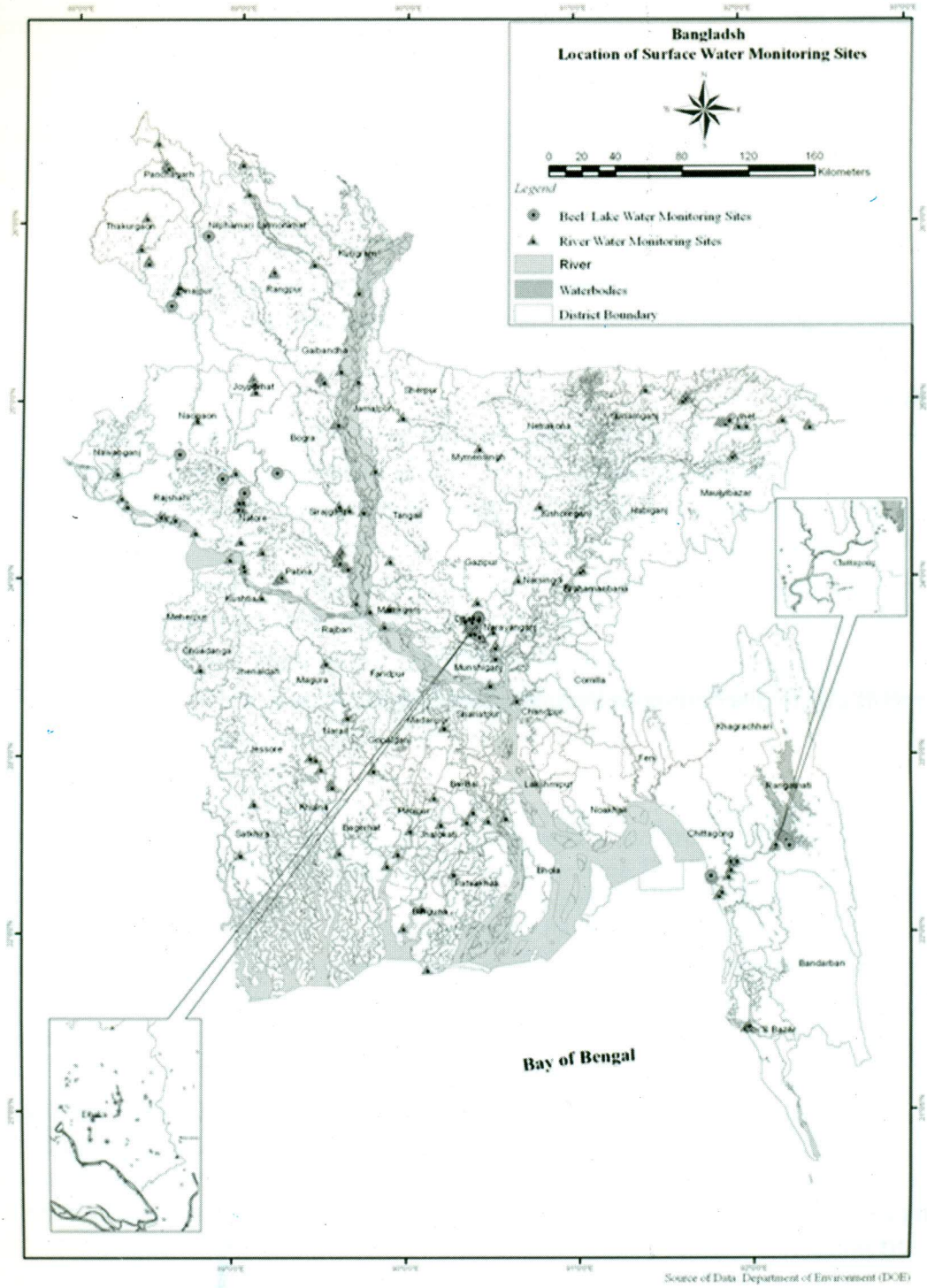

Fig. 1. Location map of surface water monitoring sites.

Chapter 2
An overview of Bangladesh's Rivers

2.1 Rivers of Bangladesh

Rivers are the most important physiographic feature of Bangladesh, and it is the rivers those created this vast alluvial delta. It's been known that the out flow of water from Bangladesh is the third highest in the world, after the Amazon and the Congo systems. The Padma, Jamuna and the lower Meghna are the widest rivers, with the latter expanding to around eight kilometers across in the wet season, and even more during the floods.

The pride of Bangladesh is its rivers with one of the largest networks in the world with a total number of about 700 rivers including tributaries and distributaries having total length of about 24,140 km (Alam and Chowdhury, 2006). They consist of tiny hilly streams, winding seasonal creeks, muddy canals (*khals*), some truly magnificent rivers and their tributaries and distributaries. These together cover about 7 percent of country's surface area. In some places, such as Patuakhali, Barisal and Sundarbans the watercourses are so plentiful that they form a veritable maze. The watercourses of the country are obviously not evenly distributed. They increase in numbers and size from the northwest to the southeastern region. Rivers of Bangladesh is shown in Fig. 1.

2.2 Major river system

The river system of Bangladesh is extremely dynamic. The annual discharge by those rivers has a wide seasonal fluctuation peaking at the monsoon (July to September). Bangladesh has predominantly four major river systems. They are –

- The Brahmaputra-Jamuna,
- The Ganges-Padma,
- The Surma-Meghna, and
- The Chittagong region river system.

However, Brahmaputra is the 22nd longest (2,850 km) and the Ganges is the 30th longest (2,510 km) river in the world (Banglapedia, 2006).

2.3 Rivers in Bangladesh

The principal rivers of Bangladesh are the Padma, the Megna, the Jamuna, the Brahamaputra, the Dhaleswari and the Karnafuli. Besides those rivers, there are many small rivers like Buriganga, Sitalakhya, Gumti, Teesta, Atrai, Kortoa, Mohananda, Madhumati and many more. They have tributaries and distributaries as well.

Chapter 3
Analysis of River Water Quality

3.1 Analytical methods of water quality parameters

In the ECR'97 there are several parameters e.g. temperature, conductivity, dissolved oxygen (DO), pH, T. alkalinity, Turbidity, Settleable solid (SS), Total solid (TS), Total dissolved solid (TDS), suspended solid, Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD) to assess inland water quality. But only a few parameters were analyzed by the divisional offices. Standard methods were applied for analysis of different parameters. *Azide Modification Method* was used to analyze DO, *Dilution Method* for BOD_5, *Closed Reflux Colorimetric Method* for COD, *Argentometric Methods* for chloride and *Gravimetric Methods* for TDS.

3.2Weather Condition

In 2010, total rainfall during the monsoon (June-September) season over Bangladesh was 47,447mm and division wise rainfall distribution is presented in Table 2. In Bangladesh normal maximum temperature is 30.33 °C where minimum temperature is 21.18 °C (BMD, 2012).

Table 2. Total Rainfall (mm) in Monsoon over Bangladesh in 2010.

Division	**Month**				**Monsoon**
Dhaka	June	July	August	September	
	1721	1295	1191	809	5016
Chittagong	8917	5696	5091	3272	22976
Rajshahi	1358	769	1062	947	4136
Rangpur	1860	926	796	696	4278
Khulna	1355	1000	872	1000	4227
Barisal	2024	1387	662	847	4920
Sylhet	1358	769	1062	947	4136
All over Bangladesh					
Total	17857	11443	10122	8025	47447

Source: BMD, 2012

Chapter 4
River Water Quality in 2010

4.1 Buriganga River

The Buriganga River is the main river flowing beside Dhaka city, the capital of Bangladesh. The Buriganga originated from the Dhaleshwari near Kalatia. Its average width and depth are 400m and 10m respectively. This river is only 27km long (Chowdhury, 2006). Water samples were collected from eight different locations of the river e.g. Mirpur Bridge, Hazaribag, Kamrangir Char, Chandni Char, Sadar ghat, Dholaikhal, Bangladesh China Friendship Bridge and Pagla.

In 2010, pH level varies from 6.5 to 8 mg/l while standard pH for inland surface water is 6.5 to 8.5 mg/l. Level of pH of Buriganga river at different locations was within the Environmental Quality Standard (EQS) round the year (Fig. 2a). In 2011, pH varies from 6.1 to 7.9 mg/l (Fig. 2b).

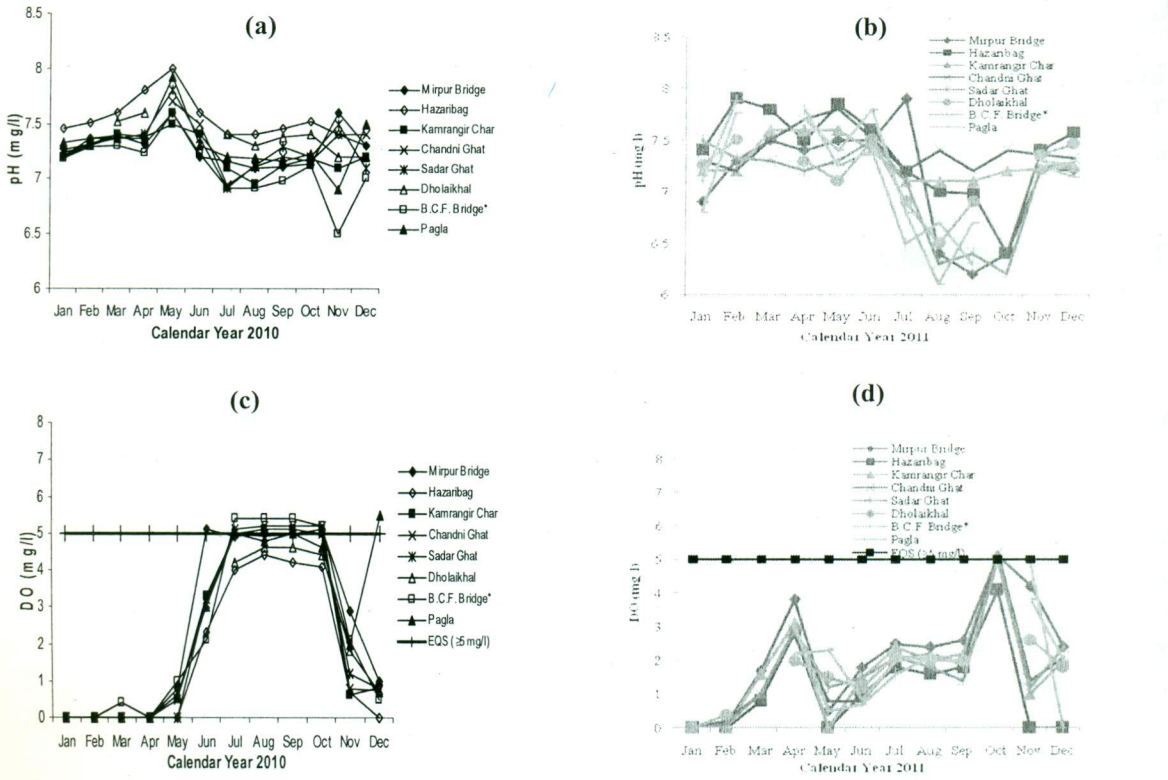

Fig. 2. Comparison of pH and DO of Buriganga between the year of 2010 and 2011.

Dissolved oxygen (DO) in Buriganga River was very low in 2010. During the first five months, DO level was nearly nil at all locations of the river (Fig. 2c). Throughout the year DO was below the standard for fisheries (≥5 mg/l) at Hazaribug and Dholaikhal point of Buriganga. In 2006, DO was below 5 mg/l in April to May and July to August while in 2011, DO level varied from 0 to 5.1 mg/l. This may be due to direct discharge of tannery waste into

the river at those points. About 183 tanneries of Hazaribagh release 2,500 gallons/day of chemicals wastes into Buriganga (Ahmed, 2009). DO level was relatively higher in wet season (June to October) at all locations of the river. A comparison of DO concentration in the calendar year of 2010 and 2011 is presented in Fig. 2(c,d).

Table 2. Concentrations of Chloride at different sampling locations of Buriganga river in

Locations	Concentration of Chloride (mg/l)												EQS
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mirpur Bridge	32	36	38	40	26	20	6.5	6	6	6	6	18	150-600 mg/l
Hazaribag	46	50	56	**62**	38	36	14	14	15	16	8.5	9	
Kamrangir Char	30	32.5	34	36	28	31	6	5.5	6	5.5	10.5	10.5	
Chandni Ghat	28	32	35.5		24	22	8	6	4	6.5	5	8	
Sadar Ghat	32	34	**3.5**	38	26	21	8.5	8	8	8	6.5	6	
Dholaikhal	38		40	42			12	12.5	10	10	6	8.2	
B.C.F. Bridge*	30	30	32	38	22	22	6	6	4.5	4.5	9	7.2	
Pagla	36	36.5	36.5	40	24	24	10	8.5	6.5	5	5.5	6.5	

In 2010, Chloride concentration of Buriganga river was below the EQS and ranged from 3.5to 62 mg/l. Table 2 represents Chloride level at different locations of Buriganga river in 2010. Chloride level varied from 6 to 48 mg/l in 2011.

Table 3. Turbidity at different sampling locations of Buriganga river in 2010.

Locations	Level of Turbidity (NTU) (EQS -10 NTU)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mirpur Bridge	10	8	6.5	6.5	6.5	6	6.5	6.5	6.5	6.5	6	6
Hazaribag	**18.5**	**18**	**18**	**16**	10	6.5	6.5	8.5	6.5	10	6	8.4
Kamrangir Char	8	6.5	6.5	6.5	6.5	6	6.5	6.5	6.5	6.5	6	8.5
Chandni Ghat	8	6.5	6.5		6.5	6.5	6.5	6.5	6.5	6.5	6	6
Sadar Ghat	8.5	6.5	6.5	6.5	6.5	6	6.5	6.5	6.5	6.5	6	6
Dholaikhal	10		**12**	**14**			6.5	8	6.5	8	6	6
B.C.F. Bridge*	8	6.5	6.5	6	6	6	6.5	6.5	6.5	6.5	6.5	6
Pagla	8	6.5	6.5	6.5	6.5	6	6.5	6.5	6.5	6.5	6	6

Turbidity varied from 6 to 18.5 NTU and was mostly within the EQS. But at Hazaribag, turbidity exceeded the EQS from January to April. Also at Dholaikhal point, turbidity exceeded the limit in March and April (Table 3). Turbidity level in 2011 varied from 6-16.6 NTU and was closer to 2010.

*Bangladesh China Friendship Bridge

Table 4. TDS at different sampling locations of Buriganga river in 2010.

Locations of Buriganga River	TDS (mg/l) (EQS – 1000 mg/l for drinking water)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mirpur Bridge	418	590	620	665	540	170	170	176	180	170	171	350
Hazaribag	560	550	**1400**	**1295**	920	360	320	304	350	370	240	480
Kamrangir Char	416	**2050**	580	627	536	192	168	170	176	156	346	223
Chandni Ghat	410	548	600	-	500	22	190	172	170	162	132	225
Sadar Ghat	412	554	590	635	526	157	200	186	190	164	182	228
Dholaikhal	510	-	**1050**	**1100**	-	-	250	254	240	218	163	242
B.C.F. Bridge*	408	528	600	640	470	168	180	174	160	102	345	285
Pagla	560	630	630	650	540	170	198	196	-	172	154	232

TDS of Buriganga river varied from 22 to 2050 mg/l against the EQS of 1000mg/l for drinking water. In dry season TDS limit was very high at Hazaribag, Kamrangir Char and Dholaikhal locations (Table 4). In 2011, TDS level varied from 149 to 1188 mg/l.

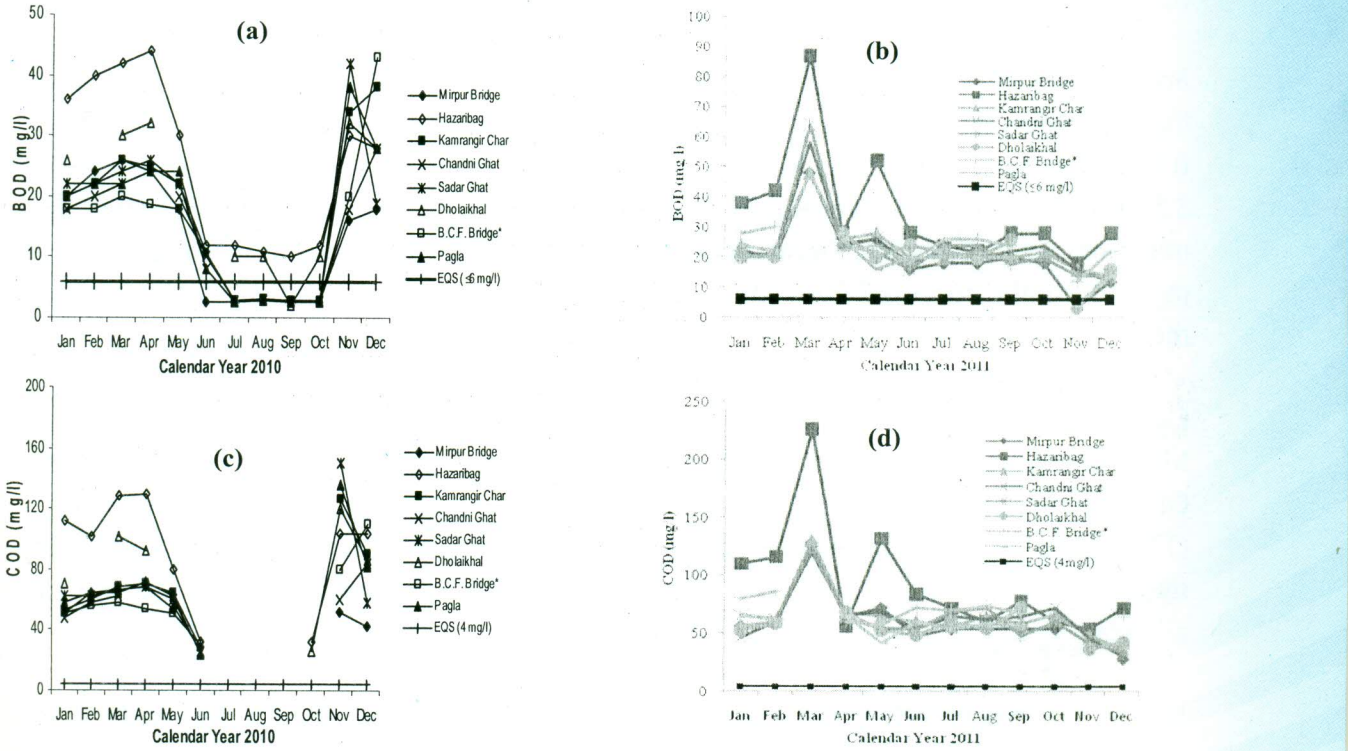

Fig. 3. Comparison of BOD and COD of Buriganga between the year of 2010 and 2011.

BOD load of Buriganga River was very high during most of the months of 2010. During wet season (June to October) BOD was decreased and at some points BOD reached the standard for fisheries (≤6 mg/l). But BOD level was always higher at Hazaribug point (Fig. 3a). This was mainly due to discharge of untreated tannery waste into the river at this point. Maximum BOD (44 mg/l) was found at Hazaribag in April and minimum (2.2 mg/l) was at Dholaikhal

in September. In 2011, BOD level ranged from 3.1 to 52 mg/l. A comparison of BOD between the year of 2010 and 2011 presented in Fig. 3(a,b). BOD level at most of the monitoring points exceeded the EQS for fisheries in 2006.

At all sampling locations of Buriganga, COD was very high in 2010 (Fig. 3c) while EQS is 4 mg/l for COD for drinking water. Sample was not collected from July to September. At Hazaribug, COD level was the highest althrough the year. Maximum COD was 150 mg/l in November while that of minimum was 24 mg/l in June at Sadar Ghat. In 2011, COD level varied from 28 to 226 mg/l. Fig. 3(c,d) represent the comparison of COD level in 2010 and 2011.

4.2 Shitalakhya River

Shitalakhya River (also known as Lakhya River) is a distributary of the Brahmaputra. It is about 110 km long and maximum width is 300 meters near Narayanganj. Its highest discharge has been measured $74m^3/s$ at Demra. It remains navigable round the year. The river on an average 10m deep while maximum depth recorded about 21m at some points (Chowdhury, 2006).

For analyses of water quality of Shitalakhya river samples were colleted from three different locations namely- Demra Ghat, Ghorasal Fertilizer Factory (Ghorasal F. F.) and ACI in 2010. It has been observed that pH level of the river throughout the year was within the EQS (6.5-8.5 mg/l) for inland surface water. Maximum pH was 7.49 mg/1 in April at Demra Ghat and minimum was 6.8 mg/l in December at Ghorasal F.F (Fig. 4a). The pH was found 7.12 to 8.3 mg/l during the period of 2002-2006 at three points of the river (Ahmed, 2009). Turbidity of the river varied from 6 to 6.5 NTU whereas standard limit is 10 NTU (Fig. 4b).

Chloride concentration in 2010 was below the EQS (150-600mg/l) for drinking water. Maximum chloride was found at Ghorasal F.F (18mg/l) in April and minimum was at Demra Ghat (4mg/l) in November (Fig. 4c). Fig. 4d. shows the variation of Total Dissolved Solid (TDS) in 2010. Maximum value of TDS was found at Demra Ghat (420mg/l) in February and minimum was at ACI (80mg/l) in November. TDS concentration was within the EQS limit at all locations of the river.

No DO was found at Demra Ghat from January to March. Also at ACI, DO was found very low from February to April and then began to increase towards June to July. DO level was good enough at all locations from August to December. Maximum level of DO was found at Ghorashal F.F (6.8mg/l) in August and October. EQS for DO for fisheries is $\geq$5mg/l. During the period of 2002-2006, DO level was not satisfactory at any point. Lowest DO (3.9 mg/l) was found at the Ghorashal point during April-May (Ahmed, 2009). In 2011, DO varied from 0 to 6.5 mg/l. Comparison of DO in 2010 and 2011 was presented in Fig. 5 (a,b).

BOD at Demra Ghat and ACI points was very high during the dry period of 2010. At Ghorasal BOD was within the EQS (≤6 mg/l) throughout the year. Highest value of BOD was found at Demra Ghat (24 mg/l) in March and the lowest BOD was at Ghorashal F.F (2.4 mg/l) in April and May. BOD concentration was higher at Demra Ghat compare to other two locations of the river. Maximum BOD (14.2mg/l) was found at Ghorashal during 2002-2006 (Ahmed, 2009). In 2011, BOD varied from 2.3 to 48 mg/l. A comparison of BOD in water between 2010 and 2011 was presented in Fig. 5c, d. Direct discharge of untreated effluents from industry, domestic wastes and low rainfall in dry season are the main reasons for low DO in water.

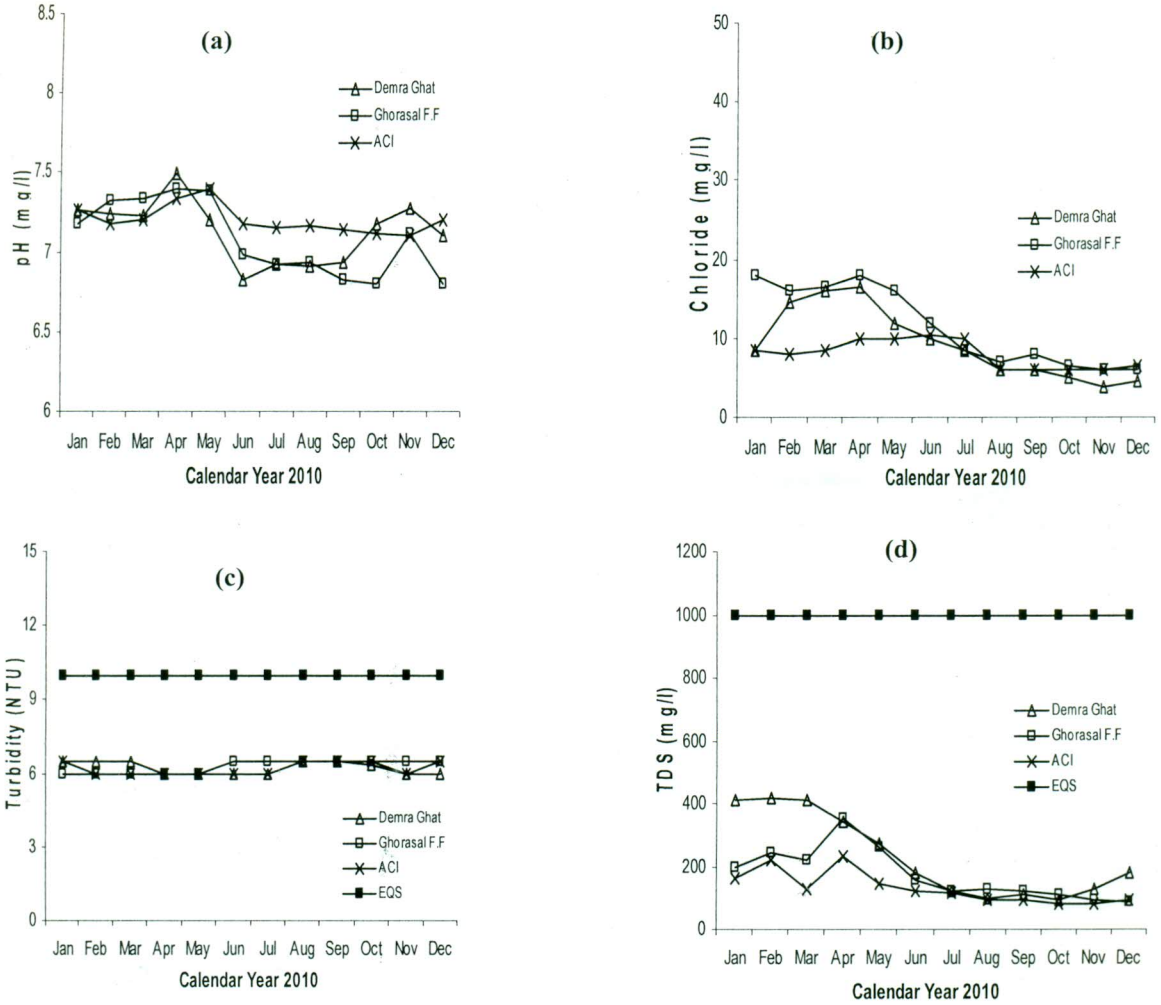

Fig. 4. Graphical presentation of pH, Chloride, Turbidity and TDS of Shitalakhya river in 2010.

4.3 Turag River

The Turag River is the upper tributary of the Buriganga. In 2010 water samples were collected from "Near Ijtema Field, Tongi" for analysis for the months of January, April, June and July.

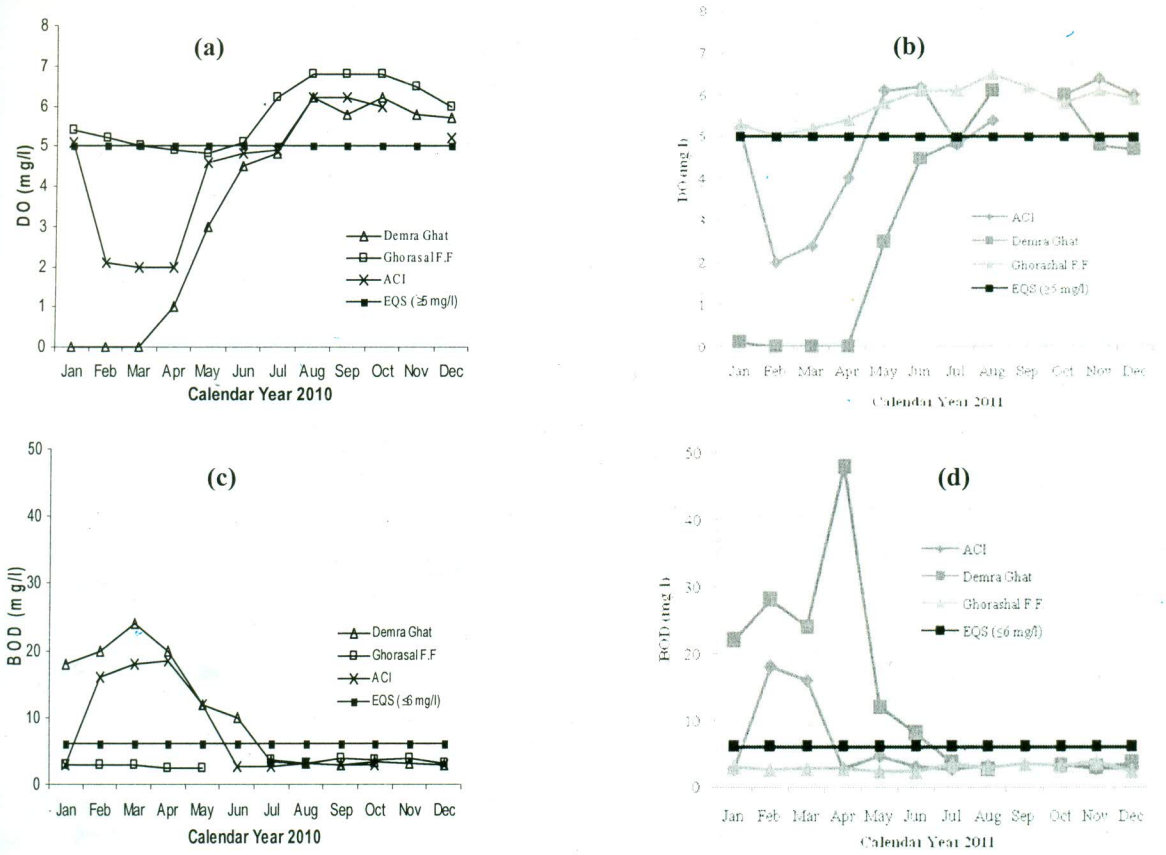

Fig. 5. Comparison of DO and BOD of Shitalakhya river in 2010 and 2011.

pH of Tuag river water varied from 7.14 to 7.6 mg/l (Fig. 6a) in 2010. In 2011 pH level varied from 7.18 to 8.24 mg/l. Chloride level of Turag was below the EQS (150 to 600 mg/l). Maximum Chloride (40 mg/l) was in April and the minimum was 6 mg/ and in July respectively (Fig. 6b). Turbidity level varied from 6.5 to 12.5 NTU (Fig. 6c) while drinking water standard for Turbidity is 10 NTU.

TDS was within the limit at all the sampling locations. Maximum TDS value was 1000 mg/l in April while that of minimum was 264mg/l in June against the EQS 1000 mg/l for drinking water is (Fig. 6d). DO concentration of Turag River was very low during the dry season of 2010 (Fig. 6e) and it was practically nil in January and April in 2010 and 2011. BOD concentration of Turag River within the sampling period in 2010 was presented in Fig. 6f. Maximum (36 mg/l) and minimum (2.6 mg/l) level of BOD was found in April and July respectively. During 2005-2006 highest BOD was 12 mg/l (Ahmed, 2009). In March 2011, highest BOD (36 mg/l) was found at north side of Tongi Bridge.

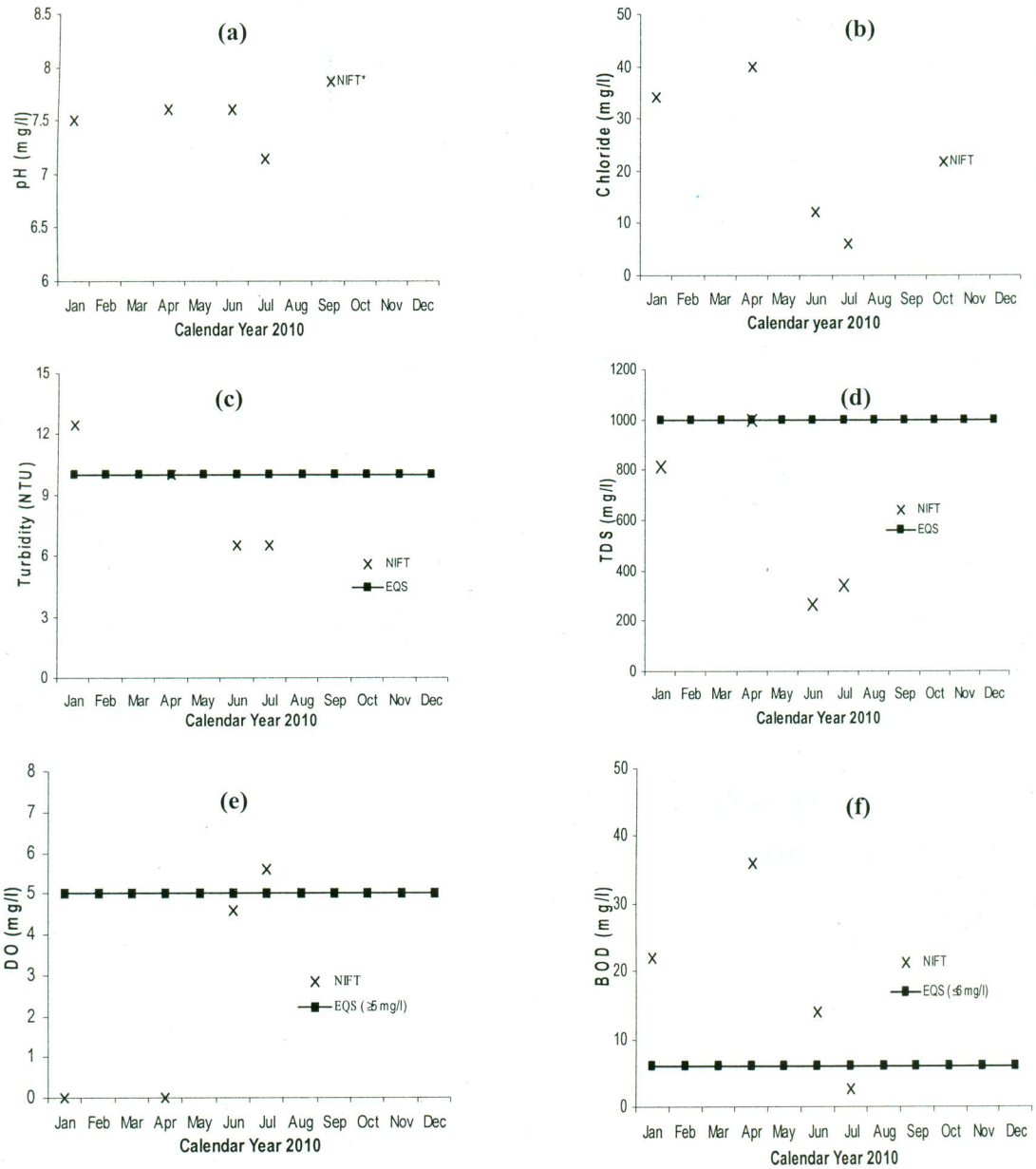

Fig. 6. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Turag River in 2010.

*Near Ijtema Field, Toongi

4.4 Balu River

The Balu River is a tributary of the Shitalakshya River. It passes through the wetlands of Beel Belai and Dhaka before joining to Shitalakshya at Demra. Three sampling locations of Balu river were Tongi, west side of Tongi Bridge and near Jabar-Jubair textile mills. Samples were collected continually from all the three locations.

pH was within the EQS for inland surface water (Fig.7a). Chloride content was far below the EQS for drinking water. Chloride level was maximum (38 mg/l) at Tongi and minimum (4.5

mg/l) near Jabar-Jubair textile mills (Fig. 7b). Turbidity was higher during Jan-May period at all the locations (Fig.7c). Turbidity was below the EQS for drinking water (10 NTU). Discharging untreated wastewater from industries was the prime cause of high turbidity.

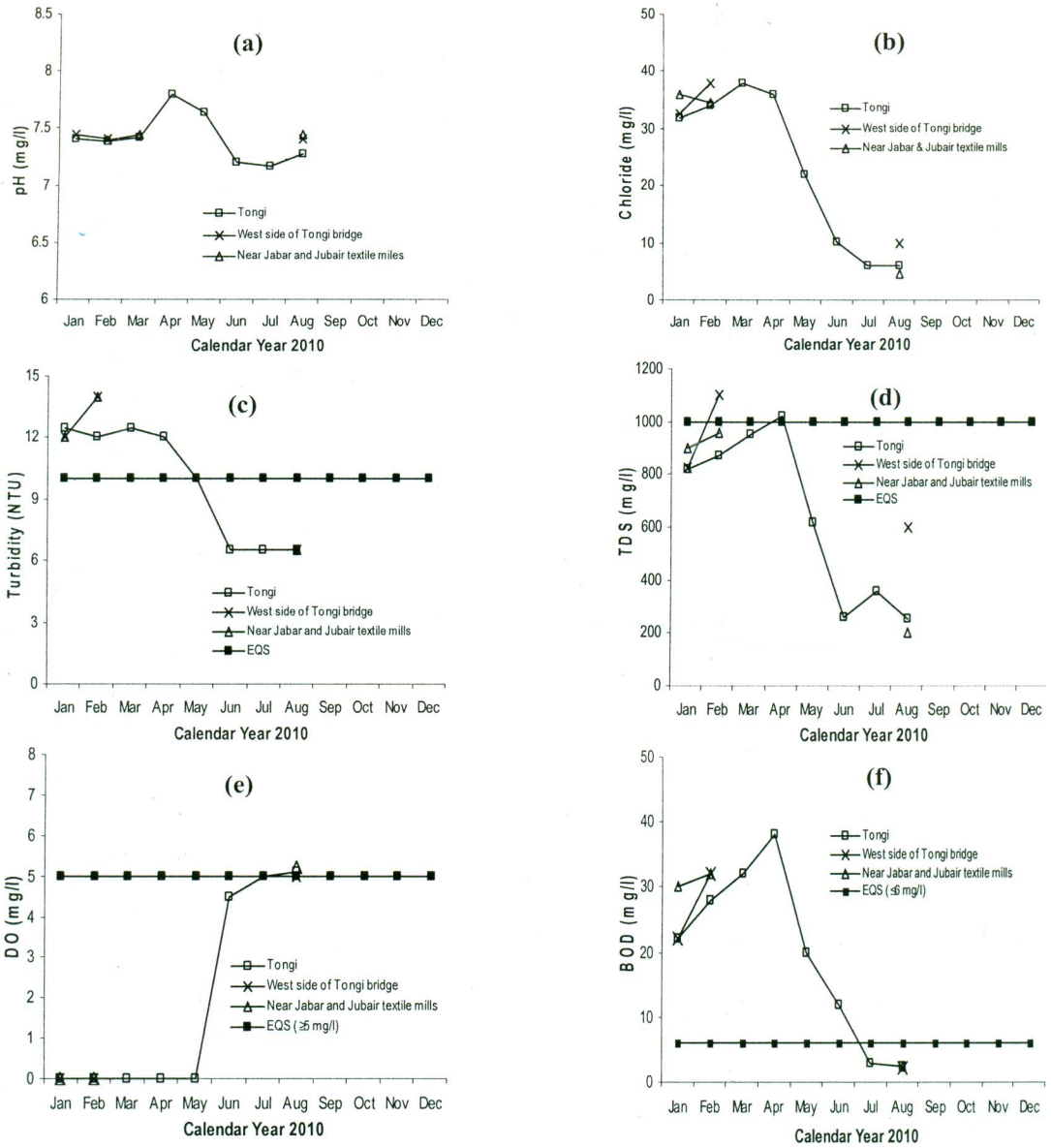

Fig. 7. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Balu river in 2010.

TDS was below the EQS except at west side of Tongi Bridge (1100 mg/l) in February (Fig. 7d). DO was nil at all three locations of Balu River from January to May of 2010 (Fig. 7e). BOD varied from 2.1 to 38 mg/l (Fig. 7f) against the EQS ($\leq$6 mg/l) of BOD for inland surface water for fisheries. Degradation of water quality was mostly due to direct/indirect discharge of domestic wastewater (human and food wastes) and industrial wastewater (from textile and other industries) into the river.

4.5 Dhaleshwari River

Dhaleshwari river is a 160km long distributary of the Jamuna river in central Bangladesh (Saleheen, 2006). It starts off the Jamuna near the northwestern tip of Tangail. Later it divides into two: the north branch retains the name Dhaleshwari while other this is Kaliganga. Near Narayanganj district Dhaleshwari and Kaliganga merged together and the combined flow goes southwards to merge into the Meghna. Water samples were collected from one location of Dhaleshwari.

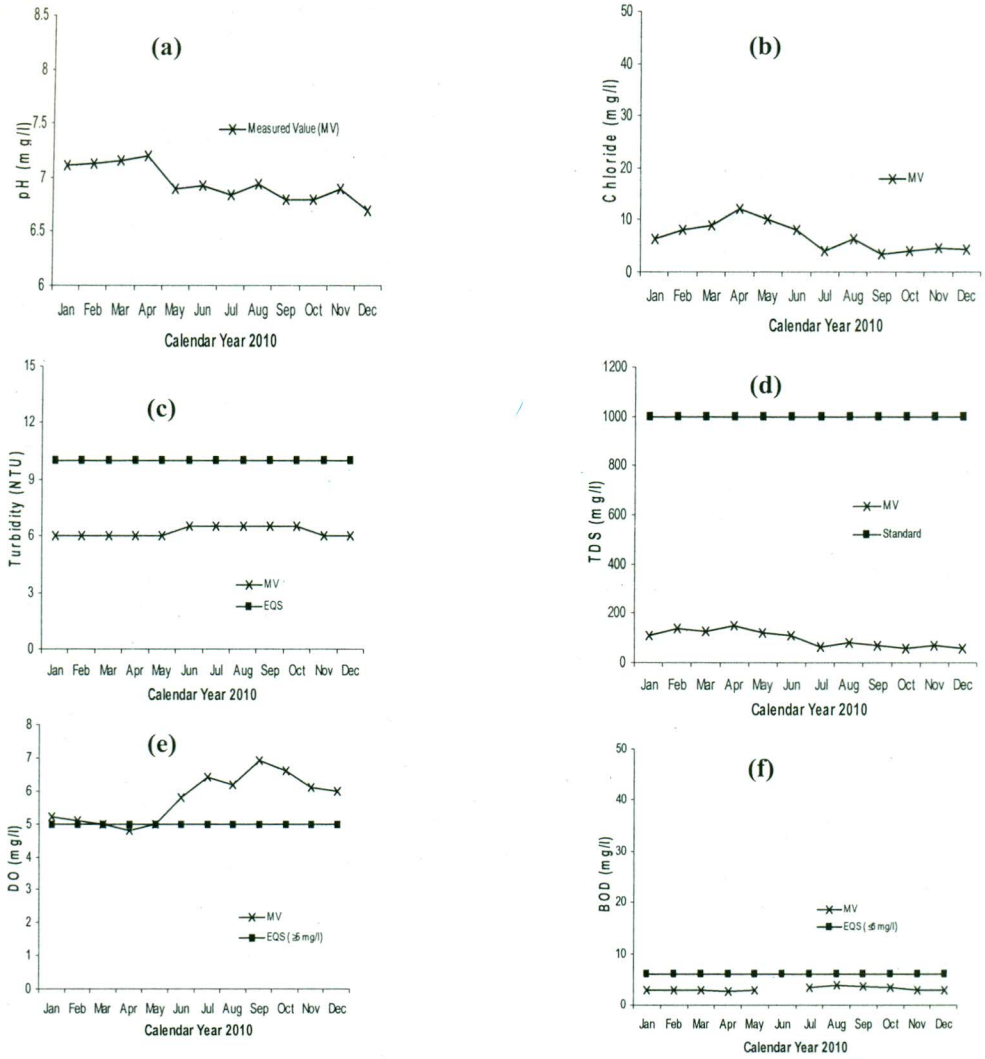

Fig. 8. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Dhaleshwari river in 2010.

In 2010, pH of Dhaleshwari varied from 6.8 to 7.2 mg/l (Fig. 8a). pH was maximum in April and minimum in July. Chloride concentration varied from 3.5 to 12 mg/l (Fig. 8b), which was far below the EQS (150-600 mg/l) for drinking water. Turbidity level was from 6 to 6.5 NTU (Fig. 8c). TDS varied from 54 to 150 mg/l and was far below the EQS (1000 mg/l). In 2010, DO varied from 4.8 to 6.9mg/l (Fig. 8e). DO was slightly below the EQS for fisheries

during January to May and then went up from June towards December. In 2010, BOD range was from 2.8 to 3.8 mg/l (Fig. 8f) while EQS is ≤6 mg/l.

4.6 Brahmaputra River

The Brahmaputra, also called Tsangpo-Brahmaputra, is a trans-boundary and one of the major rivers of Asia. It originates from Mansarovar near Mount Kailash in the Himalayas, flows via Tibbet, China, India and Bangladesh to Bay of Bengal. The total length it travels from Himalayans to the Bay is 2,850 km (Ahmed, 2006). Water sample collected from one location. Data were unavailable from September to November in 2010.

pH level of Brahmaputra river varied from 6.82 to 7.28 mg/l, while standards for inland surface water for pH is 6.5 to 8.5 mg/l (Fig. 9a). Chloride level of Brahmaputra River was within the EQS limit. It varied from 4 to 8.5 mg/l (Fig. 9b) and much less than EQS of 150 to 600 mg/l for drinking water. Turbidity level of Brahmaputra Rive was varied from 6 to 6.5 NTU (Fig. 9c) and very low compare to EQS (10 NTU) for drinking water. TDS of Brahmaputra river was very low compare to the EQS (1000 mg/l).

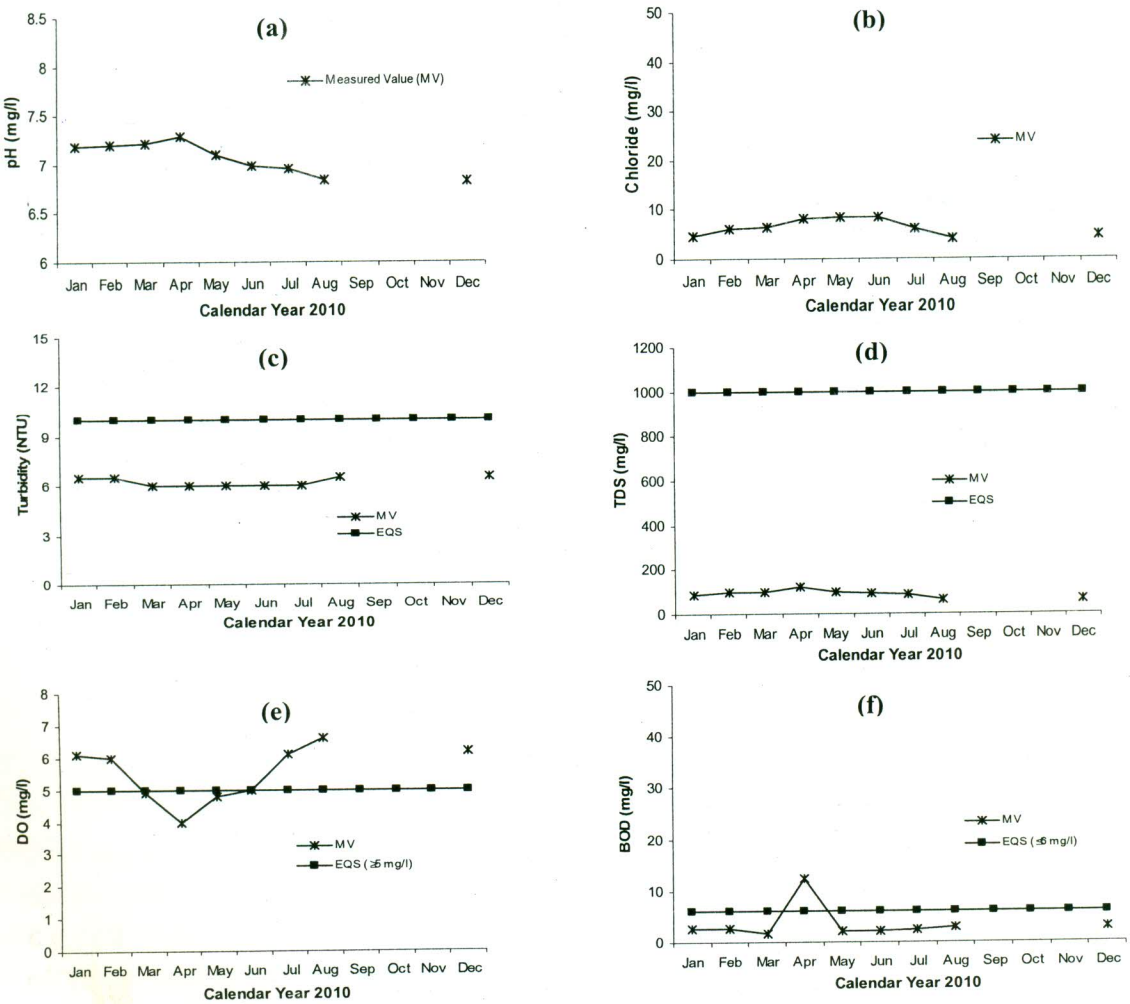

Fig. 9. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Brahmaputra river in 2010.

TDS level varied from 62 to 120 mg/l (Fig. 9d). DO concentrations varied from 4 to 6.6 mg/l (Fig. 9e) while EQS for fisheries is ≥5 mg/l. DO was the highest in August and lowest in April. BOD level was below under the EQS ≤6 mg/l limit for fisheries from January to August in 2010 except in April. BOD concentration varied from 1.8 to 12.4 mg/l (Fig. 9f).

4.7 Jamuna River

The Jamuna is one of the three main rivers of Bangladesh. It is the main distributary channel of the Brahmaputra as it flows out of India into Bangladesh. In 2010, samples were collected only from two locations e.g. Bahadurabad Ghat (B. Ghat) and Jamuna Fertilizer Factory (JFF).

Fig. 10a showed the variation in pH between the sampling locations of the Jamuna. pH level was within EQS throughout the year. Maximum pH (8.7 mg/l) was at B. Ghat in November and the minimum (6.16 mg/l) was at JFF in January. Chloride conc. varied from 3 to 14.5 mg/l (Fig. 10b). Maximum value (14.5 mg/l) was found at JFF in April, and the minimum (3 mg/l) was at B. Ghat in August.

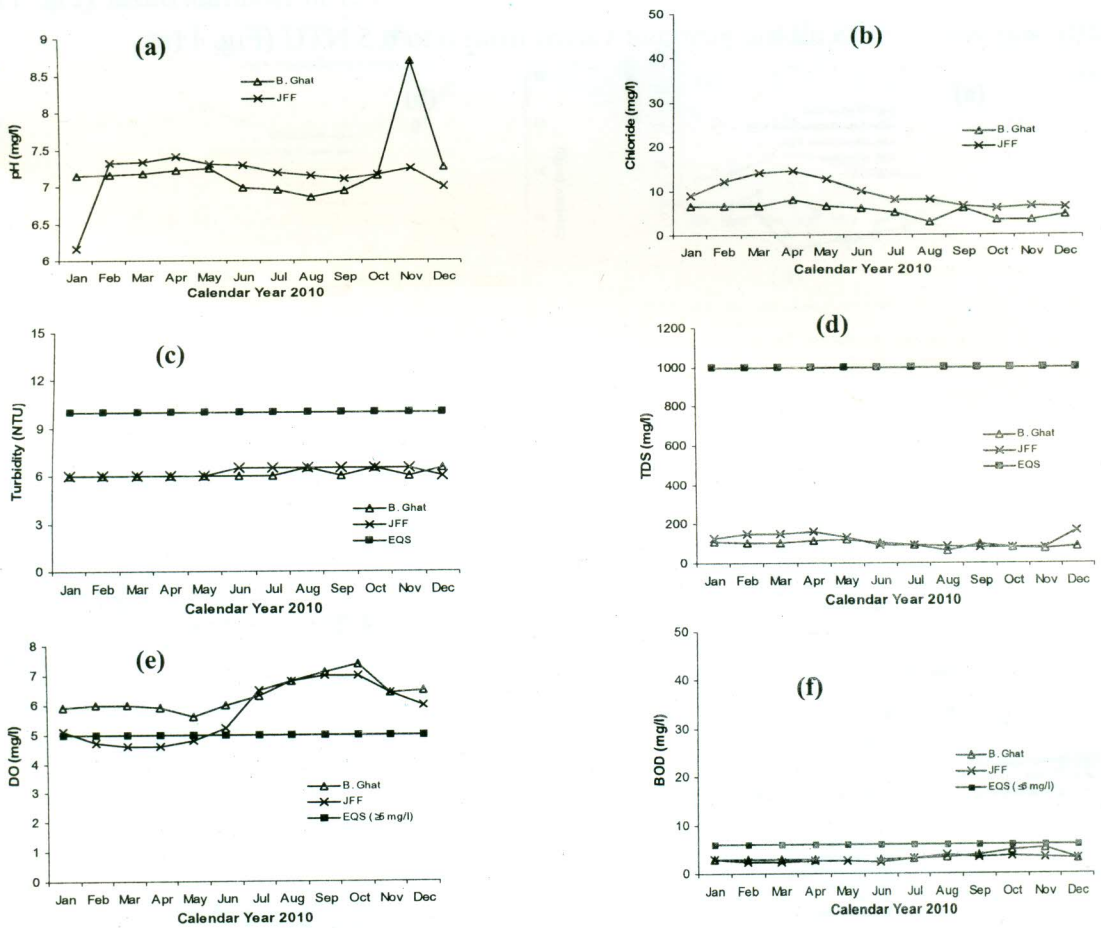

Fig. 10. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Jamuna River in 2010.

Turbidity varied from 6 to 6.5 NTU (Fig. 10c) and TDS varied from 66 to 170 mg/l (Fig. 10c). DO that varied from 4.6 to 7.4 mg/l (Fig. 10e) was mostly above the EQS for fisheries. At JFF, DO was below the EQS in February to May. BOD was within the EQS (≤6 mg/l) round the year (Fig. 10f).

4.8 Meghna River

The Meghna is an important river in Bangladesh, one of the three that forms the Ganges Delta, the largest on earth fanning out to the Bay of Bengal. To monitor water quality water samples were collected from five locations (e.g. Meghna Ghat, Near Shahjalal Paper Mills, Near Bhairab Bazar, Chandpur and Zia Fertilizer) of the Meghna river.

Throughout the year pH level was within the EQS of inland surface water. Maximum pH was 7.3 mg/l in November at Chandpur and the minimum was 6.75 mg/l in October at Near Bhairab Bazar (Fig. 11a). Chloride conc. at all the locations in 2010 was within the EQS (150-600 mg/l) for drinking water. Maximum conc. of Chloride was found at Zia Fertilizer (18 mg/l) in March and the minimum (2.5mg/l) was in October at Bhairab Bazar (Fig. 11b). Turbidity was within EQS all the year and varied from 6 to 6.5 NTU (Fig. 11c).

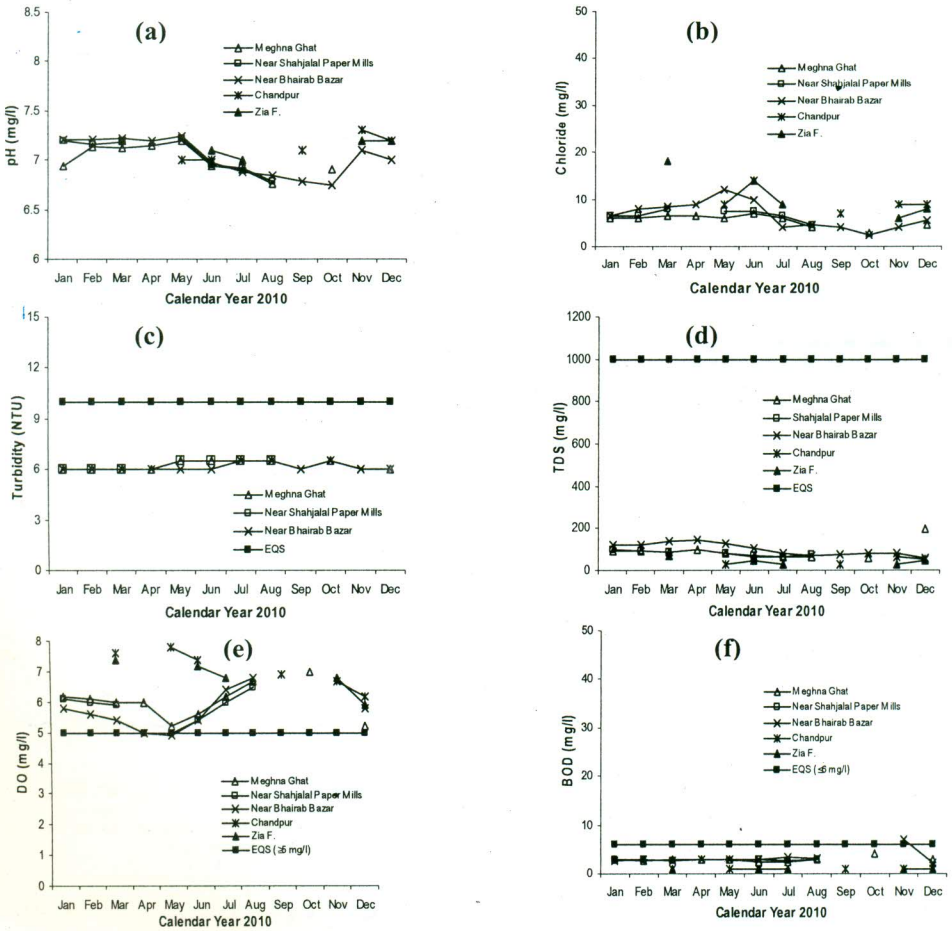

Fig. 11. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Meghna river in 2010.

TDS of Meghna ranged from 26 to 195 mg/l (Fig. 11d) in 2010 and thus, very low compare to EQS (1000 mg/l) for drinking water. DO level of Meghna was above the EQS ($\geq$5 mg/l) for fisheries all through year except in May (Fig. 11e). At all the locations BOD was within the EQS ($\leq$6 mg/l) for fisheries all the year except in November at Bhairab Bazar. Maximum and minimum conc. of BOD was 6.9 and 1 mg/l respectively (Fig. 11f).

4.9 Kaliganga River

The Kaliganga flows near by southern part of Manikganj district. Water sample was collected from one location (e.g. Manikganj) for analysis. No sample was collected in September and October.

pH level of Kaliganga varied from 6.88 to 7.6 mg/l (Fig. 12a). Maximum and minimum pH was found in December and August respectively. Chloride level was very low compare to the EQS (150-600 mg/l). Highest pH (12.5 mg/l) was found in April and the lowest (3 mg/l) in November (Fig. 12b). Turbidity level varied from 6 to 6.5 NTU (Fig. 12c).

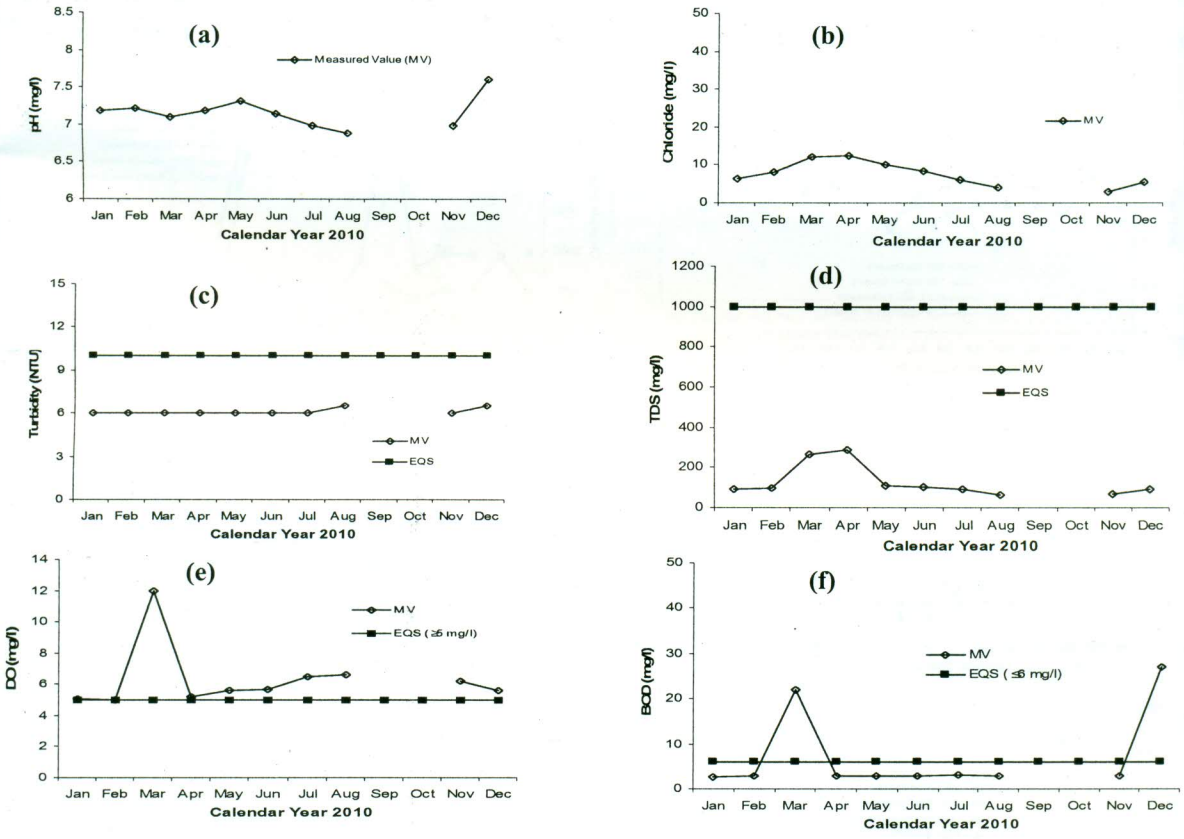

Fig. 12. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Kaliganga river in 2010.

TDS. was very low compare to the EQS of drinking water. Maximum value was 290 mg/l in April and the minimum was 68 mg/l in November (Fig. 12d). There was ample DO (ranging

5 to 12 mg/l) in water (Fig. 12e). BOD varied from 2.6 to 27 mg/l (Fig. 12f). Compare to the EQS for fisheries BOD was low all the year except in March and December.

4.10 Karnaphuli River

Karnaphuli is a 667m wide river in the south-eastern part of Bangladesh. It flows 270 km southwest through Chittagong Hill Tracts and Chittangong into the Bay of Bengal (Saleheen and Chowdhury, 2006). In 2010, water samples were collected from four locations e.g. Upstream & downstream of TSP factory, Upstream & downstream of Karnaphuli Urea Fertilizer Limited (CUFL).

Fig. 13a, showed variation in pH level at different locations of the Karnaphuli. pH varied from 7 to 7.9 mg/l. Chloride conc. of Karnaphuli was higher especially at CUFL upstream and downstream compare to EQS (150 to 600 mg/l). It varied from 99 to 5,524 mg/l (Fig. 13b). Maximum Chloride was found at CUFL downstream in June and the minimum at TSP upstream in September. In 2011, Chloride conc. was 130 to 10,700 mg/l. TDS was mostly beyond the EQS (1000mg/l). It varied from 322 to 8,206 mg/l (Fig. 13c). Maximum TDS was found at CUFL downstream in June and minimum at TSP upstream in September.

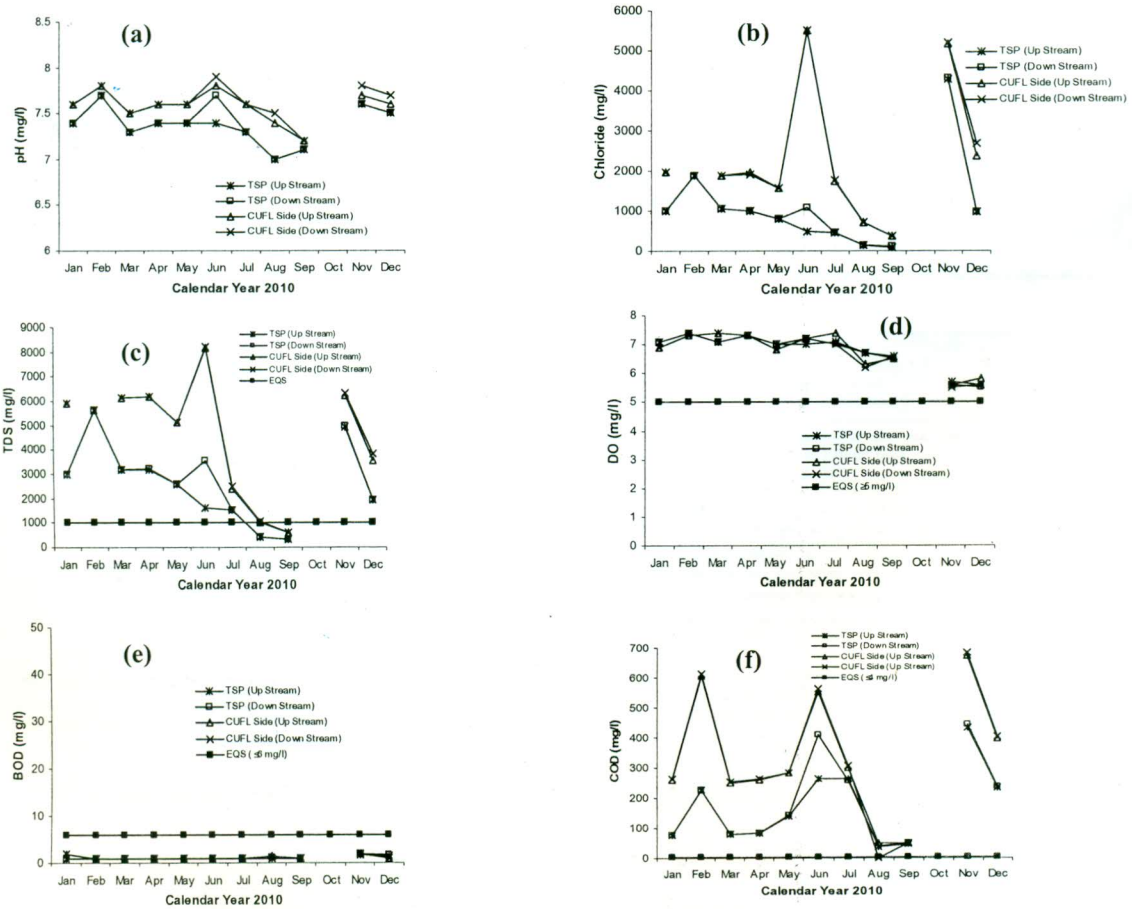

Fig. 13. Graphical presentation of pH, Chloride, TDS, DO, BOD and COD of Karnaphuli river water in 2010.

Compare to the EQS (≥5 mg/l) for fisheries. DO of Karnaphuli river was high round the year at all locations. It varied from 5.5to7.4 mg/l (Fig. 13d). BOD was lower than EQS (≤6 mg/l) for fisheries throughout the year (Fig. 13e). Fig. 13f, showed variation in COD conc. at the sampling locations of Karnaphuli. COD varied from 1.6 to 684 mg/l while EQS for drinking water is 4 mg/l. COD was high at locations of CUFL compare to locations of TSP. In 2011, COD level varied from 53 to 930 mg/l.

4.11 Bakkhali River

Bakkhali is the only important river in Cox's Bazar district. It originated from the ranges that divided Chittagong from Arakan and flows north, then turning to the west and passes Ramu and Cox's Bazar town. Finally it falls into the Maheshkhali channel (Chowdhury, 2006). Water samples were collected from two locations (e.g. Mazer Ghat and Fishery Ghat of Cox's Bazar) of Bakkhali river for seven months.

pH level varied from 7.1 to 7.9 mg/l (Fig. 14a). Chloride conc. varied from 94 to 7,313 mg/l (Fig. 14b) against the EQS (150 to 600 mg/l) for drinking water. Chloride content went down in rainy season. In 2011, Chloride content ranged from 342 to 9100 mg/l.

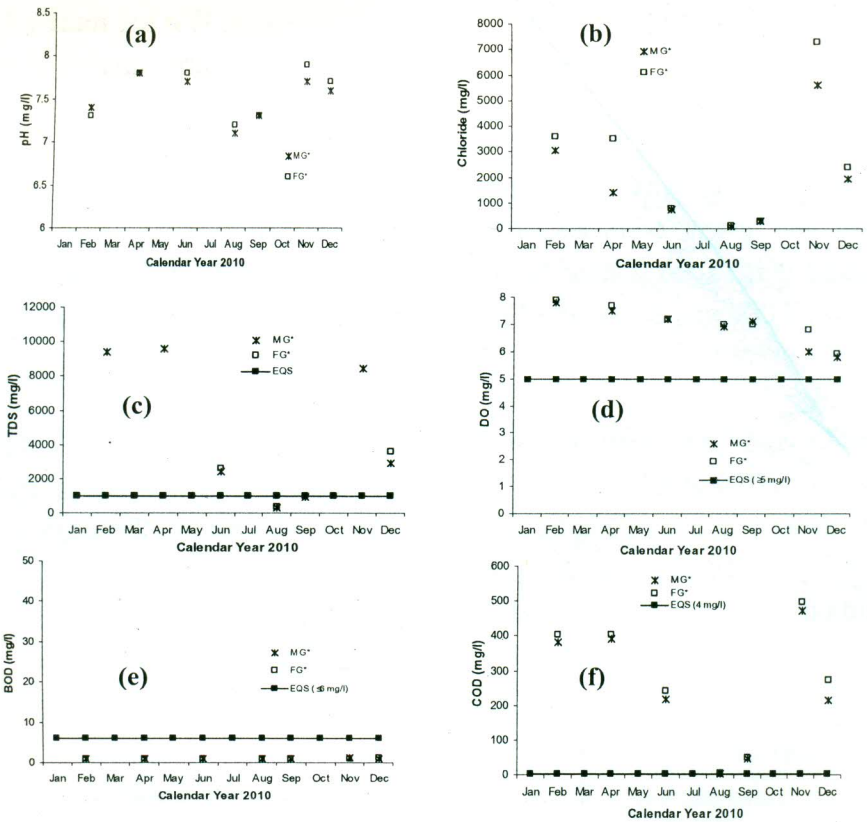

Fig. 14. Graphical presentation of pH, Chloride, TDS, DO, BOD and COD of Bakkhali River in 2010.

* MG and FG-Mazer Ghat and Fishery Ghat, Cox's Bazar

TDS of Bakkhali river was very high that ranged from 306 to 9558 mg/l (Fig. 14c). But in August and September TDS was below the EQS (1000 mg/l). DO varied from 5.8 to7.9 mg/l (Fig. 14d). At all sampling points, DO was above the EQS ($\geq$5 mg/l) for fisheries. BOD level of Bakkhali river was below the EQS ($\leq$6 mg/l) for fisheries. BOD varied from 1.2 to 1 mg/l (Fig. 14e). COD level of Bakkhali river was much higher than the EQS (4 mg/l) for drinking water. It varied from 3 to 497 mg/l throughout the sampling period (Fig. 14f). In 2011, COD varied from 1.0 to 735 mg/l and highest COD was found in April at Fishery Ghat.

4.12 Halda River

Halda river passes through the South-Eastern part of Bangladesh. Its total length is about 81km, of which 29 km upto Nazirhat is navigable by big boats throughout the year. Depth varies for 6.4m to 9.1m (Chowdhury, 2006). Water sampling points were WASA intake points (upstream and downstream), Maduna Ghat (Bank and Middle). Samples were collected during high and low tide at all locations. To simplify the analysis, only high tide and low tide variation for the sampling points were considered. Because no significant variation was found between up and downstream of Chittagong WASA intake Point as well as between river bank- middle point of Maduna Ghat. Data was unavailable from August to October.

In 2010, pH of Halda river was within the EQS and varied from 7 to 7.6 mg/l (Fig. 15a). Chloride level of was lower compare to EQS (150-600mg/l) for drinking water. It varied from 4 to 126 mg/l (Fig. 15b). Chloride conc. was higher during high tide compare to low tide at all locations. TDS was below the EQS (1000 mg/l), which varied from 34 to 384 mg/l (Fig. 15c).

DO level of Halda river was well above the EQS ($\geq$5 mg/l) for fisheries throughout the monitoring period of 2010 at all locations during high and low tide. It varied from 5.2 to 7.6 mg/l (Fig. 15d). BOD content of Halda river water was well below the EQS ($\leq$6 mg/l) for fisheries round the year. BOD. ranged from 1.2 and 1mg/l (Fig. 15e). COD load at sampling locations of Halda during high and low tide varied from 2 to 17mg/l (Fig. 15f).

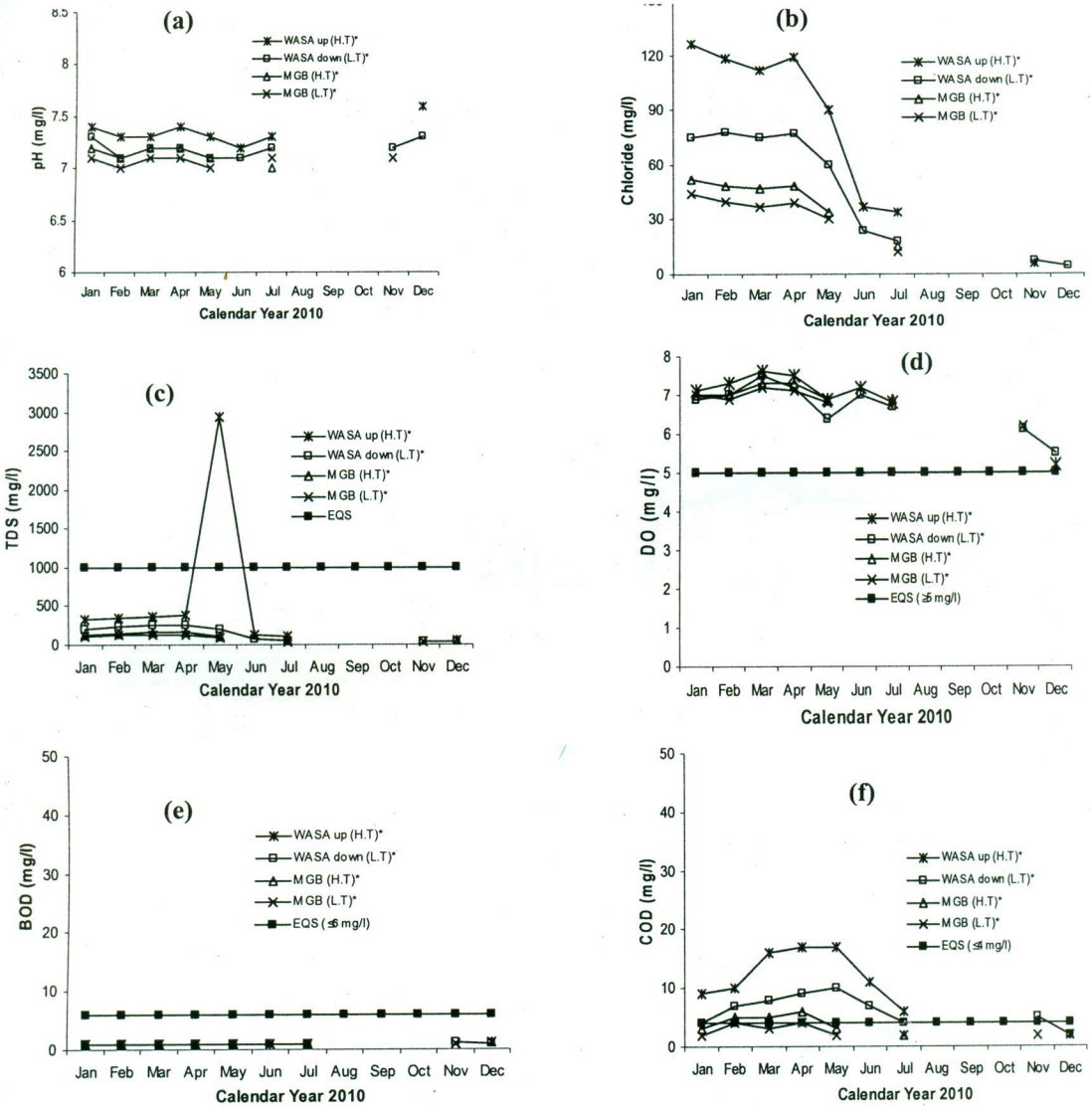

Fig. 15. Graphical presentation of pH, Chloride, TDS, DO, BOD and COD of Halda rver in 2010.

4.13 Moyuri River

For analysis of water quality of Moyuri river in 2010, water samples were colleted from one location of three different points of Gallamari Bridge (Bank, Middle and Opposite Bank) of the river.

pH of Moyuri River varied from 7.36 to 7.78 mg/l at all the points (Fig. 16a) and of 2010 was within the EQS. Chloride was much higher (March-June) compare to rest of the period of 2010 and EQS for drinking water (150-600 mg/l) as well. Chloride conc. varied from 12 to 5980 mg/l (Fig. 16b) in 2010 and 21 to 6483 mg/l in 2011. Turbidity of Moyuri at all the points was very high compare to EQS (10 NTU). Turbidity varied from 41 to 189 NTU (Fig. 16c).

TDS was varied from 160 to 9480 mg/l (Fig. 16d) and the highest TDS was in April and the lowest was from July to December. In 2011, TDS varied from 190 to 10300 mg/l. DO of Moyuri river was below the EQS ($\geq$5 mg/l) for fisheries. DO varied from 0 to 4.2 mg/l (Fig. 16e). No dissolved oxygen was found in January to June and December at all the sampling locations. In 2011, DO was nil during March to April all the points and ranged from o to 4.8 mg/l. BOD level varied from 1.8 to 36 mg/l (Fig. 16f) while EQS is $\leq$6 mg/l for fisheries. Similar BOD was found in 2011. COD of Moyuri river was very high in 2010. Maximum and minimum COD was 672 and 56 mg/l respectively (Fig. 16g) while EQS is 4 mg/l for drinking water. Similar range of COD was found in 2011.

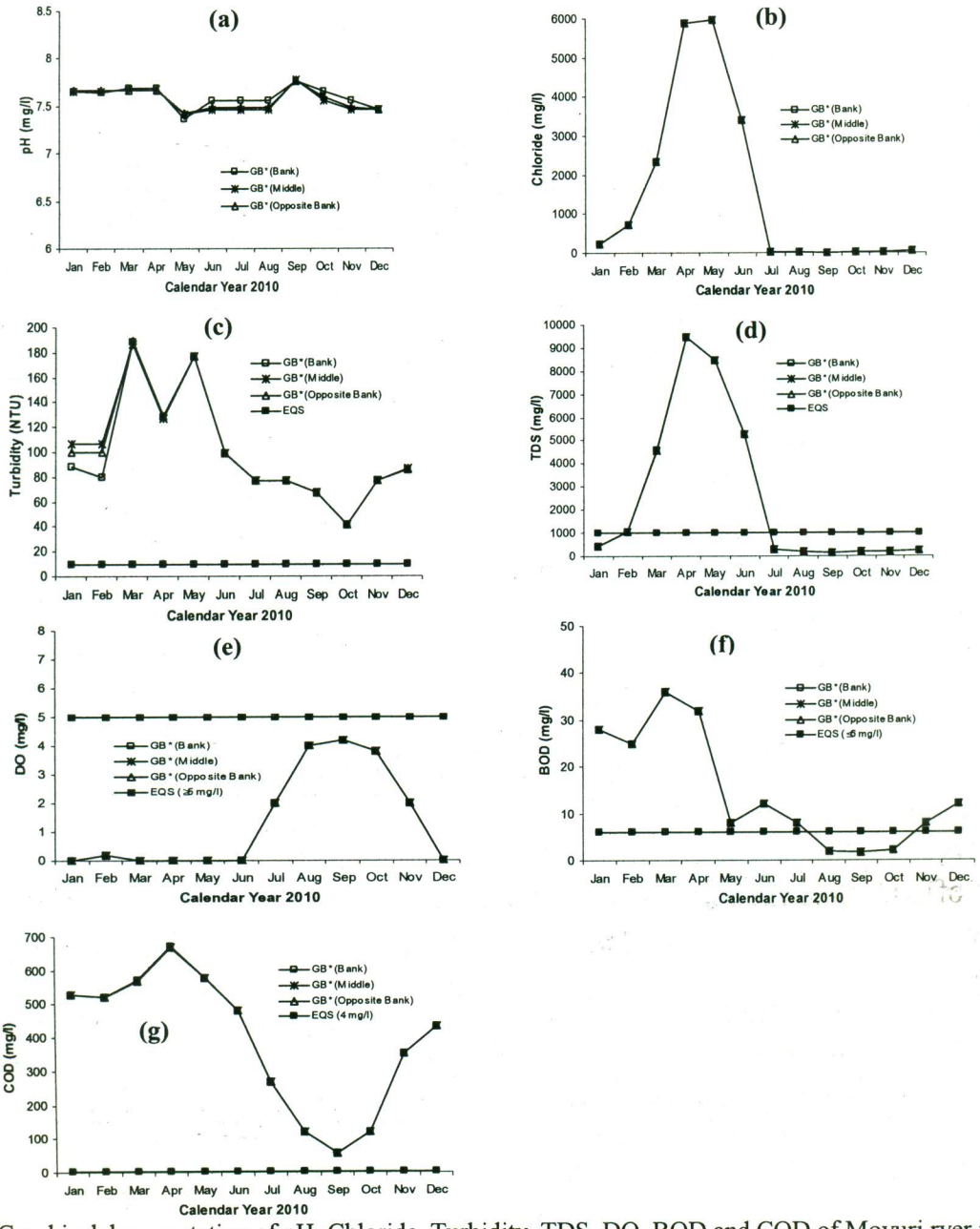

Fig. 16. Graphicalal presentation of pH, Chloride, Turbidity, TDS, DO, BOD and COD of Moyuri rver in 2010.

* Gallamari Bridge (GB)

4.14 Bhairab River

Bhairab river is approximately 100 miles long and 300 feet wide. Its average depth is 4 to 5 feet (Chowdhury, 2006). In 2010 samples were collected from three locations e.g. Noapara Ghat, Fultala Ghat and Charerhat Ghat of Bhairab river for water quality analyses.

pH at different locations was varied from 7.51 to 7.79 mg/l (Fig. 17a). High level of Chloride was found from March to June and the level varied from 9.2 to 9340 mg/l (Fig. 17b) while drinking water standard for chloride is 150 to 600 mg/l. Highest Chloride (9340 mg/l) was found in May and the lowest (9.2 mg/l) was in September. Turbidity at all locations was very high in 2010 which varied from 38 to 189 NTU (Fig. 17c).

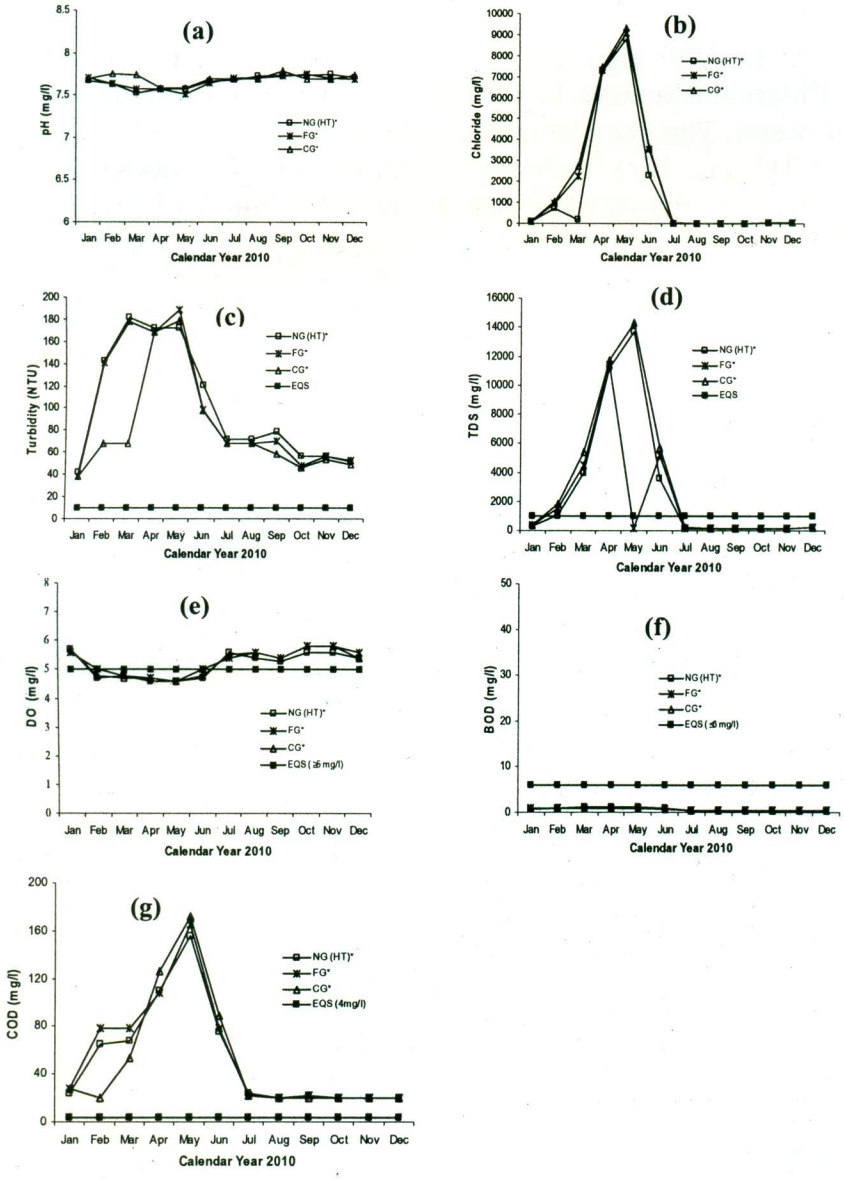

Fig. 17. Graphicalal presentation of pH, Chloride, Turbidity, TDS, DO, BOD and COD of Bhairab rver in 2010.

* Noapara Ghat (NG), Fultala Ghat (FG) & Charerhat Ghat (CG)

TDS level of Bhairab river was very high during February to June at all locations. It was varied from 130 to 14,300 mg/l respectively (Fig. 17d) while EQS is 1000 mg/l. DO was low from February to June compare to EQS (≥5 mg/l) for fisheries. DO varied 4.6 to 5.8 mg/l (Fig. 17e). BOD content of water was below the EQS (≤6 mg/l) in 2010. It was from 0.4 to 1.1 mg/l (Fig. 17f). COD was relatively high in 2010 which ranged from 20 to 172 mg/l (Fig. 17g) while EQS for drinking water is 4 mg/l.

4.15 Rupsha River

Rupsha river flows by Khulna city, and falls to the Bay of Bengal through Poshur River at Mongla channel. Water samples were collected from two different locations viz. Rupsha Ghat and Labanchara Ghat of Rupsha river for analyses of water quality in 2010.

pH level varied from 7.51 to 7.79 mg/l (Fig. 18a). Chloride level was varied from 15.6 to 9640 mg/l (Fig. 18b). Chloride was much higher (February-June) compare to the EQS (150-600 mg/l) for drinking water. This may be due to reduction in flow of the river. Turbidity varied from 65 to 201 NTU (Fig. 18c). Turbidity at both locations of Rupsha river was very high during dry period and was relatively low during June to December of 2010.

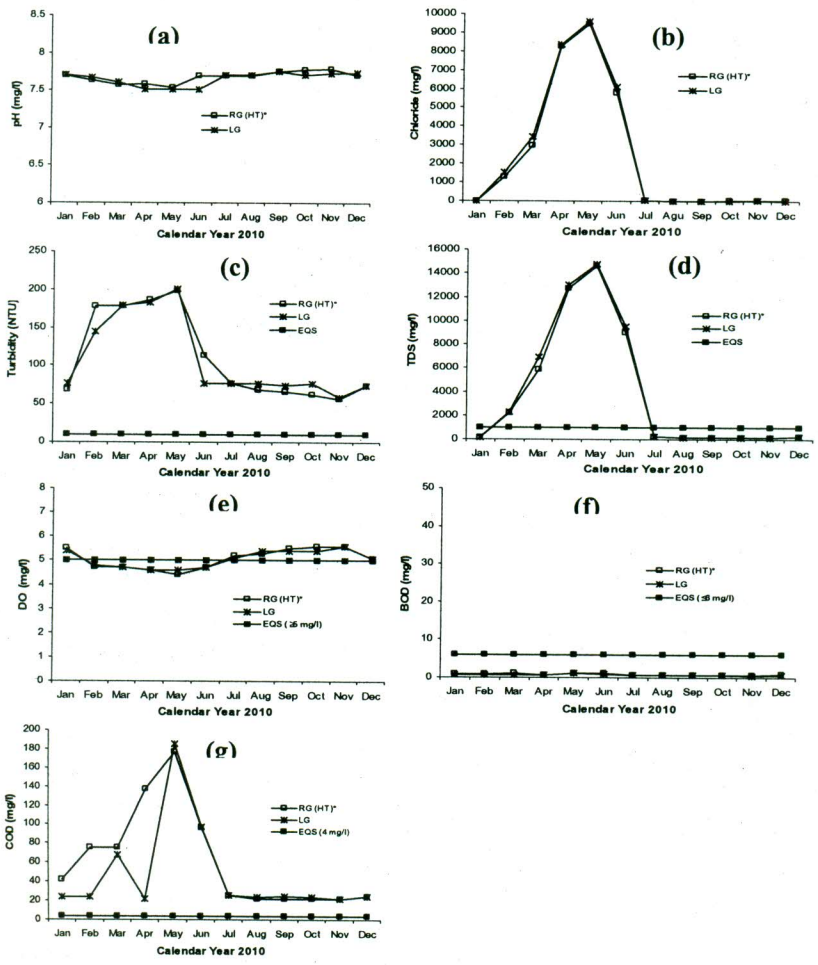

Fig. 18. Graphical presentation of pH, Chloride, Turbidity, TDS, DO, BOD and COD of Rupsha rver in 2010.

In 2011 turbidity varied from 52.2 to 210.6 NTU. TDS level varied from 135 to 14800 mg/l (Fig. 18d). At both locations, TDS was high from Febuary to June in 2010 while comparing to EQS (1000 mg/l) for drinking water.

Compare to EQS (≥5 mg/l) for fisheries, DO was lower during February to June. It was varied from 5.6 and 4.4 mg/l (Fig. 18e). The level of DO in 2011 was varied from 4.5 to 6.8 mg/l. BOD level of Rupsha river was below the allowable limit (≤6 mg/l) for fisheries throughout the year of 2010. BOD was varied from 0.6 to 1.2 mg/l (Fig. 18f). In 2011 BOD was found slightly higher compare to 2010. COD level was high in 2010 and was varied from 22 to 186 mg/l (Fig. 18g) while allowable limit for COD is 4 mg/l for drinking water. In 2011, COD varied from 22 to 225 mg/l.

4.16 Mathavanga River

Water samples were collected from three different locations e.g. Pipeghat, 200m upstream and 200m downstream of Pipeghat, Darshana of Mathavanga river.

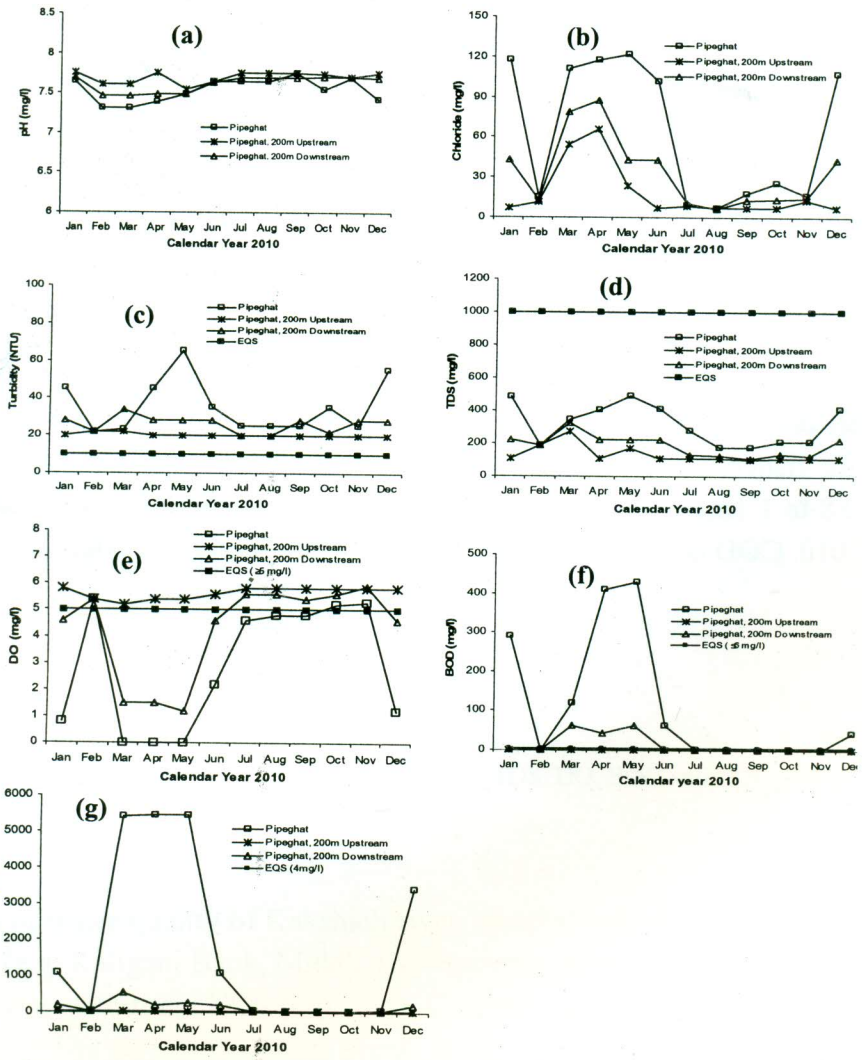

Fig. 19. Graphical presentation of pH, Chloride, Turbidity, TDS, DO, BOD and COD of Mathavanga rver in 2010.

pH of Mathavanga river was within the EQS (6.5-8.5 mg/l) for inland surface water all over the year and was varied from 7.31 to 7.75 mg/l (Fig. 19a). Chloride level varied from 6.4 to 122mg/l (Fig. 19b). Chloride conc. was higher at all locations during February to June compare to rest of times of the year. Turbidity varied from 20 to 66 NTU (Fig. 19c) and was higher than EQS (10 NTU). In 2011, COD varied from 20.2 to 210.7 NTU.

In 2010, TDS varied from 105 to 490 mg/l (Fig. 19d). At all sampling locations, TDS was below the EQS (1000 mg/l) for drinking. TDS was higher at Pipeghat compare to rest of the sampling points. In 2011, TDS varied from 105 to 555 mg/l. DO varied from 0 to 5.9 mg/l. DO was high at Upstream of Pipeghat but no DO was found at Pipeghate from March to May (Fig. 19e). In 2011, DO varied from 0 to 7.2 mg/l. BOD varied from 0.5 to 430 mg/l (Fig. 19f). BOD level was within the limit of EQS at all points from July to November. COD was very high at Pipeghat during March to May. COD varied from 20 to 5460 mg/l (Fig. 19g) while EQS is 4 mg/l for drinking water.

4.17 Pashur River

To analyse water quality of Pashur river, water sample was collected from one location comprising three points (e.g. Monglaport Bank, Middle and Opposite bank). pH of Pashur river water was within the EQS limit and varied from 7.51 to 7.78 mg/l (Fig. 20a). Chloride content varied from 76 to 11,390 mg/l (Fig. 20b). Chloride conc. was much higher during dry period (January-July) compare to the EQS. This was mostly due to reduction in water flow. Turbidity varied from 57 to 179 NTU (Fig. 20c).

TDS level that varied from 270 to 17750 mg/l (Fig. 20d) was above the EQS from January to July in 2010 at all points of the river. DO range was 4.5 to 5.4mg/l (Fig. 20e) and it was below the EQS for fisheries ($\geq$5 mg/l) from February to July. BOD content of this river water was from 0.8 to 1.1mg/l (Fig. 20f). BOD level did not exceed the EQS ($\leq$6 mg/l) for fisheries during 2010. COD conc. varied from 24 mg/l to 210 mg/l (Fig. 20g).

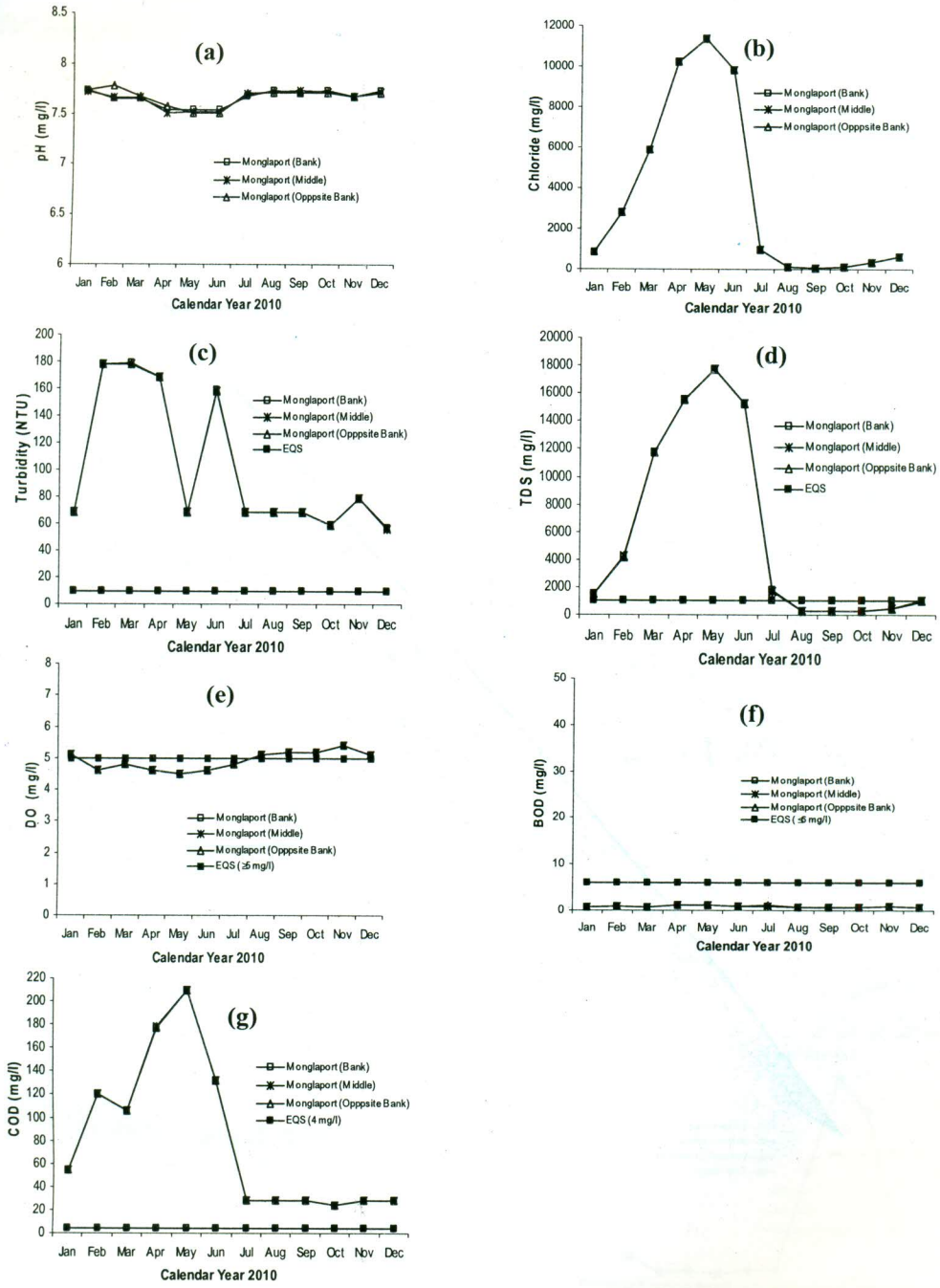

Fig. 20. Graphical presentation of pH, Chloride, Turbidity, TDS, DO, BOD and COD of Pashur rver in 2010.

4.18 Kakshiali River

For analysis of water quality of Kakshiali river, samples were collected from one location of three points (e.g. Kaliganj Bank, Middle and Opposite Bank) in 2010. pH (7.51 to 7.78 mg/l) of the river was within the EQS (Fig. 21a). Chloride conc. varied from 72.4 to 11,290 mg/l (Fig. 21b) and was very high during March to June if compared with EQS (150-600 mg/l).

Highest Chloride was found in May and lowest in September. Turbidity (47 to 188 NTU) (Fig. 21c) was above the EQS (10 NTU) for drinking water.

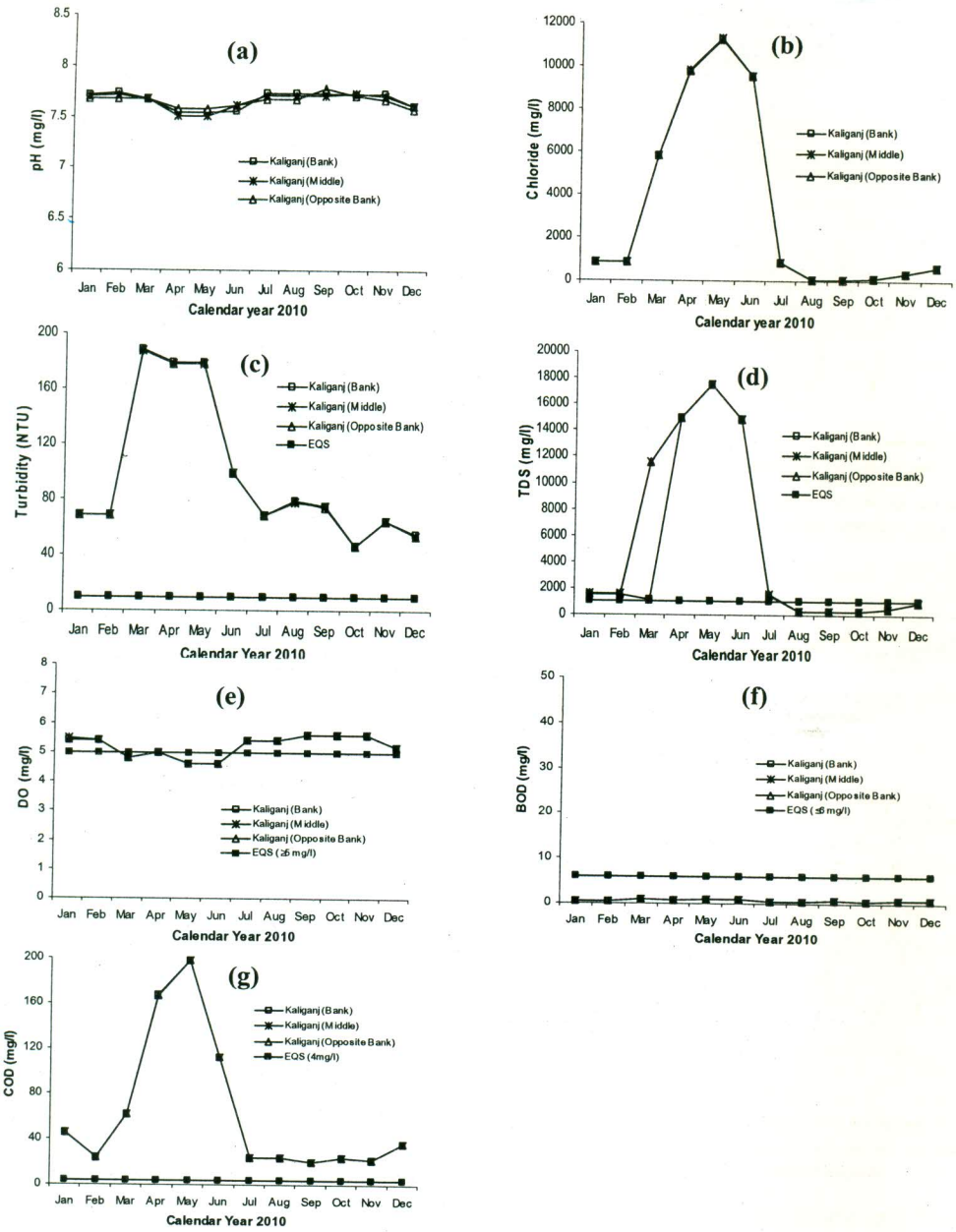

Fig. 21. Graphical presentation of pH, Chloride, Turbidity, TDS, DO, BOD and COD of Kakshiali rver in 2010.

TDS level was very high in the first seventh months of 2010. It varied from 270 to 17,500 mg/l (Fig. 21d) while EQS is 1000 mg/l. DO varied from 4.6 to 5.6 mg/l throughout the year while EQS for fisheries is $\geq$5 mg/l (Fig. 21e). BOD level was far below the EQS limit for fisheries ($\leq$6 mg/l). It varied from 0.5 to 0.9 mg/l (Fig. 21f). COD (20 to 198 mg/l) concentration (Fig. 21g) of the river was above the EQS.

4.19 Gorai River

Water samples were collected from two locations namely Kamarkhali ghat, Magura and G K ghat Kustia. In 2010, pH of Gorai river varied from 7.67 to 7.81 mg/l (Fig. 22a) and was within the EQS (6.5-8.5 mg/l) for inland surface water. Chloride content (30 and 7 mg/l) was also within the EQS (Fig. 22b). Fig. 22c, showed the variation in turbidity (18 to 22 NTU). Compare to EQS (10 NTU) turbidity was higher throughout the year.

TDS (85 to 220 mg/l) (Fig. 22d) was below the EQS of 1000 mg/l. DO was above the EQS (≥5 mg/l) for fisheries at both locations. Level of DO varied from 5.7 to 6.3 mg/l (Fig. 22e). BOD was far below the EQS (≤6 mg/l) for fisheries. It varied from 0.4 to 0.6 mg/l (Fig. 22f). At both locations, COD was under 20 mg/l all the year while EQS is 4 mg/l.

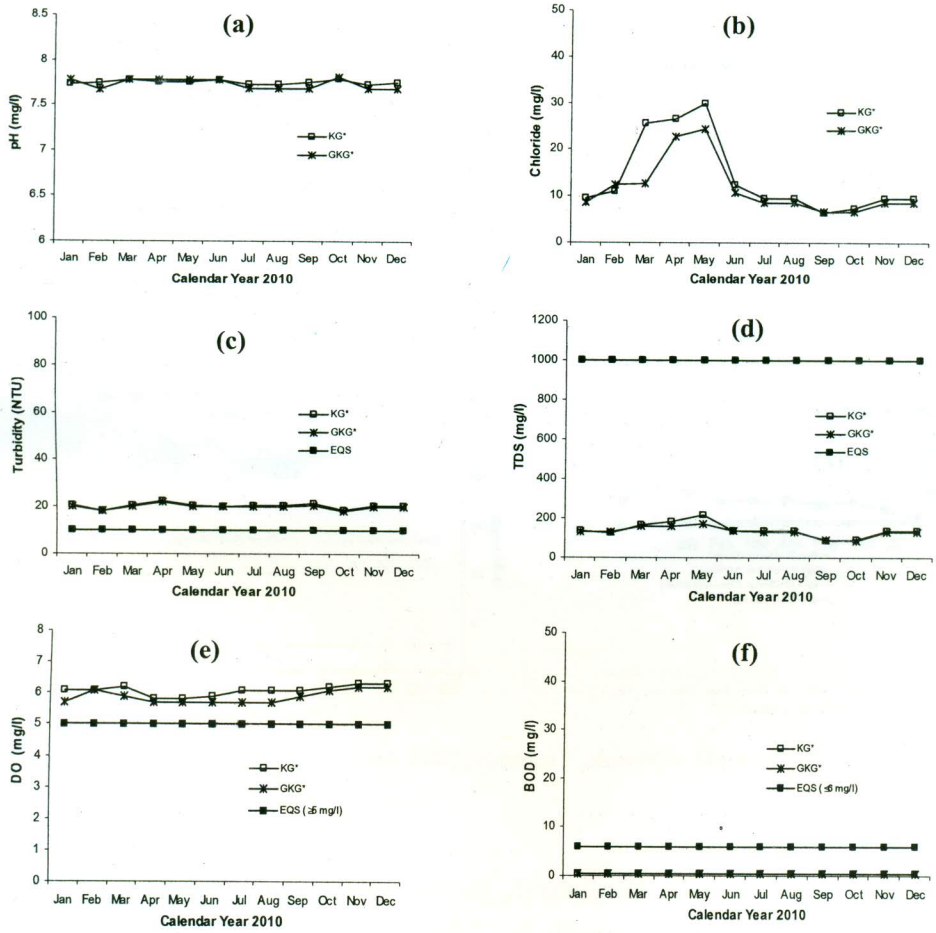

Fig. 22. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Gorai rver in 2010.

4. 20 Modhumoti River

For analysis of water quality of Modhumoti river in 2010, samples were collected from one location comprising three points (e.g. Mollarhat side, middle and opposite bank). pH level varied from 7.7 to 7.8 mg/l (Fig. 23a) and was within the EQS. Chloride level ranged from 6 to 731 mg/l (Fig. 23b) and was within EQS (150 to 600 mg/l) for drinking water. Maximum

Chloride was found in April and minimum was in July. Turbidity varied from 18 to 23 NTU (Fig. 23c) and was slightly higher than EQS (10 NTU) for dirking water.

TDS range was from 84 to 1320mg/l (Fig. 23d) and was below the EQS (1000 mg/l) except in April. DO (5.2 to 6.2 mg/l) level was high round the year (Fig. 23e). BOD (0.4 to 0.8 mg/l) was below the EQS (≤6 mg/l) for fisheries (Fig. 23f).

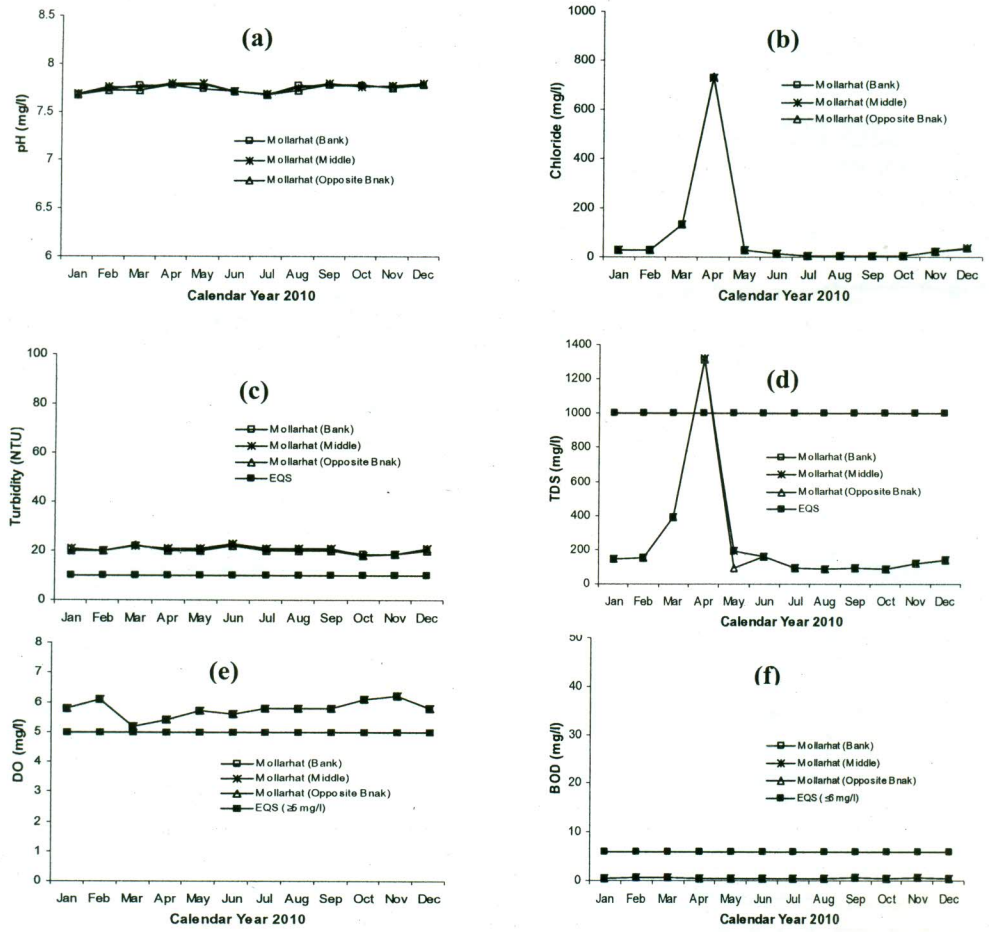

Fig. 23. Graphical presentation of pH, Chloride, Turbidity, TDS, DO and BOD of Modhumoti river in 2010.

4.21 Surma River

The Surma river is a major river in Bangladesh, part of the Surma-Meghna river System. The average depth is 86m and maximum depth is 170m (Chowdhury, 2006). To analyse water quality in 2010 samples were collected from six different locations of the river namely Mehendipaka Bridge, Knee Bridge, Kazi bazaar, Chattak, Shajalal Bridge and Shak Ghat. In October water sample was not collected.

pH level varied from 5.6 to 7.8 mg/l (Fig. 24a) while EQS is 6.5 to 8.5 mg/l for inland surface water. Acidic condition of water was found at Chattak and Kazi Bazar in July 2010.

Chloride level of Surma river varied from 33 to 200 mg/l (Fig. 24b) and was within the EQS (150-600 mg/l) for drinking water. TDS level was varied from 260 to 710 mg/l (Fig. 24c).

DO level of Surma river varied from 4.1 to 6.8 mg/l (Fig. 24d). It was mostly above the EQS (≥5 mg/l) for fisheries except in July at Chattak point, BOD value was found from 1 and 1.3mg/l (Fig. 24e) and was below the EQS at all locations. In 2006, DO was 5.52 mg/l and 5.72 mg/l during dry and monsoon season respectively. In the similar temporal context, BOD was 1.0mg/l and 0.878 mg/l respectively (Alam et al., 2007).

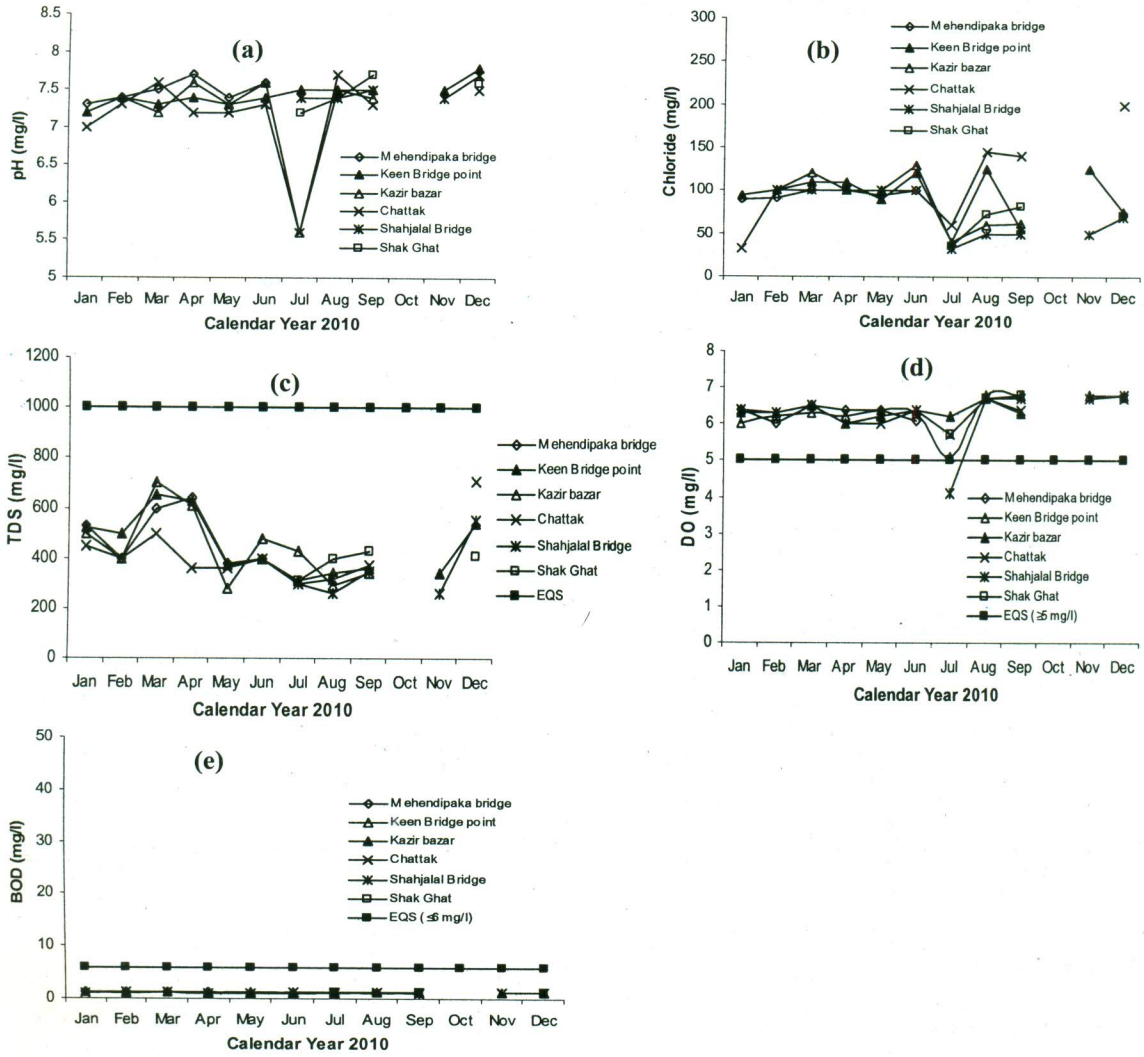

Fig. 24. Graphical presentation of pH, Chloride, TDS, DO and BOD of Surma River in 2010.

4.22 Kushiara River

Kushiyara river is one of the Trans-Boundary rivers of Bangladesh. Total length of Kushiyara is about 161 km. Mean width of the river is 250m, and depth reaches upto 10m in rainy season (Ahmed, 2006). Water samples were collected from two locations e.g. Jokigonj

and Fenchugonj Fertilizer Factory on Kushiyara for analysis of water quality. Samples were collected during the first seven months of 2010.

pH level varied from 7 to 7.6 mg/l (Fig. 25a) and was within the EQS for inland surface. Chloride was also within the EQS (150-600 mg/l) for drinking water. Maximum Chloride was 225mg/l at Jokigonj in January and minimum was 120mg/l in June at Fenchugonj (Fig. 25b). TDS varied from 300 to 550 mg/l (Fig. 25c) and was below the EQS. DO varied from 5.6 to 6.4 mg/l (Fig. 25d) and was above the EQS ($\geq$5 mg/l) for fisheries. BOD level varied from 1 to 1.4 mg/l while EQS for fisheries is $\leq$6 mg/l (Fig. 25e).

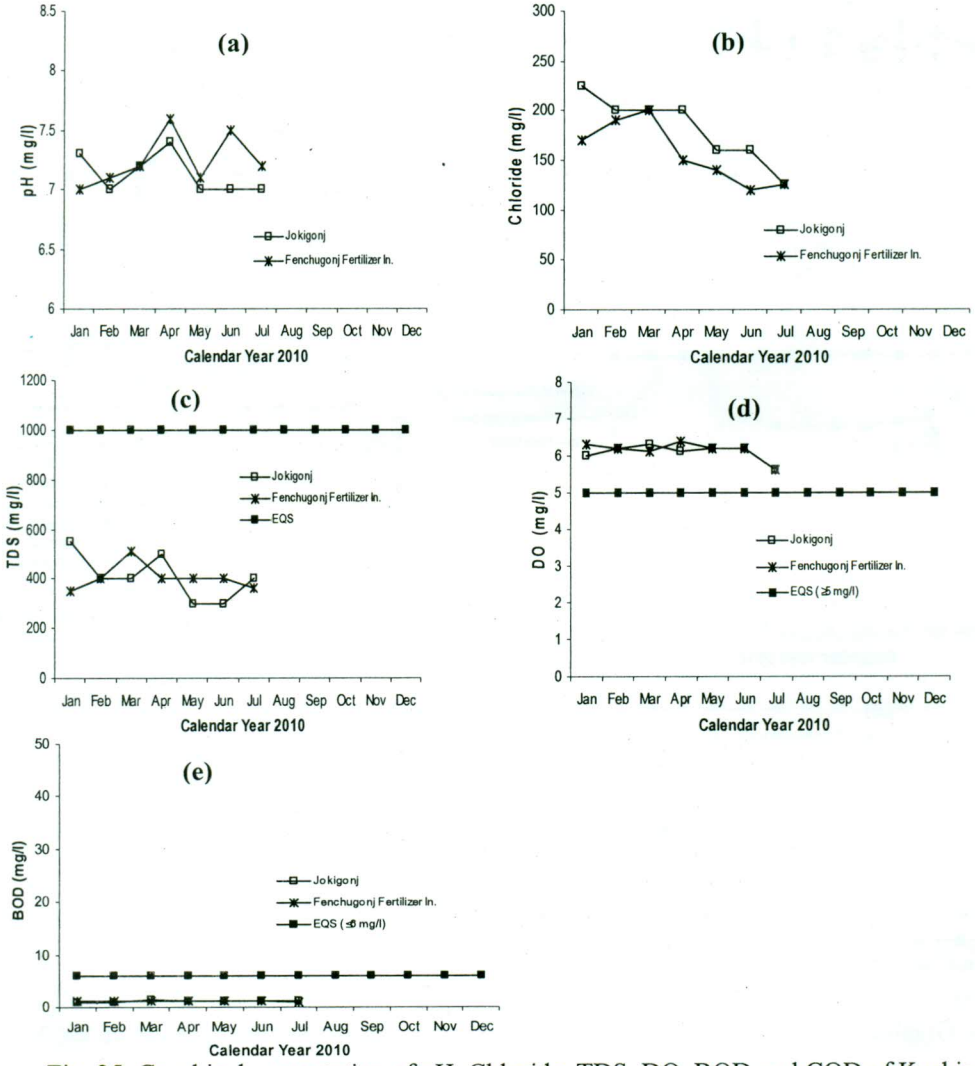

Fig. 25. Graphical presentation of pH, Chloride, TDS, DO, BOD and COD of Kushiara River in 2010.

4.23 Korotoa River

For analysis of water quality of Korotoa river in 2010, samples were collected from four locations of the river e.g. Near Fateh Ali Bridge (Up and Downstream) and Near Dutta Bari Bridge (Up and Downstream). Samples were collected only four months of 2010.

pH was from 6.24 to 8.38 mg/l (Fig. 26a) and was within the EQS. Chloride conc. varied from 25 to 46 mg/l (Fig. 26b) and was below the EQS. TDS varied from 96 mg/l to 719 mg/l (Fig. 26c) and was below the EQS (150 to 600mg/l).

DO level varied from 5.24 to 8 mg/l (Fig. 26d) and was above the EQS for fisheries ($\geq$5 mg/l) for all the locations throughout the year. BOD was from 1.1 to 3.3 mg/l (Fig. 26e) and was within the EQS ($\leq$6 mg/l) for fisheries. COD varied from 21 to 45 mg/l (Fig. 26f) and was higher compare to EQS ($\leq$4mg/l) for drinking water standard.

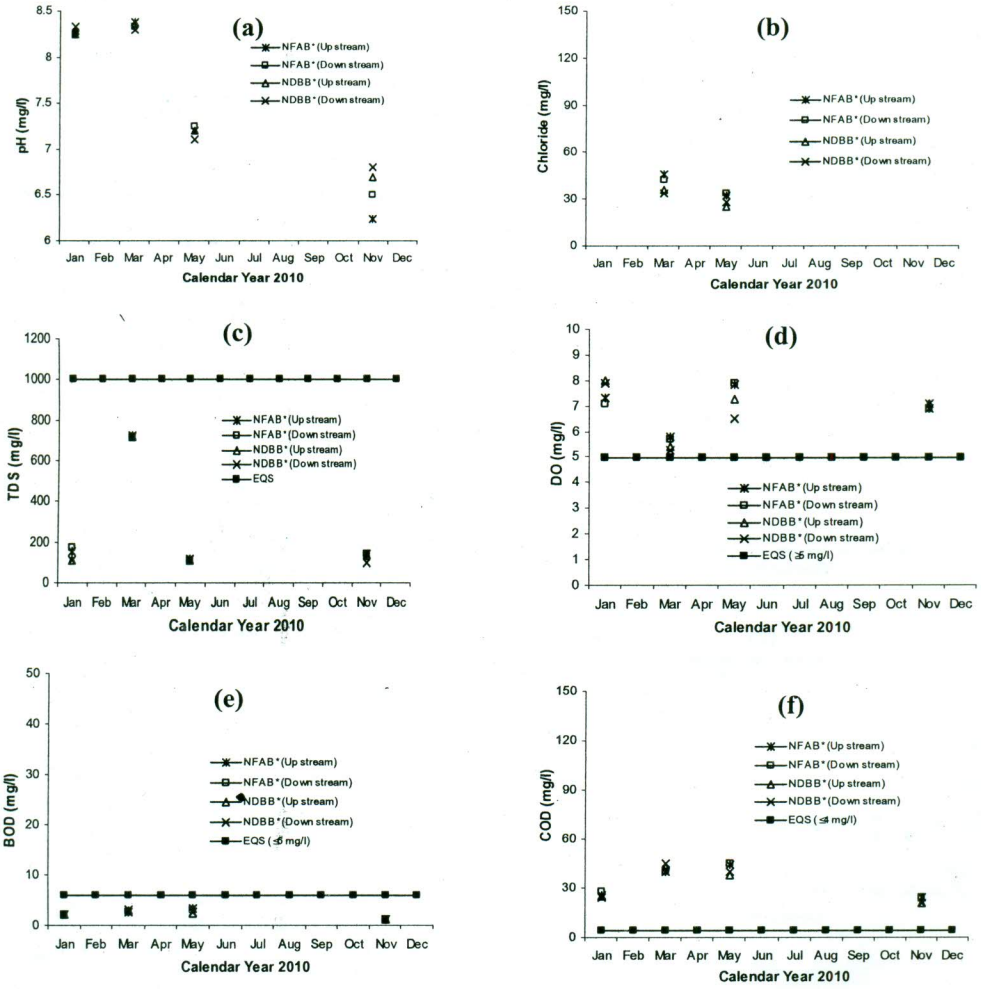

Fig. 26. Graphical presentation of pH, Chloride, TDS, DO, BOD and COD of Korotoa river in 2010.

* Near Fateh Ali Bridge (NFAB) & Near Dutta Bari Bridge (NDBB)

4.24 Padma River

The Padma is a major trans-boundary river of Bangladesh. Its maximum depth is 479m and average depth is 295m (Chowdhury, 2006). Water samples were collected from two locations

of the river namely Pakshi Ghat of Pabna, Iswardi and Baro Kuti Ghat of Rajshahi. Samples were collected only for five months of 2010.

River water pH level varied from 7.1 to 8.1 mg/l (Fig. 27a) and it was within the EQS (6.5 to 8.5 mg/l) for inland surface water. pH was maximum at Baro Kuti Ghat in May and minimum was at Pakshi Ghat in March. Chloride content of water varied from 15 to 26 mg/l (Fig. 27b) and was below the allowable limit for drinking. TDS level varied from 168 to 282 mg/l (Fig. 27c) and was within EQS throughout the sampling period of 2010.

DO of Padma river varied from 6.1 to 10.4 mg/l (Fig. 26d) and was above the EQS ≥5 mg/l for fisheries at all the locations. BOD ranged from 0.6 to 2.1mg/l (Fig. 27e) and was lower than EQS (≤6 mg/l) for fisheries at all locations. The range of COD load was from 15 to 20 mg/l (Fig. 27f) and was higher than the EQS (≤4 mg/l) for drinking water at all locations during the sampling period of 2010.

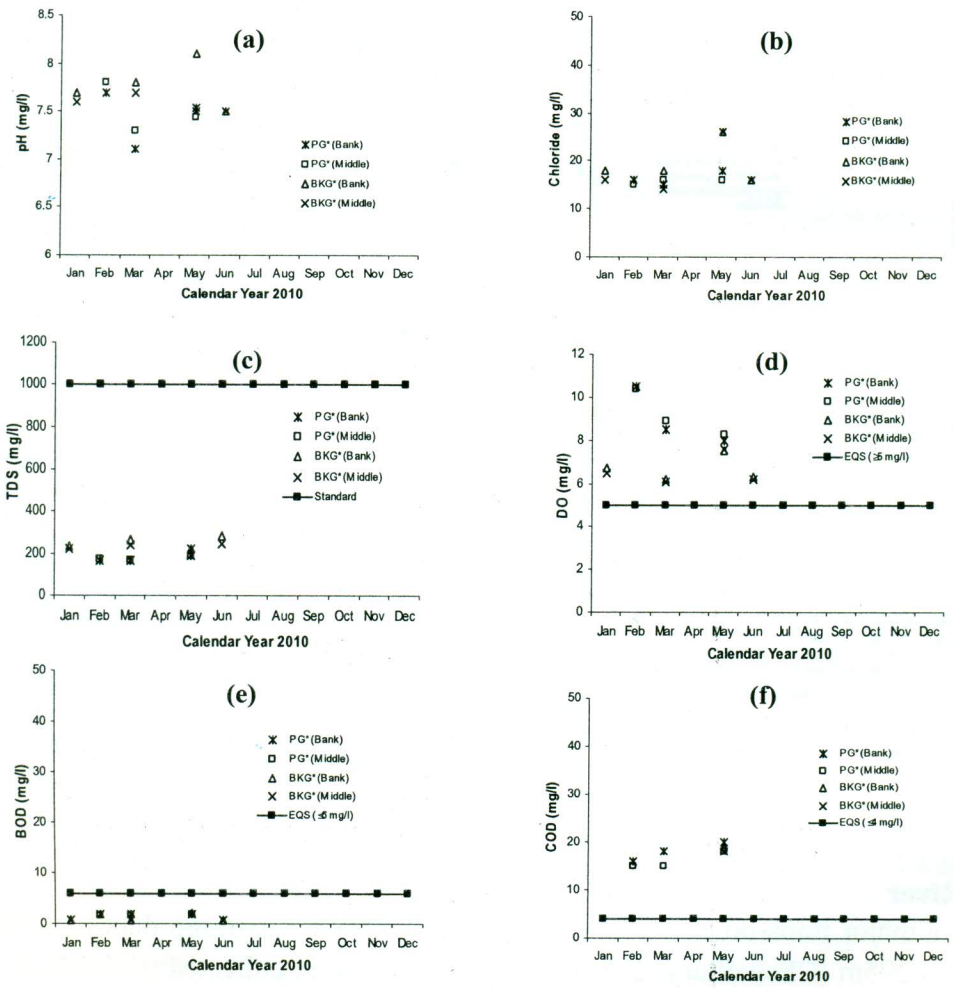

Fig. 27. Graphical presentation of pH, Chloride, TDS, DO, BOD and COD of Padma River in 2010.

* Pakshi Ghat (PG), Pabna, Iswardi & Baro Kuti Ghat (BKG), Rajshahi

4.25 Kirtankhola River

Kirtankhola river starts from Sayeshtabad in Barisal and ends into the Gajalia near Gabkhan khal (canal). This old river is now known as the Barisal river. The total length of the river is about 160km (Murshed 2006). To analyze water quality of Kirtankhola, water samples were colleted from one location comprising two points of the river (e.g. Launch ghat bank and middle). Samples were collected during low tide (January-April and November) and high tide (June-September). Water sample was not collected in May, October and December.

pH level of Kirtankhola varied from 6.8 to 7.8 (Fig. 28a) and was within the EQS. Chloride content was from 23 to 160 mg/l (Fig. 28b). TDS varied from 20 to 420 mg/l (Fig. 28c) and was within the EQS (1000 mg/l) throughout the year.

DO varied from 4.5 mg/l to 9.5mg/l (Fig. 28d). Except June and July, DO level was above the EQS ≥5 mg/l for fisheries at both locations of Kirtankhola. BOD was found from 0.5 to 3.3mg/l (Fig. 28e) and was below the EQS round the year of 2010. COD varied from 16 to 367 mg/l (Fig. 28f) and was above the EQS (4 mg/l) for drinking water.

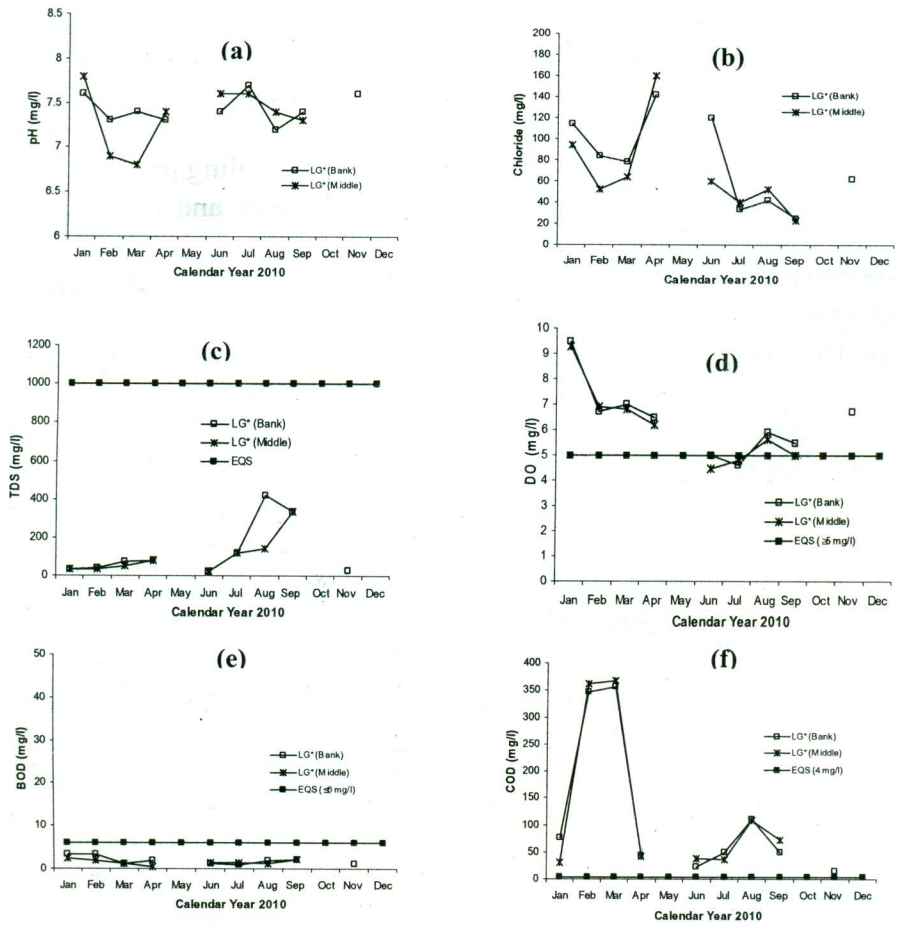

Fig. 28. Graphical presentation of pH, Chloride, TDS, DO, BOD and COD of Kirtankhola river in 2010.

* Launch Ghat (LG), Barisal

Chapter 5

Conclusions and Recommendations

5.1 Conclusions

Water quality parameters of most rivers represented in this report were mostly within the EQS. Sometimes parameters like Chloride, TDS, BOD and COD were beyond the limit or exceptionally high those need careful and close monitoring to find out sources/causes of water quality degradation. Water quality of rivers surrounding Dhaka was generally highly polluted especially in dry season. Seasonality and regional/geographic aspects impacting water quality clearly surfaced up from the analyses those need sincere consideration. Despite discontinuity of monitoring data in some cases, this report would shed light on overall surface water quality status of Bangladesh and provide food for thought of how to plan for proper monitoring of water quality and conservation of rivers.

5.2 Recommendations

Lack of continuous sampling/monitoring data was one of the major problems for analyses river water quality. Also there is a lack of comprehensive set of parameters for proper representation of water surface quality. Since water quality monitoring information shall form the basis for surface water management plan, the following actions are recommended to address better monitoring and conservation of rivers of Bangladesh.

- Judicious selection of sampling locations and develop sampling protocol.
- Collection of water samples must be in a consistent way and on regular basis for assessment of water quality.
- Information related to water quality and quantity needs to integrate for better understanding of surface water pollution situation.
- Increase skilled manpower at all level of water quality analysis including sample collection.
- Microbial test (Fecal Coliform, E-Coli etc.) of river water is essential to analyze water quality of rivers.
- Use Global Positioning System (GPS) to represent monitoring results in global context.
- Establish Water Quality Index (WQI) to assist water quality analysis.
- Establish standard limit of Fecal Coliform, Temperature, Total Phosphate, Nitrates, Turbidity, and Total Solids for inland surface water.
- Establishment of Water Control Zone (WCZ) to facilitate monitoring and management of surface water.
- Strict enforcement of existing environmental, agricultural and water resource management laws, policy and guidelines.
- Initiating/introducing "polluter pay" principle for abetment of water pollution.
- Introducing Water Tax to ensure efficient use of water.
- Increase institutional cooperation and buildup network among institutions for effective management of water resources.

- Strengthening regional cooperation for the sustainable management of trans-boundary rivers, Integrated Watershed Management (IWM) approach can be implemented in this regard.
- Undertake capacity building programme of the laboratory (both human and logistics capacity).

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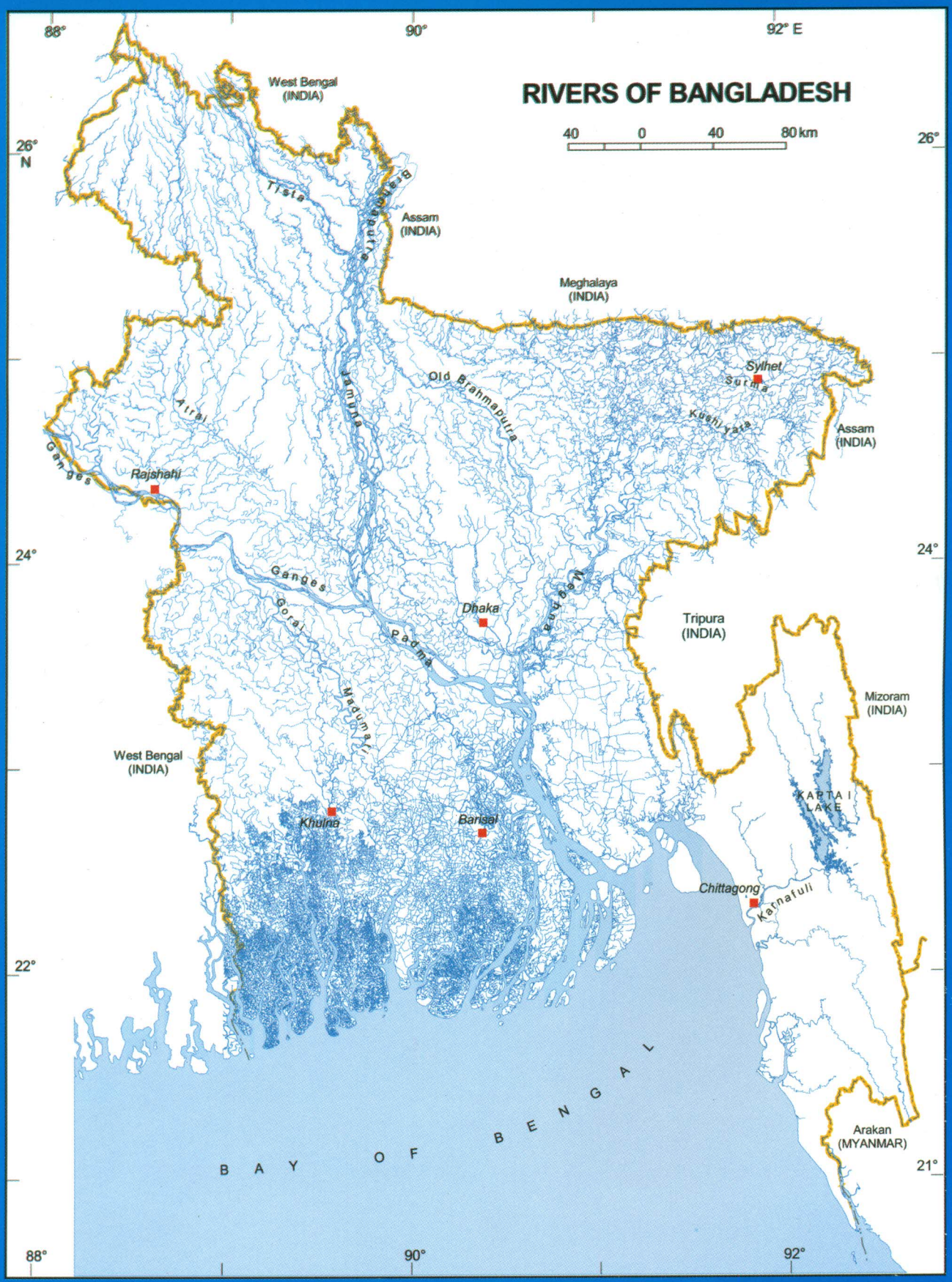
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Meghalaya (INDIA)
Tripura (INDIA)
Mizoram (INDIA)
Arakan (MYANMAR)
Tista
Brahmaputra
Jamuna
Old Brahmaputra
Surma
Kushiyara
Atrai
Ganges
Gorai
Padma
Meghna
Madumati
Karnafuli
KARTAI LAKE
Rajshahi
Dhaka
Khulna
Barisal
Sylhet
Chittagong
BAY OF BENGAL