RIVER WATER QUALITY REPORT 2014

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River Water Quality Report 2014

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MESSAGE

Bangladesh is criss-crossed by hundreds of rivers, streams, canals and creeks with a total length of,at least , 24,000 km and an area of 4,600 sq.km. The combined total catchment area of the Ganges, the Brahmaputra and the Meghna (GBM) rivers systems is about 1.74 million sq. km. of which only seven percent lies within Bangladesh. In this riverine Bangladesh water greatly occupies most avenues of lives and livelihoods.

Water is an essential component of all production systems while productivity and quality of products greatly depends on quality as well as quantity of water. Considering its importance the Department of Environment (DoE) has been monitoring surface water quality since its inception in 1973. DoE monitors surface water quality following its monitoring network that includes major rivers and lakes. Monitoring information provide water resource quality of major rivers of Bangladesh.

"River Water Quality Report 2014" is the fifth of its kind that shed light on overall status of river water quality in Bangladesh. Dumping of city and industrial wastes into rivers highly polluted rivers surrounding cities. To improve the quality of rivers the government declared Buriganga, Turag, Balu and Sitalakhya as Ecologically Critical Area (ECA) in 2009. Water quality of big rivers such as Padma, Megna, Jamuna, Brahmmputra is still good and has been within water quality standards set in the Environment Conservation Rules, 1997. Water quality of rivers in southern region degraded due to high salinity and turbidity and thus water of the rivers often unfit for domestic use.

This report also highlighted the necessary steps to be taken for sustainable management of aquatic ecosystems. Hopefully this document will be useful in the decision making process for conservation of degraded riverine ecosystems of Bangladesh.

I express my sincere gratitude to the Natural Resource Management and Research section of DoE for preparing this report.

Md. Raisul Alam Mondal
Director General

FOREWORD

Being a country of rivers, Bangladesh needs to adopt adequate measures to halt further degradation of our precious water resources. The river water quality report 2014 contains statistical analyses of various water quality parameters of different rivers of the country for the period from January to December 2014. This report also gives a comparative statement of river water quality for the period of 1995-1979 and 2010-2014. It offers a clear view of present situation and recommends ways and means for conservation and sustainable use of water.

Population pressure, release of untreated waste and effluent from urban areas and industrial units, and encroachment are the main causes for deterioration of water quality. Upstream withdrawal of water and salinity intrusion due to sea level rise is also responsible for degradation of river water quality. River water resources will always serve as the basis for securing lives and livelihoods for millions of people by providing different ecosystem services in this river-floodplain country.

The report suggests future programme of actions for conservation of river water resources. We have to implement these activities recommended in this report to pave the way of conservation and sustainable use of water resources at various levels of our development agenda.

Dr Sultan Ahmed
Director (NRM and Research)

Editorial Notes

Being a vital component of an ecosystem, water and its quality greatly affects ecosystems productivity and services they provide. To provide with necessary information for sustainable services especially of aquatic ecosystem, continuous monitoring of water quality is essential. Despite discontinuous sampling and measurement of a few parameters, this report would shed some light on water quality of major rivers of the country. Water quality parameters like p^H, Dissolve Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Turbidity, Total Dissolve Solis (TDS), Suspended Solid (SS), Total Alkalinity, Electrical Conductivity (EC) and Chloride presented in this report were measured more or less round the year of 2014. There was spatiotemporal variation in water quality. From the analyses, impact of seasons industrialization and urbanization on water quality surfaced up especially for the rivers surrounding Dhaka city. During the rainy season water quality of most rivers (under the monitoring programme) was more or less good while comparing with the Environmental Quality Standard (EQS) set in the ECR, 1997. Water quality of rivers around Dhaka city, Chittagong and Khulna did not comply with EQS in the dry season indicating the most probable effect of dense industrialization in those areas followed by huge human pressure on rivers. The difference in pollution level among the sampling points along a single river was also evident. Salinity level of rivers in southern Bangladesh greatly increases during dry seasons while salinity comes down to EQS during wet season. Sometimes salinity becomes exceptionally high. Long dry period and reduced upstream flow are the proximate causes of high salinity of surface water in southern region. High salinity together with high turbidity are making river ecosystem in the southern region fragile. Soil erosion from catchment area, dumping of solid wastes into rivers are the main causes of high turbidity. To get clearer picture on water quality, more intense and systematic monitoring is essential. However, current condition of surface water quality finds to noncompliance of rules by the industries as well as intuitions responsible for domestic and other wastes management. Hence, this is necessary for escalating monitoring and enforcement activities as well as awareness building in all walks of life to achieve sustainable management of water resources.

Dr. Md. Sohrab Ali
Deputy Director (Water & Bio.)

ACKNOWLEDGEMENT

We greatly acknowledge kind support and guidance of Mr Md Raisul Alam Mondal, Director General, Department of Environment for preparation of this report. We are also expressing our sincere thanks to the reviewers for their suggestions. We are very much thankful and grateful to our Divisional Offices and their laboratory personnel for their kind contribution in terms of collecting sample, analysis and finally providing us with river water quality data of 2014. We also thank Mr Md Abubakar Ahmed, Junior Consultant, for data analysis and compilation of compiling data for this report.

Farhana Mustari
Assistant Director (Water & Bio.)

EXECUTIVE SUMMARY

Bangladesh is a riverine country where hundreds of rivers crisscrossed the landmass and playing role of artery and veins for of the revival ecosystem of the country. Rivers are mainly used for irrigation, open water fisheries, drinking water supply, navigation and water supply for industrial purposes. Bangladesh's streams and rivers are also the home to a wide variety of aquatic flora and fauna. The volumes of water they carry vary widely depending on the seasons, 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 sampling to includes 63 stations of 27 rivers in Bangladesh. DoE through the divisional offices monitored river water quality on monthly bagis. 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 and spatio-temporal context, we took ten parameters (viz. pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solid (SS), Total Dissolved Solid (TDS), Electrical Conductivity (EC), Chloride, Turbidity and Total Alkalinity for analyses.

Based on the parameters mentioned above water quality of the major rivers viz. Padma, Meghna, Jumuna, Dhaleshwari, Surma, Korotoa etc. was upto the Environmental Quality Standards (EQS) in 2014 while rivers around greater Dhaka were highly polluted spicially in the first five months of 2014 in terms of DO, BOD and COD value. DO was almost nill from January to May at different locations of Buriganga, Shitalakhya and Turag river. High levels of Chloride (400 mg/l), TDS (782 mg/l), BOD (132 mg/l) and COD (219 mg/l) were found in Buriganga river from January to December in 2014.

High level of Chloride, TDS and Turbidity were found in Moyuri, Rupsha, Pashur and Khakshiali river. Highest level of Chloride (12646 mg/l) and TDS (15500 mg/l) were found in Pashur river. Highest value of Turbidity (136.3 NTU) was found in Khakshiali river. Generaly hgih turbidity of water was found in the riverrs flowing in the southern part Bangladesh. High turbidity reduced transperencey of water that ultimately caused reducetion in phytoplankton production on one hand and up lift river channel bed through silt deposition on the other hand of Hight 300 COD (353 mg/l) was found in Karnaphuli river. Sand chloride content in Karnaphuli river water mostly were beyond the Eqs. Do and BOD of halda river water were within the EQS. Do was abone the EQS throught the year 2014: chloride sontent was relatively higher during high tide.)

Seasonality on water quality surfaced up while analyzing data. During dry seasons water quality become worse. On the contrary, river water quality improved greatly during the wet seasons indicating clear relationship between increased flow of river and river water quality. Sand Choloride content in Karnaphuli river water mostly were beyond the EQS. DO and BOD of Halda river water were witthin the EQS Do was alone the EQS throughout the yerar 2014 chloride content was relatively higher during high tide

A conparative analysis between the reviod of 1975-1979 and 2010- 2014 waswas carried out for buriganga, sitalakhya and trurag river analysis renealed the fact that water quality was up to the EQS during eighties of the lase century. then withy the passage of time water quality began to degrade following enormong popularation pressure., dumping of huge in dustrial and lity wastes into riness, enchroachment, etc. and finally reached to ecologically critical condition.

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ABBREVIATIONS

BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
EC	-	Electrical Conductivity
ECA	-	Ecologically Critical Area
ECR	-	Environment Conservation Rules
DO	-	Dissolved Oxygen
DoE	-	Department of Environment
EC	-	Electrical Conductivity
EQS	-	Environmental Quality Standard
GEMS	-	Global Environment Monitoring System
GPS	-	Global Positioning System
IWM	-	Integrated Watershed Management
NTU	-	Nephelometric Turbidity Unit
SoE	-	State of the Environment
TDS	-	Total Dissolved Solid
SS	-	Suspended Solid
TDS	-	Total Disolved Solid

CHAPTER 1: INTRODUCTION

1.1 Background

In Bangladesh, rivers, their tributaries and distributaries are the main source of fresh water for all forms of lives. Monitoring surface water quality is one of the vital work of the Department of Environment (DoE). To evaluate water quality for human consumption and other uses the Government has set EQS for inland surface water in the Environmental Conservation Rules (ECR), 1997. The information obtained from monitoring would constitute part of diagnosis of functionality of aquatic ecosystem. Also it would help evaluating effectiveness of the pollution control measures.

There are 57 transboundary rivers. Of them 54 with India and three with Myanmar. The flows in the rivers varies greatly depending on seasons, rainfall intensity and upstream diversion of trans-boundary rivers. Following fluctuation in flow river water quality varies significantly. A significant portion of the river's base flow in the country is obstructed for potable use. This together with dry winter and diversion of upstream flow greatly reduce the river's flow volume, and its natural flushing and purification capacity. Dumping of industrial untreated Waste waters, household and municipal wastes etc. into water courses further degrade surface water quality. Because of severe pollution, Government has already declared four rivers (Buriganga, Shitalakhya, Turag and Balu) as Ecologically Critical Area (ECA) to protect from further pollution.

To monitor surface water quality the Department of Environment (DoE) has setup a monitoring network. Following this network, DoE collect surface water samples for laboratory analyses. Samples are collected on monthly basis from selected sampling station of rivers under the monitoring network. In 2014, the monitoring program covered 61 sampling stations in 27 rivers.

1.2 Major objectives of the report

- To provide updated information on the river's water quality to help information based decision-making process for sustainable development and management of water resources.
- Sensitization and awareness building among the stakeholders.
- To provide information for research/study in the relevant fields.
- Information sharing and preparation of State of the Environment (SoE) Report.
- To provide water quality data to Global Environment Monitoring System (GEMS).

1.3 Limitation of the report

This report has been prepared based on primary data and information collected from six divisional offices of DoE for the period of January to December 2014. The following are the limitations of the report:

- Data on all the parameters as per ECR 1997, for the entire period could not be furnished with this report due to lack of irregular sampling and laboratory analyses.
- This report lacks of information on microbiological parameters.
- Data on weather conditions of the sampling locations at the time of sampling were unavailable.

CHAPTER 2: AN OVERVIEW OF BANGLADESH'S RIVERS

Rivers of Bangladesh

Rivers are the most important elements of physiographic features of Bangladesh. The Padma, the 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 (Banglapedia, 2006). These all together cover about 7 percent of country's surface area. The watercourses of the country are unevenly distributed. They increase in numbers and size from the northwest to the southeastern region.

The river system of Bangladesh is extremely dynamic. The discharge carried 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.

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 the Buriganga, the Sitalakhya, the Gumti, the Tista, the Atrai, the Korotoa, the Mohananda, the Madhumati and many others.

CHAPTER 3: MEASUREMENT OF RIVER WATER QUALITY

3.1 Water quality parameters

A comprehensive range of physico-chemical parameters like Temperature, Electrical Conductivity (EC), Dissolved Oxygen (DO), pH, Total alkalinity, Turbidity, Total Dissolved Solid (TDS), Suspended Solid (SS), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD) measured to assess the inland surface water quality in Bangladesh. But only a few of them commonly analyzed by the divisional offices. *Modified Winkler's 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.

3.2 Comparison with standards for inland surface water

River water quality was compared with the Environmental Quality Standard (EQS) set in the rules for inland surface water to get insight about the state of the river ecosystems in Bangladesh. This is essentially helpful for development planning and management of aquatic ecosystems.

CHAPTER 4: RIVER WATER QUALITY IN 2014

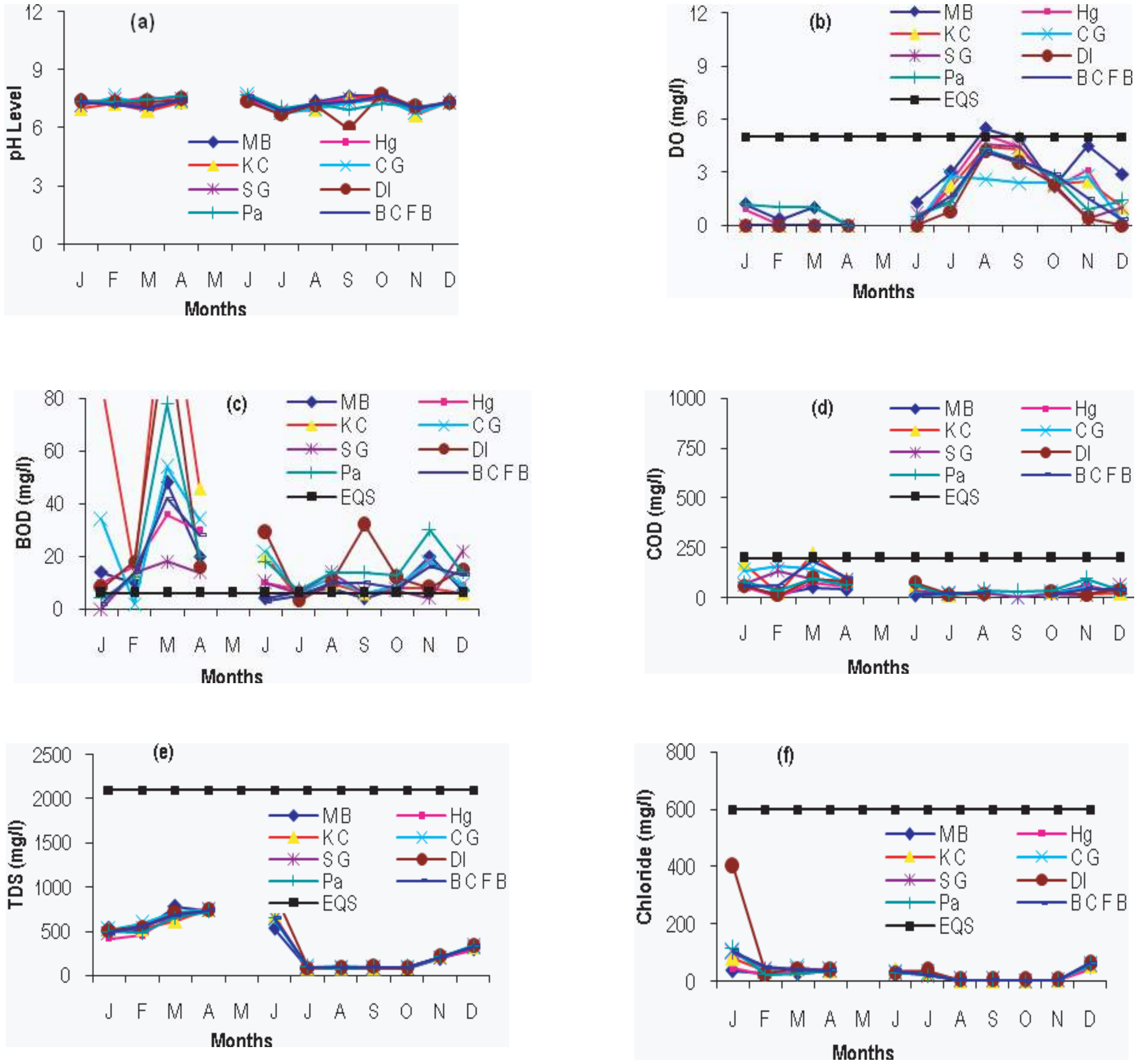
4.1 Buriganga River

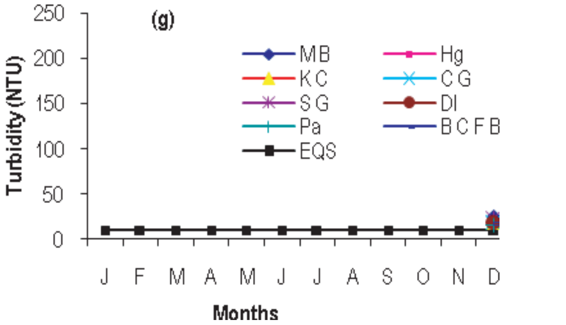
To monitor water quality of Buriganga river, samples were collected from eight different locations viz. Mirpur Bridge, Hazaribag, Kamrangir Char, Chandni Ghat, Sadar Ghat, Dholaikhal, Bangladesh China Friendship Bridge and Pagla along the river.

In 2014, pH among different locations varied from 6.66 to 7.79 (Fig.1a) while standard pH range for inland surface water for fisheries is 6.5 to 8.5. In 2013, pH range was bit wider and varied from 5.36 to 8.03. Dissolved oxygen (DO) in Buriganga river water was very low in 2014. In 2014, DO of Buriganga river was lower than EQS (≤5 mg/l). The maximum DO (5.48 mg/l) was found at Mirpur Bridge in August and the minimum (0.0 mg/l) was at Sadar Ghat in January (Fig.1b). Direct discharge of untreated effluent from industries, domestic wastes, tannery wastes into the river and reduced flow of water are the proximate causes for depletion of DO in dry season. DO level was slightly increased in wet season (June to October) at all locations of the river. In 2013, DO level varied from 0.0 mg/l to 7.3 mg/l.

In 2014, BOD of Buriganga river was higher than EQS (≤6 mg/l). At Hazaribag point BOD level was much higher than EQS for fisheries round the year (Fig.1c). This was mainly because of discharge of untreated tannery wastewater into the river. The maximum BOD (132 mg/l) was found at Kamrangir Char in March and the minimum (0.0 mg/l) was at Sadar Ghat in January. In 2013, BOD range was 0.0 to 57 mg/l. In 2014, COD level was mostly below the EQS (200 mg/l) set for industrial wastewater after treatment. The maximum and the minimum COD concentration of Buriganga river was 219 mg/l at Kamrangir Char in May and 5.0 mg/l at Hazaribag point in February (Fig.1d). In 2013, COD varied from 1.0 mg/l to 782 mg/l.

TDS of Buriganga river varied from 72.1 to 782 mg/l (Fig.1e) against the EQS of 2100 mg/l for industrial wastewater after treatment. In 2013, TDS concentration varied from 14 to 714 mg/l. Chloride concentration of the Buriganga river was below the EQS for industrial wastewater after treatment. The maximum concentration was 400 mg/l at Dholikhal point in January and the minimum 2.1 mg/l at Mirpur Bridge in Octabor (Fig.1f). In 2013, Chloride concentration varied from 1.25 mg/l to 144.5 mg/l. Turbidity range varied from 15.4 to 24.6 NTU against the EQS (10 NTU) (Fig.1g). In 2013, Turbidity range varied from 1.25 to 62.7 NTU.





Note: Highest BOD was recorded 132 mg/l at Kamrangir Char in March 2014.

Fig.1. Graphical presentation of pH, DO, BOD, COD, TDS, Chloride, Turbidity of Buriganga river in 2014

Note: M B= Mirpur Bridge, Hg = Hazaribag , K C= Kamrangir Char, C G = Chandni Ghat,
S G =Sadar Ghat , Dl= Dholaikhal, B C F B = Bangladesh China Friendship Bridge, Pg = Pagla

Table-1. Total alkalinity of Buriganga river water in 2014

Sampling Locations	Total Alkalinity (mg/l)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mirpur Bridge	239	280	298	310	-	25	18	22	52	27	64	140
Hazaribag	195	265	285	320	-	29	21	24	60	28	62	210
Kamrangir Char	232	290	300	**390**	-	33	28	30	55	32	66	200
Chandni Ghat	221	179	225	370	-	30	25	28	58	30	64	200
Sadar Ghat	239	294	320	370	-	28	22	20	54	29	68	210
Dholaikhal	195	297	308	300	-	27	30	24	50	38	66	220
Pagla	216	265	195	340	-	**20**	21	28	48	41	66	200
B.C.F. Bridge*	200	300	295	330	-	24	22	34	48	30	64	210
EQS for wastewater after treatment from industrial units 150 mg/l												

The maximum and the minimum Total Alkalinity of Buriganga river was 390 mg/l at Kamrangir Char in April and 20 mg/l at Pagla in June (Table-1). T. Alkalinity was very high during dry season.

Table-2. Electrical Conductivity (EC) of Buriganga river water in 2014

Sampling Locations	EC (µmhos/cm)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mirpur Bridge	1006	735	**1587**	1517	-	1111	168.1	**160.1**	157.9	172	366	519
Hazaribag	799	889	1497	1553	-	1382	186.6	169	172.4	175	403	532
Kamrangir Char	999	1026	1322	1510	-	1400	184.7	184.4	168.1	176	419	558
Chandni Ghat	982	1158	1511	1516	-	1312	218.9	230	196	185	400	548
Sadar Ghat	920	1056	1466	1516	-	1319	202.6	186.1	170.5	191	419	560
Dholaikhal	968	1087	1495	1480	-	1914	192.3	172.1	207.4	174.3	434	582
Pagla	939	946	1402	1481	-	1301	198.9	175.9	211	213	437	599
B.C.F. Bridge*	919	1087	1445	1485	-	1302	206.4	197.1	203.9	186.9	435	589
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

The maximum and the minimum EC of Buriganga river was 1587 mg/l in March and 160.1 mg/l in August at Mirpur Bridge (Table-2). During March-April, EC was high.

Table-3. Suspended Solid (SS) of Buriganga river water in 2014

Sampling Locations	SS (mg/l)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mirpur Bridge	6	63	89	38	-	19	19	51	32	32	38	28
Hazaribag	15	67	73	34	-	10	10	24	30	28	36	22
Kamrangir Char	53	51	143	88	-	12	12	1	28	36	38	18
Chandni Ghat	22	115	83	85	-	5	5	1	32	32	42	19
Sadar Ghat	25	64	31	79	-	6	6	7	34	27	38	30
Dholaikhal	57	73	96	48	-	7	1	6	30	34	36	25
Pagla	31	40	68	57	-	9	9	1	34	31.9	42	19
B.C.F. Bridge*	27	**202**	90	82	-	**1**	7	6	32	32	40	22
EQS for wastewater after treatment from industrial units 150 mg/l												

SS of Buriganga river at different locations was below the EQS (150 mg/l) for wastewater after treatment from industrial units. The maximum and the minimum SS was 202 mg/l in February and 1 mg/l at Dholaikhal in June at B.C.F Bridge (Table-3)

4.2 Shitalakhya River

Shitalakhya river is a distributary of the Brahmaputra river. It remains navigable round the year. For monitoring water quality, samples were colleted from three different locations viz. Demra Ghat, Ghorasal Fertilizer Factory (GFF) and near ACI factory at Narayanganj.

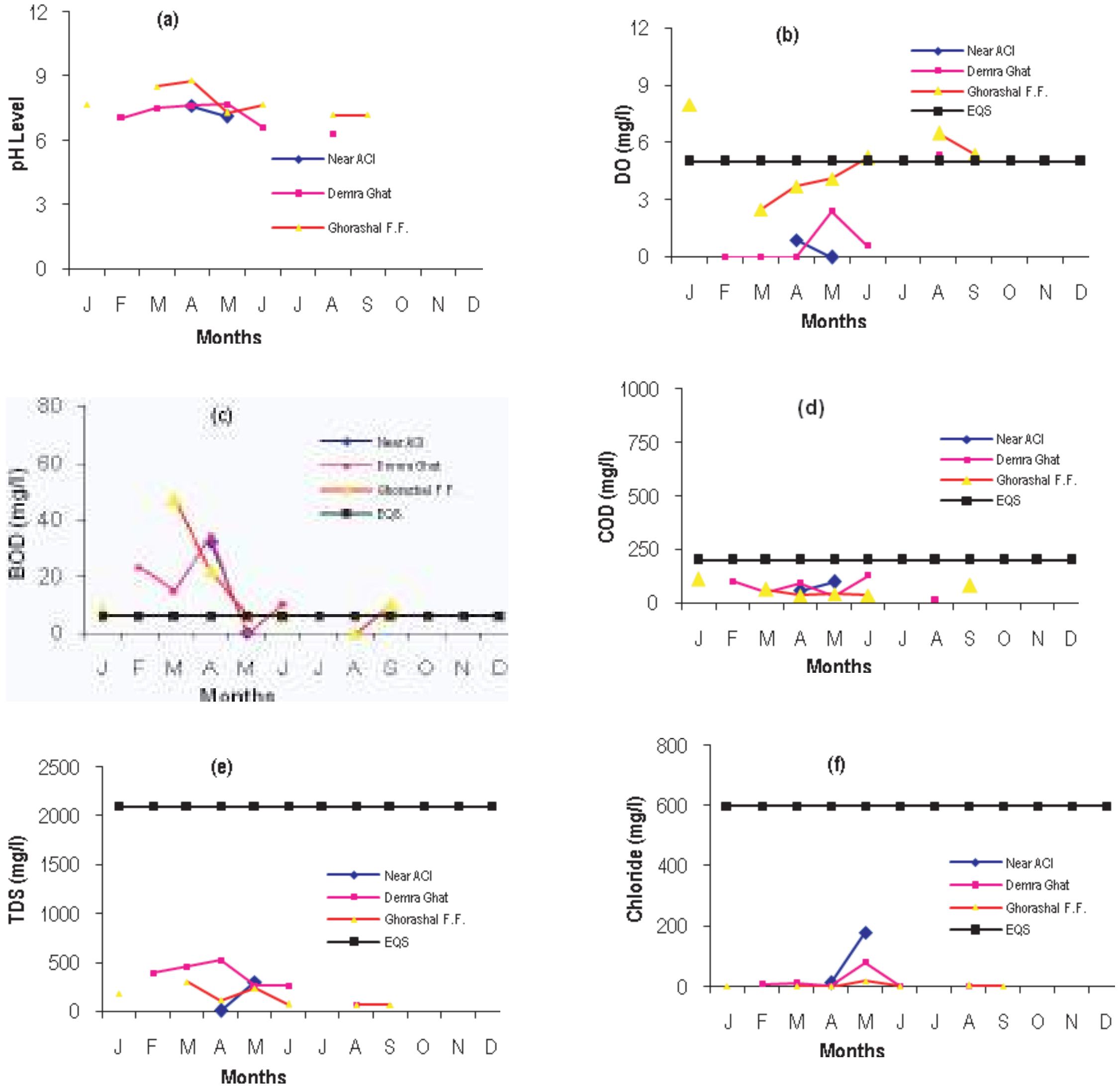


Fig.2. Graphical presentation of pH, DO, BOD, COD, TDS and Chloride of Shitalakhya river in 2014

In 2014, pH of Shitalakhya river water was within the EQS (6.5-8.5) for inland surface water. The maximum pH was 7.8 in June at and the minimum P^{H} was 6.8 in November at Damra Ghat respectively (Fig.2a). In 2013, pH varied from 6.31 to 8.8. In 2014, the maximum DO (5.6 mg/l) was found at Damra Ghat in August and the minimum (0.0 mg/l) was found at Demra Ghat in April (Fig.2b). In 2013, DO varied from 0.6 to 6.5 mg/l.

In 2014, BOD at Demra Ghat was very high during dry period. At Ghorasal F.F BOD was within the EQS (≤6 mg/l) for fisheries in May and June. Highest value of BOD (32 mg/l) was found at Damra Ghat in February and that of the lowest (0.0 mg/l) was in June near ACI station (Fig.2c). In 2013, BOD concentration varied from 0.0 mg/l to 47 mg/l. In 2014, COD level was within the EQS (200 mg/l) for wastewater after treatment from industrial units at all locations of Shitalakhya river. Among all the sampling locations of the Shitalakhya river COD was lowest at Damra Ghat (Fig.2d). The maximum COD (141 mg/l) was at ACI in September and the minimum COD (4 mg/l) was at Damra Ghat in January, respectively. In 2013, COD level varied from 16 mg/l to 130 mg/l. TDS of Shitalakhya river varied from 5.0 to 523 mg/l against the EQS (2100 mg/l) for wastewater after treatment from industrial units. In dry season maximum TDS (523 mg/l) was at Damra Ghat and minimum (70.6mg/l) at Ghorasal F.F (Fig.2e). In 2013, TDS range was 5 to 523 mg/l. Chloride concentration of the Shitalakhya river in 2014 was below the EQS (600 mg/l) for wastewater after treatment from industrial units. The maximum Chloride (44 mg/l) was found at Damra Ghat in Jabuary and the minimum was 3.1 mg/l at ACI factory in September, 2014 (Fig.-2f). In 2013, Chloride concentration varied from 0.7 mg/l to 179.5 mg/l.

Table-4. Suspended Solid (SS) of Shitalakhya river water in 2014

Sampling Locations	**SS (mg/l)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Narayanganj (Near ACI)	-	-	-	-	-	31	-	-	52	-	32	35
Demra Ghat	9	9	-	35	-	10	-	18	48	-	21	33
Ghorashal Fertilizer Factory (GFF)	-	-	-	22	-	**8**	-	22	**124**	-	-	-
EQS for wastewater after treatment from industrial units 150 mg/l												

SS of Shitalakhya river water at different sampling locations was within the EQS (150 mg/l). Maximum SS concentration of Shitalakhya River was 124 mg/l at Ghorashal Fertilizer Factory in September and minimum 8 mg/l in June respectively (Table-4).

Table-5. Electrical Conductivity (EC) of Shitalakhya river water in 2014

Sampling Locations	**EC (µmhos/cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Narayanganj (Near ACI)	-	-	-	-	-	311	-	-	160	-	412	589
Demra Ghat	589	902	-	**1370**	-	1006	-	140.4	159.2	-	422	423
Ghorashal Fertilizer Factory (GFF)	-	-	-	518	-	153.4	-	478	**120.3**	-	-	-
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

EC of Shitalakhya river at different locations was mostly within the EQS (1200 µmhoms/cm) for treated wastewater from industrial units (Table-5) except in the month of April. The maximum EC (1370 µmhoms/cm) was at Demra Ghat in April and the minimum EC (120.3 µmho/cm) was at Ghorashal Fertilizer Factory in September.

Table-6. Total alkalinity of Shitalakhya river water in 2014

Sampling Locations	**Total alkalinity (mg/l)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Narayanganj (Near ACI)	-	-	-	-	-	25	-	-	49	-	36	141
Demra Ghat	**1.8**	**190**	-	20	-	10	-	28	52	-	29	155
Ghorashal Fertilizer Factory (GFF)	-	-	-	90	-	29	-	34	38	-	-	-
EQS for wastewater after treatment from industrial units 150 mg/l												

Maximum T. alkalinity (190 mg/l) was at Demra Ghat in February and that of minimum was (1.8 mg/l) at Demra Ghat in January (Table-6).

4.3 Turag River

The Turag river is the upper tributary of the Buriganga. To monitor water quality in 2014, water samples were collected from five locations such as Fulpukuria Dyeing Ltd. Hossain Dyeing Ltd. Tongi Rail Bridge, Indigo Washing Plant Ltd. and Azmeri Composite Ltd.

In 2014, the pH range (7.01- 8.4) (Fig.3a) of Turag river was within EQS (6.5 -8.5). The maximum pH 8.4 (near Hossain Dyeing Ltd) was found in March and the minimum pH 7.01 was found in July respectively. In 2013, pH range was 7.1 to 8.03. DO concentration of Turag river was very low during dry season of 2014 and it varied 0 to 4.5 (Fig.3b). In 2013, DO was varied 0.0 to 4.6. BOD of Turag river water was beyond the EQS (≤6 mg/l) for all locations. The maximum BOD was 154 mg/l in March at Azmeri Composite Ltd and the minimum was 2 mg/l in August at South Side Tongi Rail Bridge. (Fig.-3c). In 2013, BOD varied from 0.0 mg/l to 65 mg/l. In 2014, COD at all locations of Turag river was below the EQS (200 mg/l) for wastewater after treatment from industrial units. The maximum and the minimum COD content of Turag river water was 475 mg/l at Azmeri Composite Ltd. in March and 5 mg/l at South Side Tongi Rail Bridge in August (Fig.-3d). In 2013, COD range was from 4 mg/l to 303 mg/l. TDS was below the EQS (2100 mg/l) for wastewater after treatment from industrial units (Fig.-3e) at all the sampling points. The maximum TDS was 959 mg/l in March while that of minimum was 76.2 in August. In 2013, TDS varied from 98.4 mg/l to 1049 mg/l. Chloride content of Turag river water was below the EQS (600 mg/l). The maximum Chloride was (141 mg/l) found in January at Fulpukuria Dyeing Ltd. and the minimum Chloride was (3.0 mg/l) in June respectively (Fig.-3f). In 2013, Chloride varied from 8.0 mg/l to 133.8 mg/l. In 2014, SS varied from 3.0 mg/l to 110 mg/l.

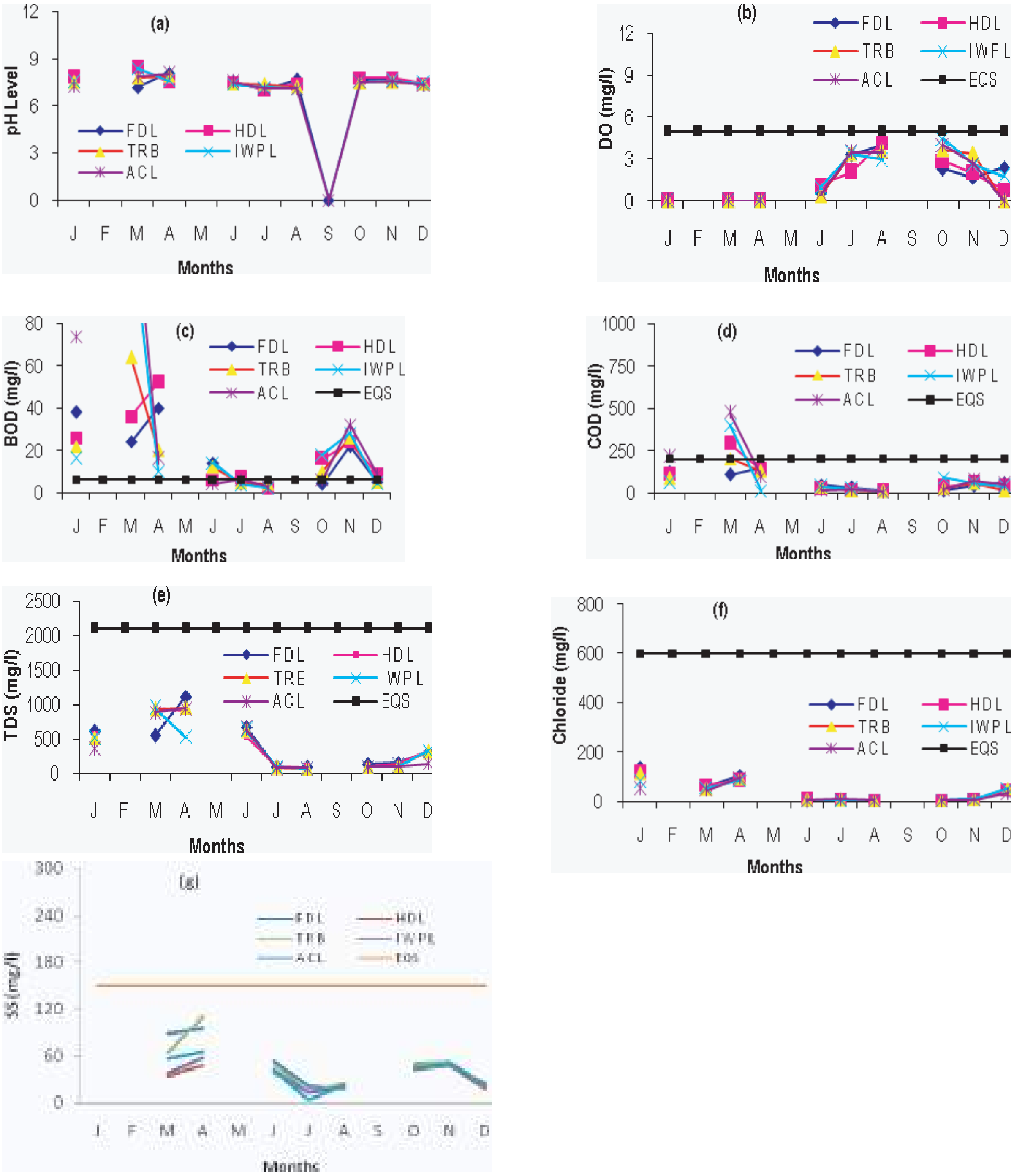


Fig.3. Graphical presentation of pH, DO, BOD, COD, TDS, Chloride and SS of Turag river in 2014

Note: F P D = Fulpukuria Dyeing Ltd., H D L = Hossain Dyeing Ltd., T R B = Tongi Rail Bridge, I W P L = Indigo Washing Plant Ltd. and A C L = Azmeri Composite Ltd.

Table-7. Total Alkalinity of Turag river water in 2014

Sampling Locations	Total Alkalinity (mg/l)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fulpukuria Dyeing Ltd.	276	-	390	380	-	33	31	40	-	34	48	190
Hossain Dyeing Ltd.	300	-	402	260	-	36	34	42	-	38	50	180
Tongi Rail Bridge	292	-	375	320	-	30	29	38	-	32	58	220
Istema FieldTongi	270	-	**425**	300	-	31	**30**	42	-	34	48	210
Indigo Washing Plant Ltd.Tongi	285	-	292	280	-	32	30	40	-	32	44	180
EQS for wastewater after treatment from industrial units 150 mg/l												

Total alkalinity at different locations of Turag river was mostly above the EQS. The maximum T. alkalinity (425 mg/l) was Istema Field,Tongi in April and the minimum (30 mg/l) in July respectively (Table-7).

Table-8. EC of Turag river water in 2014

Sampling Locations	EC (µmhos/cm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fulpukuria Dyeing Ltd.	1167		1121	**2230**		1374	196.9	191.4		284	310	588
Hossain Dyeing Ltd.	1106		1925	1845		1122	224	181.2		236	248	604
Tongi Rail Bridge	1004		1875	1938		1299	199.6	154.8		221	236	594
Istema Field,Tongi	994		1916	1106		1294	205.5	**154.5**		204.1	212	593
Indigo Washing plant Ltd.Tongi	715		1787	1913		1330	165.8	162.4		206.3	218	225
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

At different locations EC of Turag river water was within the EQS (1200 µmhos/cm). The maximum EC (2230 µmhos/cm) was in April at Fulkpukuria Dyeing Ltd. and the minimum (154.5 µmhos/cm) was in August Istema fieldTongi (Table-8).

4.4 Dhaleshwari River

The Dhaleshwari river is a 160 km long distributary of the Jamuna river flowing through central part of Bangladesh. It starts off the Jamuna near the northwestern tip of Tangail. Then it divided into two: the north branch retains the name Dhaleshwari and the other branch flows as Kaliganga. The both branches merged at the southern part of Manikganj district. Finally the merged flow meets the Shitalakhya River near Narayanganj district. In 2014, water samples were collected from two locations namely Muktarpur Ghat, Munshiganj and Harindhara, Hemayetpur, Savar, Dhaka for analyses.

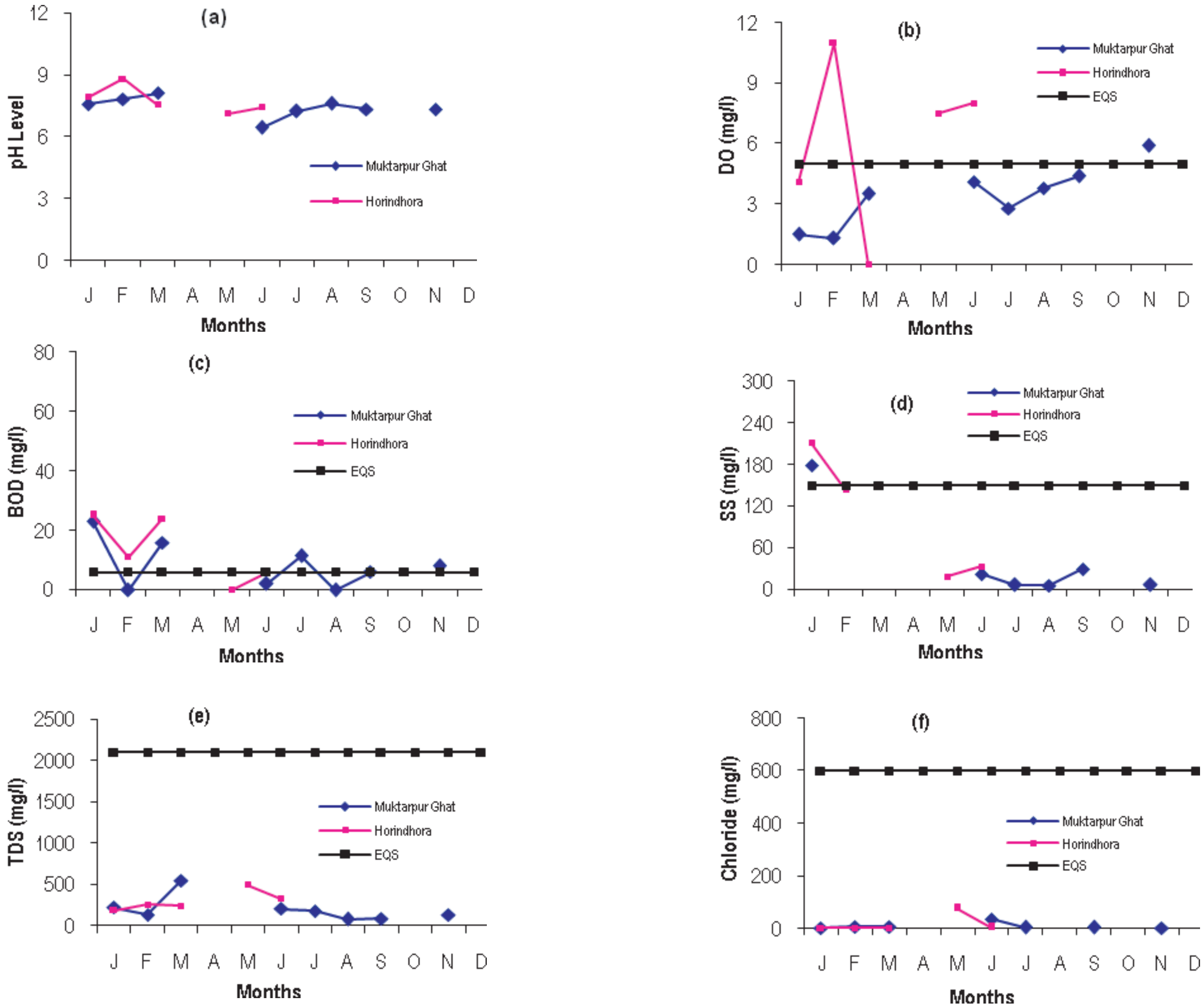


Fig.4. Graphical presentation of pH, DO,BOD, SS, TDS and Chloride of Dhaleshwari river in 2014

In 2014, Dhaleshwari river water was almost neutral and pH varied from 6.91 to 7.72 (Fig.-4a). In 2013, pH level varied from 6.44 to 8.8. In 2014, the maximum DO concentration (6.2 mg/l) was at Harindhara in July and the minimum (0.3 mg/l) at Muktarpur Ghat in December (Fig.4b). In 2013, DO concentration varied from 0.0 to 11.0 mg/l. In 2014, BOD varied from 0.0 to 17.8 mg/l (Fig.4c) while EQS for fisheries is ≤6 mg/l. In 2013, BOD varied from 0.0 to 25 mg/l. Level of SS of Dhaleshwari river water was within the EQS. The maximum SS of Dhaleshwari river water was 28 mg/l in November at Muktarpur Ghat and the minimum was 8.0 mg/l in July at Horindhora (Fig.4d) against EQS (150 mg/l) for wastewater after treatment from industrial units. In 2013, SS varied from 5 to 146 mg/l. TDS concentration varied from 71.9 to 287 mg/l (Fig.4e) while standard TDS level is 2100 mg/l for wastewater after treatment from industrial units. In 2013, TDS varied from 79.1 to 552 mg/l. Chloride concentration ranged from 5 to 21 mg/l (Fig.4f), which is far below the EQS (600 mg/l) for wastewater after treatment from industrial units. In 2013, Chloride concentration range of Dhaleshwari river water was from 1.8 to 76.5 mg/l.

Table-9. Total alkalinity of Dhaleshwari river water in 2014

Sampling Locations	Total alkalinity (mg/l)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Muktarpur Ghat, Munshigonj	-	-	-	-	-	-	14	-	-	-	28	**208**
Horindhora,Hemayetpur, Saver, Dhaka	75	-	80	80	-	-	17	-	**14**	-	30	-

EQS for wastewater after treatment from industrial units 150 mg/l

The maximum Total Alkalinity of Dhaleshwari river water was 208 mg/l in December at Muktarpur Ghat and the minimum was 14 mg/l in September (Table-9) at Horindhora.

Table-10. EC of Dhaleshwari river water in 2014

Sampling Locations	EC (µmhos/cm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Muktarpur Ghat, Munshiganj	-	-	-	-	-	-	185.3	-	-	-	401	552
Harindhara,Hemayetpur, Saver, Dhaka	-	-	**1304**	**1304**	-	-	**149.4**	-	174.9	-	353	-
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

Electrical Conductivity of Dhaleshwari river at different locations was mostly within the EQS (1200 µmhos/cm) except the month of March and April. The maximum and the minimum EC of Dhaleshwari river water was 1304 µmhos/cm and 149.4 µmhos/cm respectively. in July at Harindhara (Table-10)

4.5 Brahmaputra River

The Brahmaputra, a trans-boundary river that originates from Manossarobar near Mount Kailash in the Himalayas and flows via Tibbet, China, India and Bangladesh to Bay of Bengal. The total length it travels from Himalayans to the Bay of Bangal is 2900 km (Chowdhury, 2006).

In 2014, pH level of Brahmaputra river varied from 7.73 to 8.06 (Fig.5a), while standard range for fisheries is from 6.5 to 8.5. In 2013, pH level varied from 7.69 to 8.67. DO concentration varied from 8.4 to 11 mg/l (Fig.5b). The highest and the lowest DO was found in December and January respectively, while EQS of DO for fisheries is ≥5 mg/l. In 2013, DO varied from 5.9 to 13.5 mg/l. BOD concentration varied from 2.2 to 8 mg/l (Fig.5c) while EQS for fisheries is ≤6 mg/l. In 2013, BOD varied from 0.0 to 25 mg/l. SS concentration was 15 mg/l in December (Fig.5d). In 2013, Suspended Solid (SS) varied from 18 to 22 mg/l. Chloride level varied from 1.7 to 7.71 mg/l (Fig.5e) and was less than EQS (600 mg/l) for treated wastewater from industrial units. In 2013, Chloride concentration varied from 1.7 to 6.0 mg/l. TDS level ranged from 147.1 to 180.1 mg/l (Fig.5f) and was much below the EQS (2100 mg/l). In 2013, TDS level varied from 75.1 to 225 mg/l.

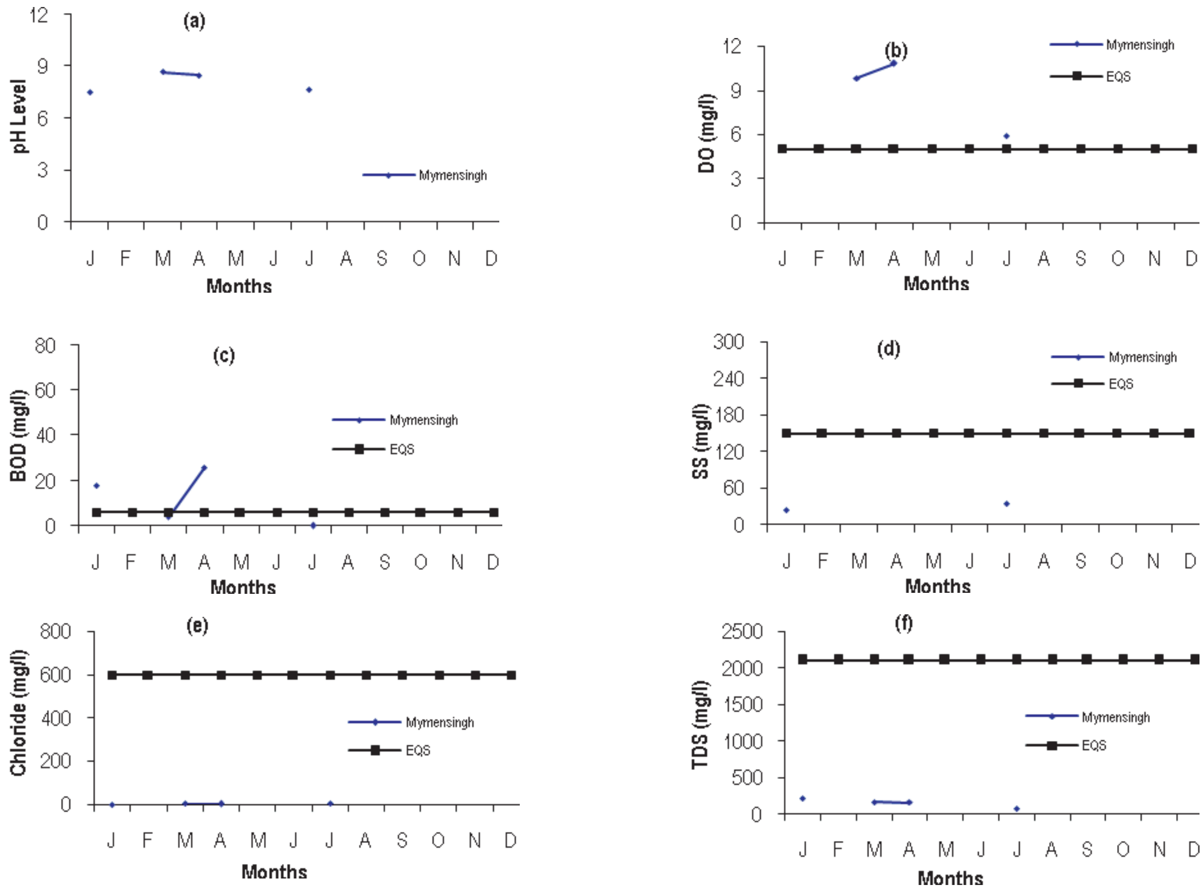


Fig.5. Graphical presentation of pH, DO, BOD, SS, Chloride, and TDS of Brahmaputra river in 2014

Table-11. Total alkalinity of Brahmaputra river water in 2014

Sampling Locations	**Total alkalinity (mg/l)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mymensingh	**16.2**	**-**	-	-	-	-	**-**	-	-	-	-	**180**
EQS for wastewater after treatment from industrial units 150 mg/l												

No sampling was done during wet season. During dry season, two samples were collected in January and in December. T. Alkalinity exceeded the EQS in December (Table-11).

Table-12. EC of Brahmaputra river water in 2014

Sampling Locations	**EC (µmhos/cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mymensingh	**357**	**-**	-	-	-	-	**-**	-	-	-	-	285
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

No sampling was collected during wet season. However, dry season (January and December) monitoring results were under the EQS (1200 µmhos/cm). The maximum and the minimum EC was 357µmhos/cm in January and 285 µmhos/cm in December (Table-12).

4.6 Kaliganga River

The Kaliganga river flows by Manikganj district. For monitoring of water quality, water samples were collected from one location (e.g. Manikganj) of the river.

In 2014, pH of Kaliganga river varied from 7.35 to 7.98 (Fig.6a). The maximum and the minimum pH was found in April and June, respectively. In 2013, pH level varied from 7.2 to 7.86. DO range was from 4.3 to 7.2 mg/l (Fig.6b). In 2013, DO varied from 5.8 to 6.9 mg/l. BOD varied within a longer range of 5.1 to 26.0 mg/l (Fig.6c) and sometime exceeded the EQS limit for fisheries throughout the year. In 2013, BOD varied from 2.0 to 10.0 mg/l. COD varied from 15 to 87 mg/l (Fig.6d). In 2013, COD range was 4.0 to 134 mg/l.

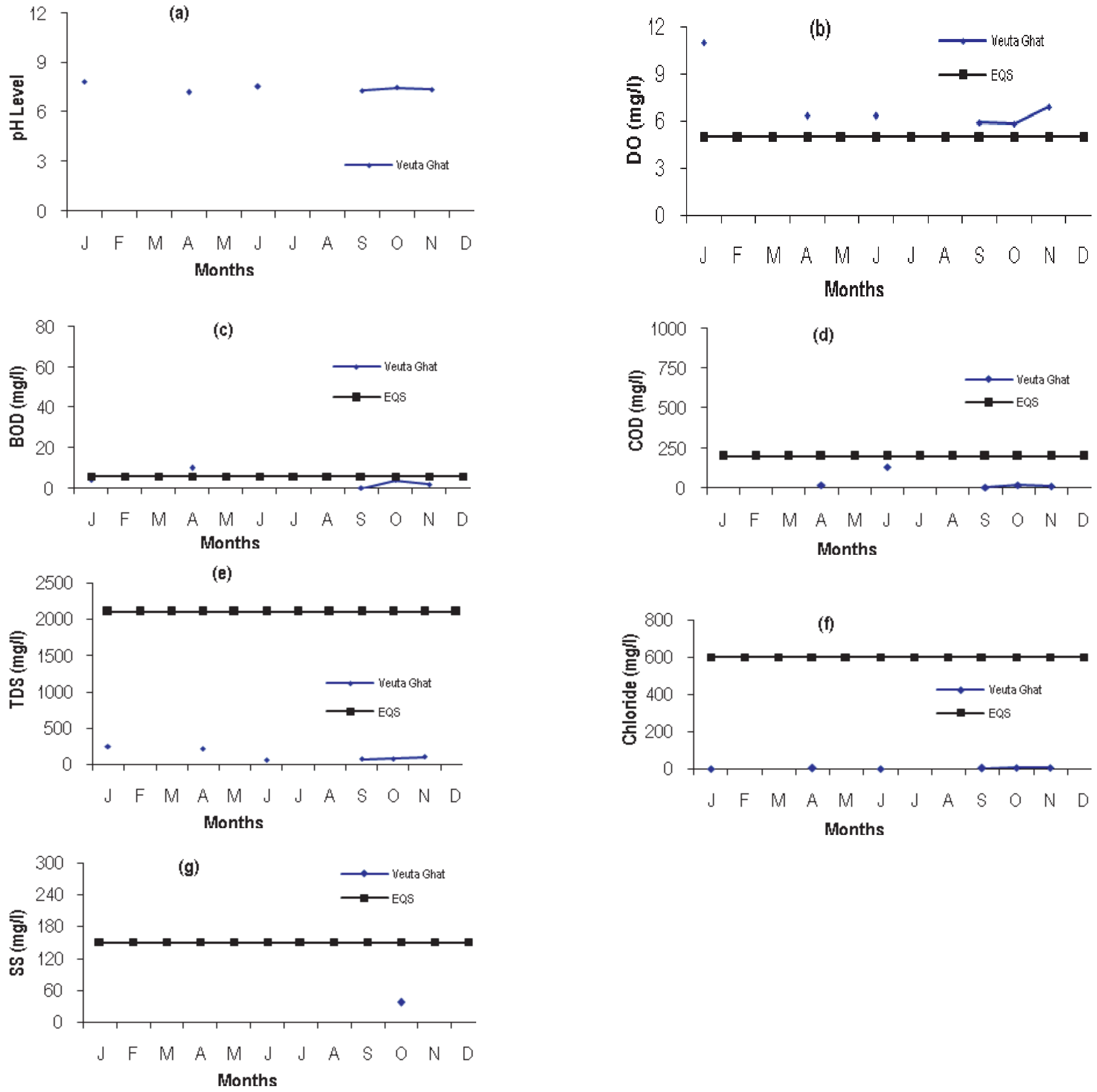


Fig.6. Graphical presentation of pH, DO, BOD, COD, TDS, Chloride and SS of Kaliganga river in 2014

In 2014, TDS concentration was very low compared to the EQS (2100 mg/l) for wastewater after treatment from industrial units. The maximum TDS was 267 mg/l in April and the minimum TDS was 66.1 mg/l in June (Fig.6e). In 2013, TDS concentration varied from 61.1 to 249 mg/l. Chloride level was lower than the EQS (600 mg/l). Highest Chloride was (8.0 mg/l) in June and that of the lowest was (5 mg/l) in September (Fig.6f). In 2013, Chloride varied from 0.5 to 6 mg/l. SS of Kaliganga river was within the EQS (150 mg/l). The maximum and the minimum SS was 61 mg/l and 8 mg/l, respectively (Fig.6g).). In 2013, SS varied from 37 to 351 mg/l.

Table-13. Total alkalinity of Kaligonga river water in 2014

Sampling Locations	**Total alkalinity (mg/l)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Veuta Ghat, Manikganj	-	-	-	200	-	18	-	-	14	-	-	250
EQS for wastewater after treatment from industrial units 150 mg/l												

Total alkalinity of Kaliganga river water was higher in dry season than in wet season (Table-13).

Table-14. Level of EC of Kaligonga river water in 2014

Sampling Locations	**EC (µmhos/cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Veuta Ghat, Manikgonj	-	-	-	557	-	141.2	-	-	166.5	-	-	418
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

EC of Kaligonga river water at different locations was within the EQS (1200 µmhos/cm). However, EC in wet season was much lesser than in dry season (Table-14).

4.7 Jamuna River

The Jamuna river is one of the main three rivers of Bangladesh. It is the main distributary channel of the Brahmaputra river that flows out of India into Bangladesh. To monitor water quality, samples were collected only from two locations e.g. Bahadurabad Ghat and near Jamuna Fertilizer Factory. In 2014. samples were collected only in December.

In 2014, pH varied from 7.88 to 7.93 and was within the EQS limits (Table-15). In 2013, pH was 8.38. DO concentrations from 8.45 to 8.5 mg/l (Table-15) and higher than the EQS (≥5 mg/l) for fisheries. In 2013, DO concentration varied from 5.2 to 8.3 mg/l. In 2014, the maximum BOD level was 2.1 mg/l and which is below the EQS (≤6 mg/l) for fisheries (Table-15). In 2013, BOD concentration varied from 5.3 to 9.0 mg/l. Average SS (25 mg/l) was far below the EQS (150 mg/l). (Table-15). In 2013, SS concentration was 70.2 mg/l. Level of TDS of Jamuna river water varied 98.6 to 263 mg/l (Table-15), while EQS for TDS is 2100 mg/l. In 2013, TDS level was 129.8 mg/l. Chloride varied from 6 mg/l to 1.1 mg/l (Table-15). In 2013, Chloride concentration was 1.1 mg/l. High Total alkalinity 240 mg/l (Table-15) was may be due to discharge of untreated waste by the Jamuna

Fertilizer Factory in to thr river. Level of EC of Jamuna river water at sampling locations was within the EQS (1200 µmhos/cm) (Table-15). In 2013, EC concentration was 366µmhos/cm.

Table-15. Level of different parameters at different locations of Jamuna river in 2014

Sampling Locations	Month	pH	DO	BOD	COD	SS	TDS	Chloride linity	T.alka	EC
Bahadurabad Ghat	Dec	7.93	8.5	2	11	22	98.6	6	94	169.8
Near Jamuna Fertilizer Factory		7.88	8.4	2.2	15	28	263	11	240	488
EQS		**6-9 mg/l**	**5 mg/l**	**6 mg/l**	**200 mg/l**	**150 mg/l**	**2100 mg/l**	**600 mg/l**	**150**	**1200 µmhos/cm**

4.8 Meghna River

The Meghna is an important river in Bangladesh and one of the three that forms the Ganges Delta, the largest on the earth ended up the Bay of Bengal. To monitor water quality, water samples were collected from Bhairab Bazar, Meghna Ghat, Shahjalal Paper Mills of the Meghna river.

High pH (9.56) in June at SPM may indicate untreated waste disposal by the SPM. The minimum pH was 6.92 Bhairab Bazar in June respectively (Fig.7a). In 2013, pH level varied from 6.4 to 8.4. DO level of Meghna river was varied 1.0 mg/l to 6.7 mg/l that often was below the EQS (≥5 mg/l) for fisheries (Fig.7b). In 2013, DO level varied from 1.8 mg/l to 6.7mg/l. BOD was below the EQS (≤6 mg/l) for fisheries round the year. The maximum and the minimum BOD load was 17 mg/l in June and 2.3 mg/l in December at Bhairab Bazar (Fig.7c). In 2013, BOD concentration varied from 0.0 to 35 mg/l. COD varied from 3.8 to 58 mg/l (Fig.7d). COD level was below the EQS (200 mg/l) for wastewater from industrial units round the year. In 2013, COD concentration varied from 3.0 to 82 mg/l. TDS of Meghna river was very low in 2014 and ranged from 27.6 to 138 mg/l (Fig.7e). In 2013, TDS concentration varied from 28.2 to 335 mg/l.

In 2014, Chloride concentration at all the sampling locations was within the EQS (600 mg/l) for wastewater after treatment from industrial units. The maximum Chloride (77.7 mg/l) was found in January at Bhairab Bridge and the minimum (3.5 mg/l) was in February at Mehna Ghat (Fig.7f). In 2013, Chloride concentration varied from 1.1 to 25.1 mg/l.

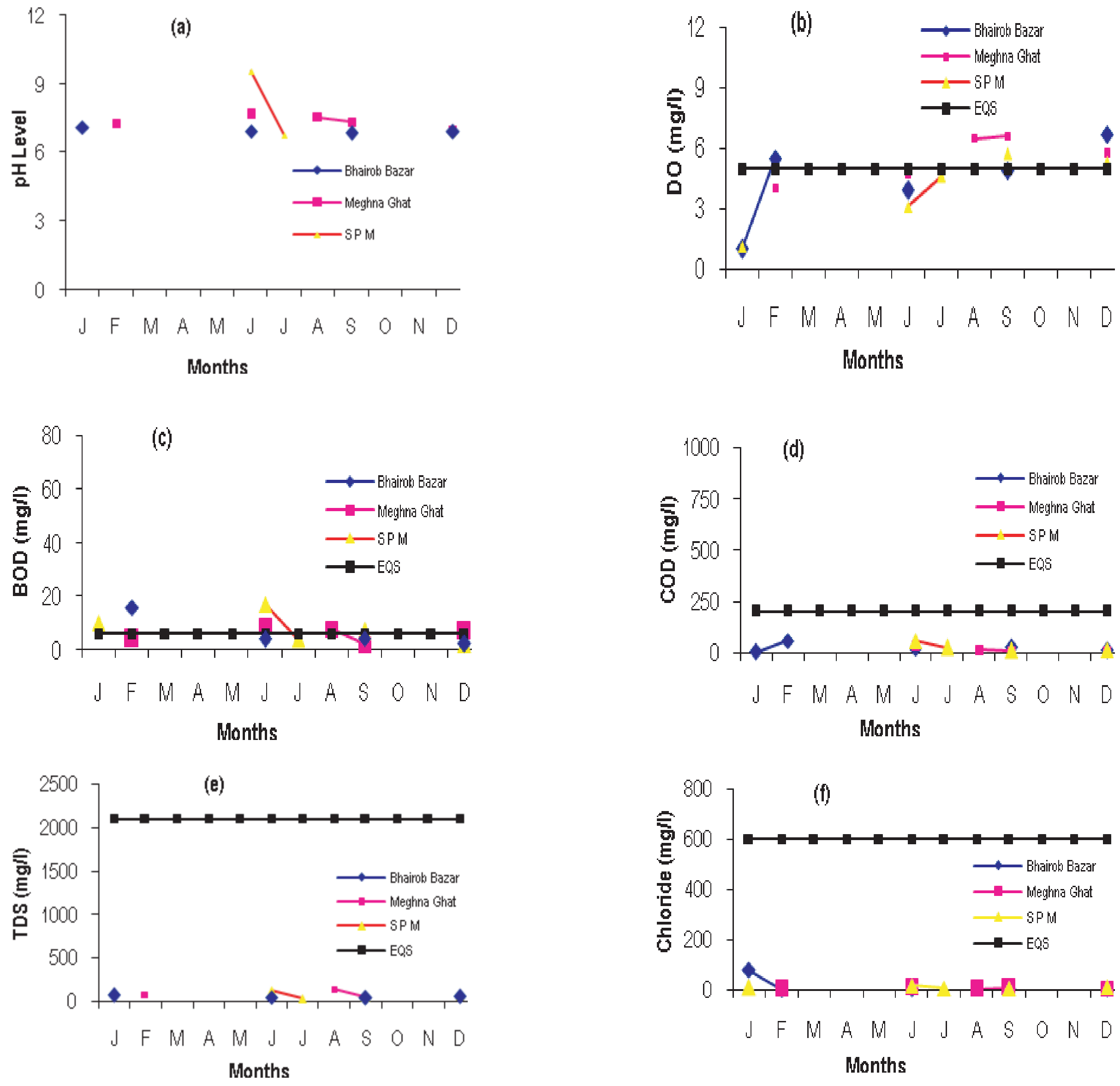


Fig.7. Graphical presentation of pH, DO, BOD, COD, TDS, Chloride and SS of Meghna river in 2014
Note: S.P.M = Shajalal Paper Mill

Table-16. EC at different locations of Meghna river water in 2014

Sampling Locations	**EC (µmhos/cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Bhairob Bazar	130.7	-	-	-	-	99.3	-	-	63.7	-	-	90.6
Meghna Ghat	-	-	-	-	-	100	-	**278**	83.6	-	-	97.4
Shajalal Paper Mill	215.8	-	-	-	-	258.6	**60.6**	-	76.7	-	-	124.2
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

EC of Meghna river water at different locations was within the EQS (µmhos/cm). The maximum and the minimum EC of Meghna river was 278 µmhos/cm in August at Megna Ghat and 60.6 µmhos/cm in June at Shajalal Paper Mill (Table-16).

4.9 Padma River

The Padma is a major trans-boundary river of Bangladesh. Water samples were collected from three locations of the river namely Pakshi Ghat (Bank and Middle) of Pabna, Iswardi and Baro Kuti Ghat (Bank and Middle) of Rajshahi only middle points were used in the analysis.

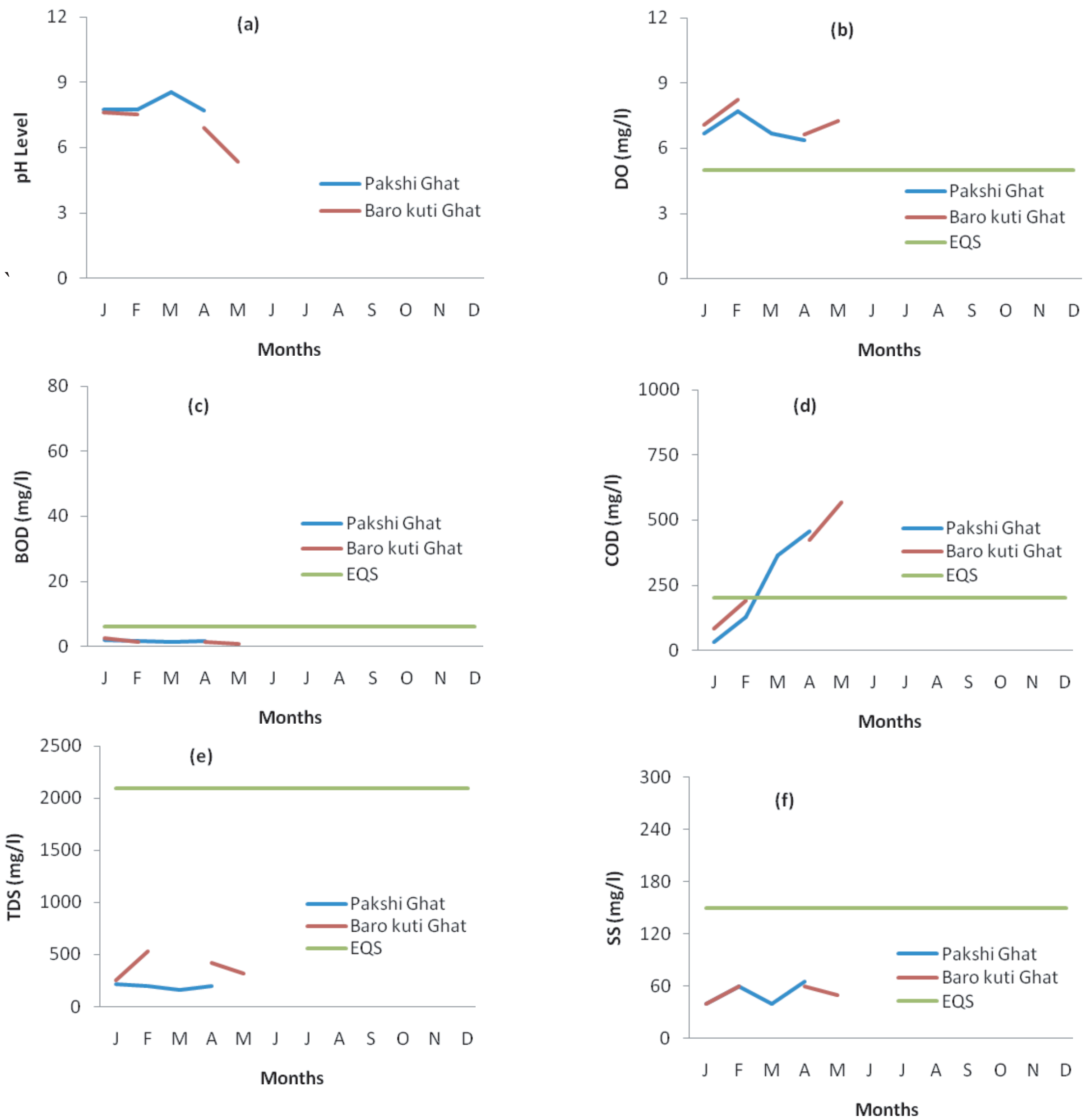


Fig.8. Graphical presentation of pH, DO, BOD, TDS, EC and SS of Padma river in 2014

In 2014, pH of Padma river was mostly neutral and varied from 5.3 to 8.6 (Fig.8a) while standard pH for inland surface water is 6.5 to 8.5. The maximum pH was found at Paksi Ghat (bank) in March and the minimum pH level was at Baro Kuti in May. In 2013, pH level varied from 3.3 to 8.0. DO level of Padma river was above EQS (≥5 mg/l) for fisheries at all the locations and it varied from 5.1 to 8.3 mg/l (Fig.8b). In 2013, DO concentration ranged from 5.8 to 7.8 mg/l. BOD load was within the EQS (≤6 mg/l) for fisheries at all locations.

The maximum BOD was found 2.9 mg/l in January and that of the minimum was O.8 mg/l in May (Fig.8c). In 2013, BOD load varied from 1.1 to 1.92 mg/l. TDS level of Padma river was within EQS throughout the year of 2014 and it varied from 110 to 270 mg/l (Fig.8d). In 2013, TDS concentration varied from 170 to 280 mg/l.

The maximum and the minimum EC of Padma river water was 561 μmhos/cm in January and 214 μmhos/cm in October (Fig.8e), while EQS is 1200 μmhos/cm for treated waste water from industrial units. In 2013, EC varied from 320 μmhos/cm to 530 μmhos/cm. Level of SS was within the EQS (150 mg/l). The maximum and the minimum SS concentration of Padma river was 73 mg/l in October and 40 mg/l in January (Fig.8f). In 2013, SS concentration varied from 60 to 90mg/l.

Table-17. Chloride at different sampling locations of Padma river water in 2014

Sampling Locations	**Total alkalinity (mg/l)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mawa Ghat	-	-	-	-	-	-	-	-	-	-	-	-
Pakshi (E), Ishurdi	**40**	35	30	40	-	-	40	-	-	-	20	**20**
Pakshi (M),Ishurdi	40	35	30	40	-	-	40	-	-	-	-	20
Baro kuti (E), Raj.	35	40	-	40	30	-	30	-	-	25	-	20
Baro kuti (M), Raj.	35	40	-	40	30	-	30	-	-	25	-	20
EQS for wastewater after treatment from industrial units 150 mg/l												

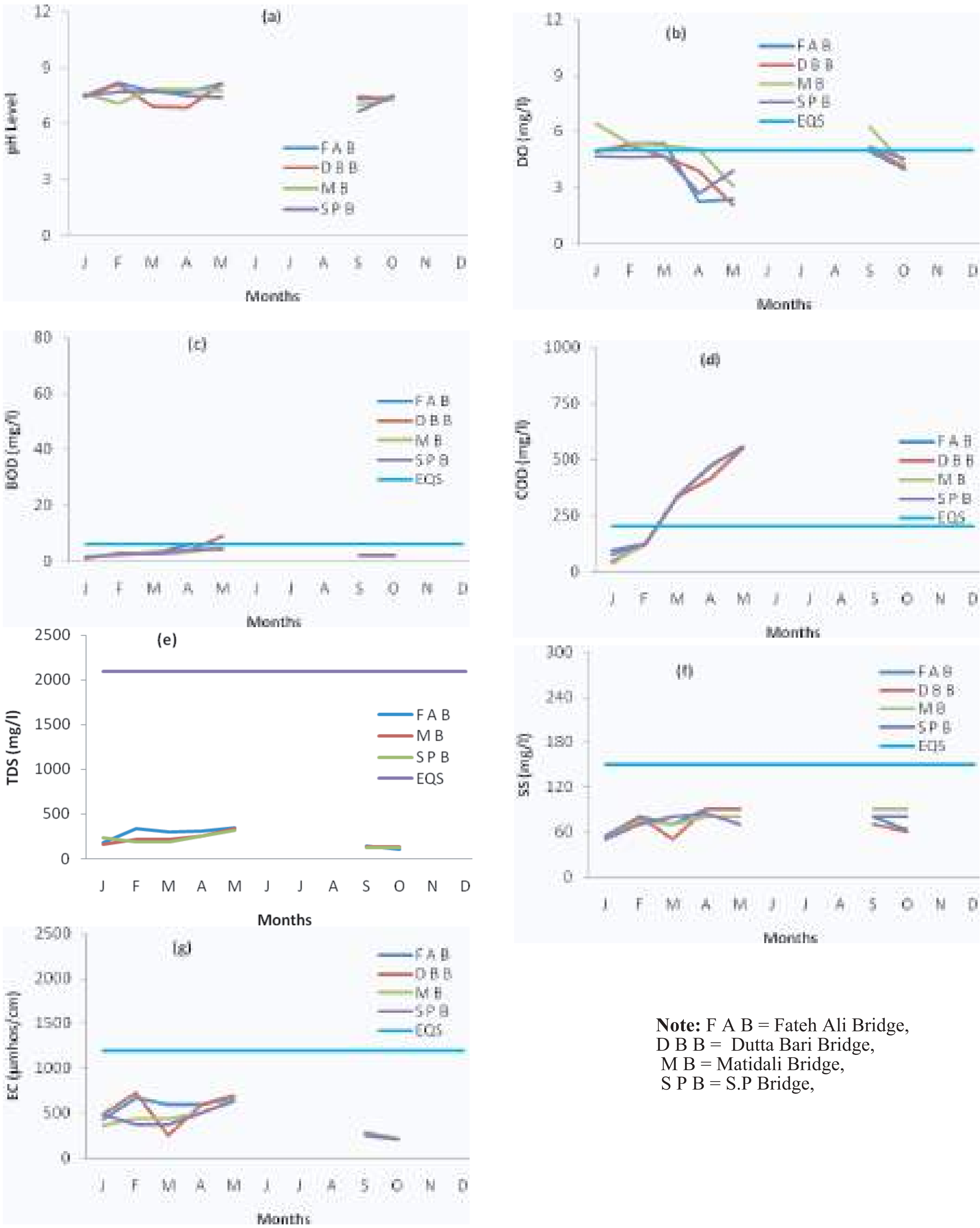
The maximum and the minimum Chloride of Padma river water was 40 mg/l in January and 20 mg/l in December (Table-17).

4.10 Korotoa River

To monitor water quality of Korotoa river in 2014, water samples were collected from four locations of the river e.g. Fateh Ali Bridge, Dutta Bari Bridge, Matidali Bridge and S.P Bridge.

pH level of Korotoa river water varied from slightly acidic to slighty alkaline (6.18 to 8.2) (Fig.9a) and was within EQS limit. In 2013, pH level varied from 4.7 to 8.35. DO level of Korotoa river water was within the EQS (≥5 mg/l) for fisheries. DO varied from 2.0 to 6.8 mg/l (Fig.9b). In 2013, DO concentration varied from 2.0 to 6.8 mg/l. In 2014, BOD varied from 1.5 to 6.4 mg/l (Fig.9c). In 2013, BOD concentration varied from 2.0 to 65 mg/l. In 2014, COD level of Korotoa river was lower than EQS (200 mg/l) for wastewater after treatment from industrial units. COD varied from 36 to1681 mg/l (Fig.9d). The maximum COD concentration was 1681 mg/l in December at downstream of D.B.B, and need to identify source of pollution. In 2013, COD concentration varied from 9.0 to 25 mg/l. TDS varied from 110 mg/l to 370 mg/l (Fig.9e). In 2013, TDS range was from 170 mg/l to 1260 mg/l. Level of SS of Korotoa river at different locations was within the EQS. The maximum and the minimum SS was 130 mg/l in July and 50 mg/l in January at M.B up stream respectively (Fig.9f).

In 2013, SS concentration varied from 70 mg/l to 110 mg/l. EC varied from 107 mg/l to 729 mg/l (Fig.9g) and was within the EQS limit. In 2013, EC concentration varied from 401 mg/l to 1440 mg/l.



Note: F A B = Fateh Ali Bridge,
D B B = Dutta Bari Bridge,
M B = Matidali Bridge,
S P B = S.P Bridge,

Fig.9. Graphical presentation of pH, DO, BOD, COD, TDS, SS and EC of Korotoa river in 2014

4.11 Karnaphuli River

Karnaphuli river is in the south-eastern part of Bangladesh that flows through Chittagong Hill Tracts and Chittagong into the Bay of Bengal. Water samples were collected from two locations comprising four points (e.g. Triple Super Phosphate industry Upstream, TSP industry Downstream, Karnaphuli Urea Fertilizer Limited Upstream and Downstream of Karnaphuli river for monitoring of water quality in 2014.

In 2014, pH level at the sampling points of the Karnaphuli river varied from 7.27 to 8.05 (Fig.10a), while standard pH for inland surface water is 6.5 to 8.5. In 2013, pH level varied from 6.1 to 8.2 . DO level of Karnaphuli river was high althrough the year of 2014 and met the standard of DO for fisheries (≥5 mg/l). DO varied from 4.5 to 5.7 mg/l (Fig.10b). In 2013, DO concentration varied from 1.0 to 5.6 mg/l. BOD level was below the EQS limit (≤6 mg/l) for fisheries throughout the year. It varied from 0.2 to 5.5 mg/l (Fig.10c). In 2013, BOD concentration varied from 4.8 to 5.7 mg/l. COD value varied from 9.0 to 144.5 mg/l (fig.10d), while EQS for wastewater after treatment from industrial units is 200 mg/l. COD value was high at KUFL upstream and downstream compare to TSP upstream and downstream. In 2013, COD value varied from 1.0 to 626 mg/l. Level of SS of Karnaphuli river water at different points was beyond the EQS (150 mg/l). The maximum and the minimum SS was 1053.5 mg/l in July at KUFL point and 130.5 mg/l in January at TSP point (Fig.10e). In 2013, SS value varied from 96 to 1132 mg/l. In 2014, Chloride concentration of Karnaphuli river was higher especially at KUFL upstream and downstream and varied from 302 to 12,500.5 mg/l (Fig.10f) where standard for Chloride is 600 mg/l for wastewater after treatment from industrial units. The maximum (12,500.5 mg/l) level was found at KUFL downstream in February and the minimum (302 mg/l) level at TSP upstream in April. In 2013, Chloride concentration varied from 13 to 13203 mg/l.

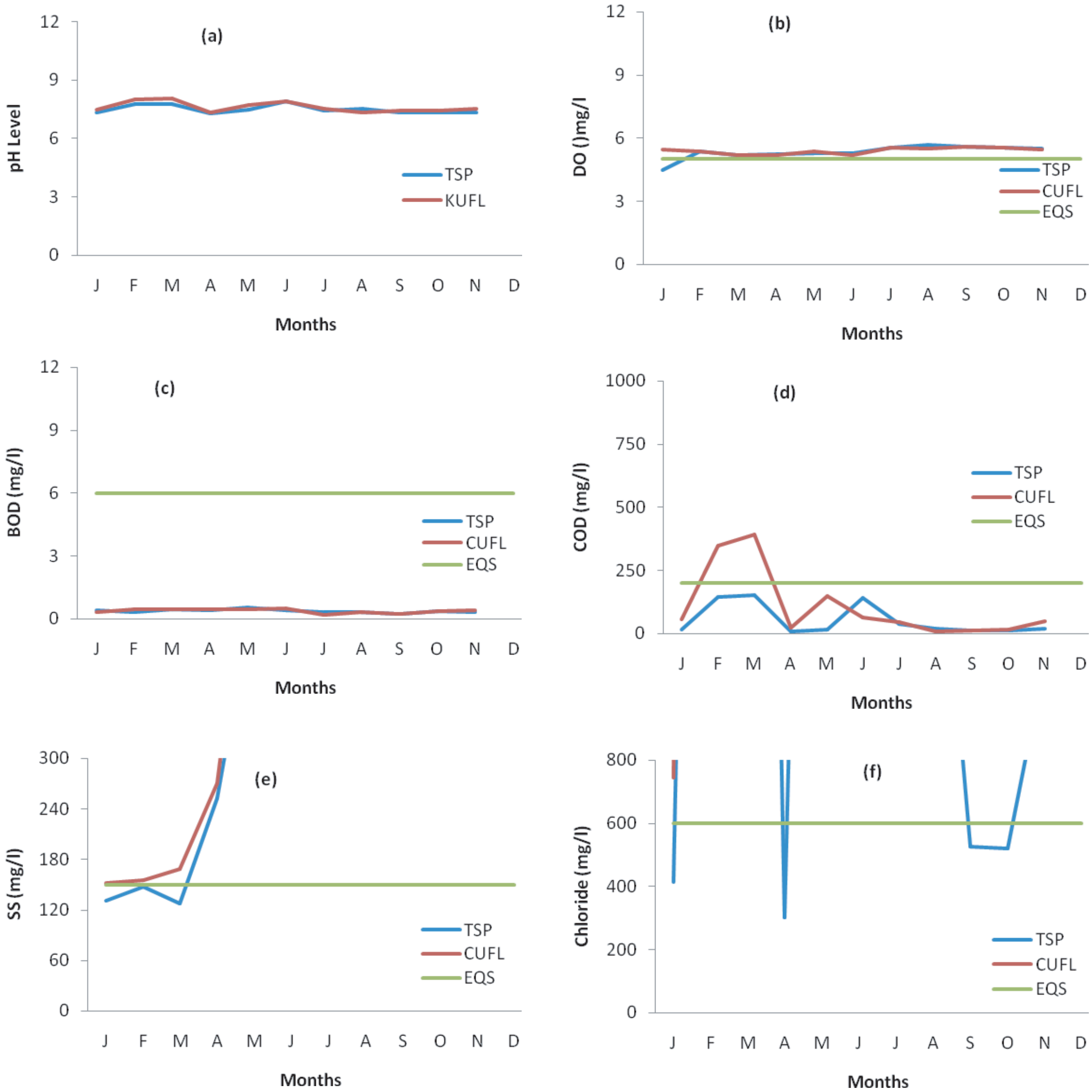


Fig.10. Graphical presentation of pH, DO, BOD, COD, SS and Chloride of Karnaphuli river in 2014

Note: TSP =Triple Super Phosphate, KUFL = Karnaphuli Urea Fertilizer Ltd.

4.12 Halda River

Halda river passes through the South-Eastern part of Bangladesh. Water sampling stations were WASA intake Point (upstream), WASA intake Point (downstream), Maduna Ghat (Bank) and Maduna Ghat (Middle) of Halda river. Samples were collected during high tide and low tide at all locations of the river. To simplify the analysis, only high tide and low tide variation for the sampling points were considered. Because no significant variation was found between upstream and downstream (WASA intake Point) and river bank- middle (Maduna Ghat).

pH of Halda river water was within EQS limit in 2014 and varied from 7.0 to 7.315 (Fig.11a). In 2013, pH level varied from 7.0 to 7.51. DO level of Halda river was above the EQS limit throughout the monitoring period of 2014. DO varied from 5.0 to 5.7 mg/l (Fig.11b). In 2013, to 5.7 mg/l. The maximum and the minimum BOD was 0.2 and 0.45 mg/l respectively (fig.11c). In 2013, BOD concentration varied 0.2 and 0.8 mg/l. In 2014, COD at the sampling locations of Halda river during high and low tide was varied 2.0-4.0 mg/l (Fig.11d). In 2013, COD was 1.0 mg/l throughout the year. The maximum and the minimum SS content of Halda river water was 313 mg/l in September and 17.5 mg/l in April (Fig.-11e). In 2013, SS value varied from 11 to 174 mg/l. Chloride level of Halda River in 2014 was well below the EQS (600 mg/l) for treated wastewater from industrial units. Chloride varied from 7 to 909 mg/l (Fig-11f). Chloride concentration was relatively higher during high tide at all locations of the river. In 2013, Chloride concentration varied from 8 to 148 mg/l.

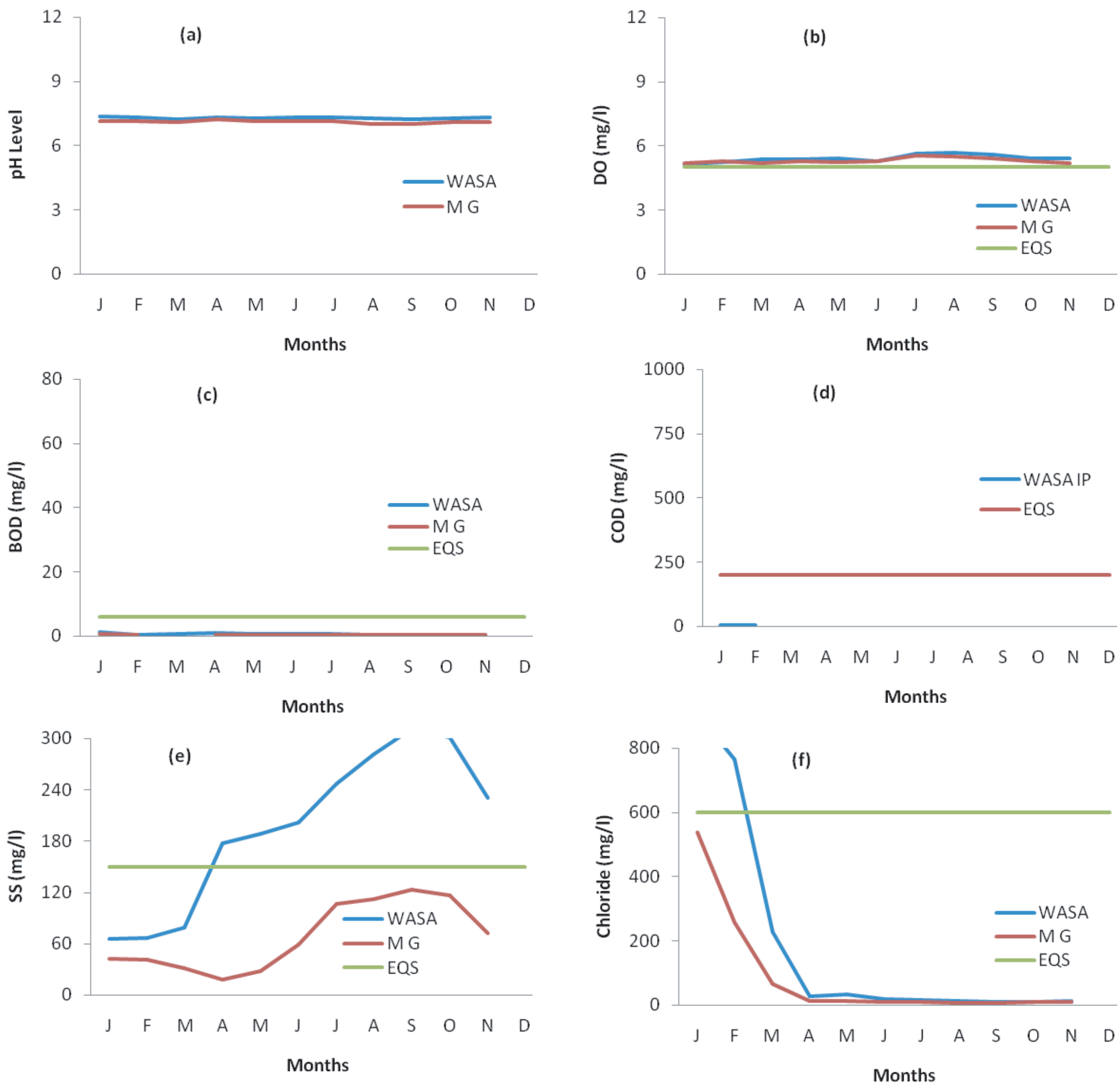


Fig.11. Graphical presentation of pH, DO, BOD, COD, SS and Chlorideof Halda river in 2014

Note: MG = Maduna Ghat

4.13 Titas River

Titas river flows by Brahmanbaria district. In 2014, water samples were collected from one location e.g. Bakail Bridge, Brahmanbaria.

In 2014, pH level varied from 7.1 to 7.12 (Fig.12a) and was within the EQS (6.5-8.5) of inland surface water for fisheries. In 2013, pH level varied from 6.6 to 8.7. BOD level of Titas river water was below the EQS (≤6 mg/l) for fisheries throughout the sampling period. On an average BOD was 0.5 mg/l throughout year (Fig.12b). In 2013, BOD concentration varied from 0.3 to 0.6 mg/l. Annual average COD was 1.0 mg/l throughout the sampling period (Fig.12c). In 2013, COD concentration was 1.0 mg/l throughout the year. SS of Titas river water was within the EQS. SS concentration varied from 33 to 34 mg/l. (Fig.12d). In 2013, SS concentration varied from 16 to 63 mg/l. TDS concentration varied varied from 146 to 149 mg/l. (Fig.12e).

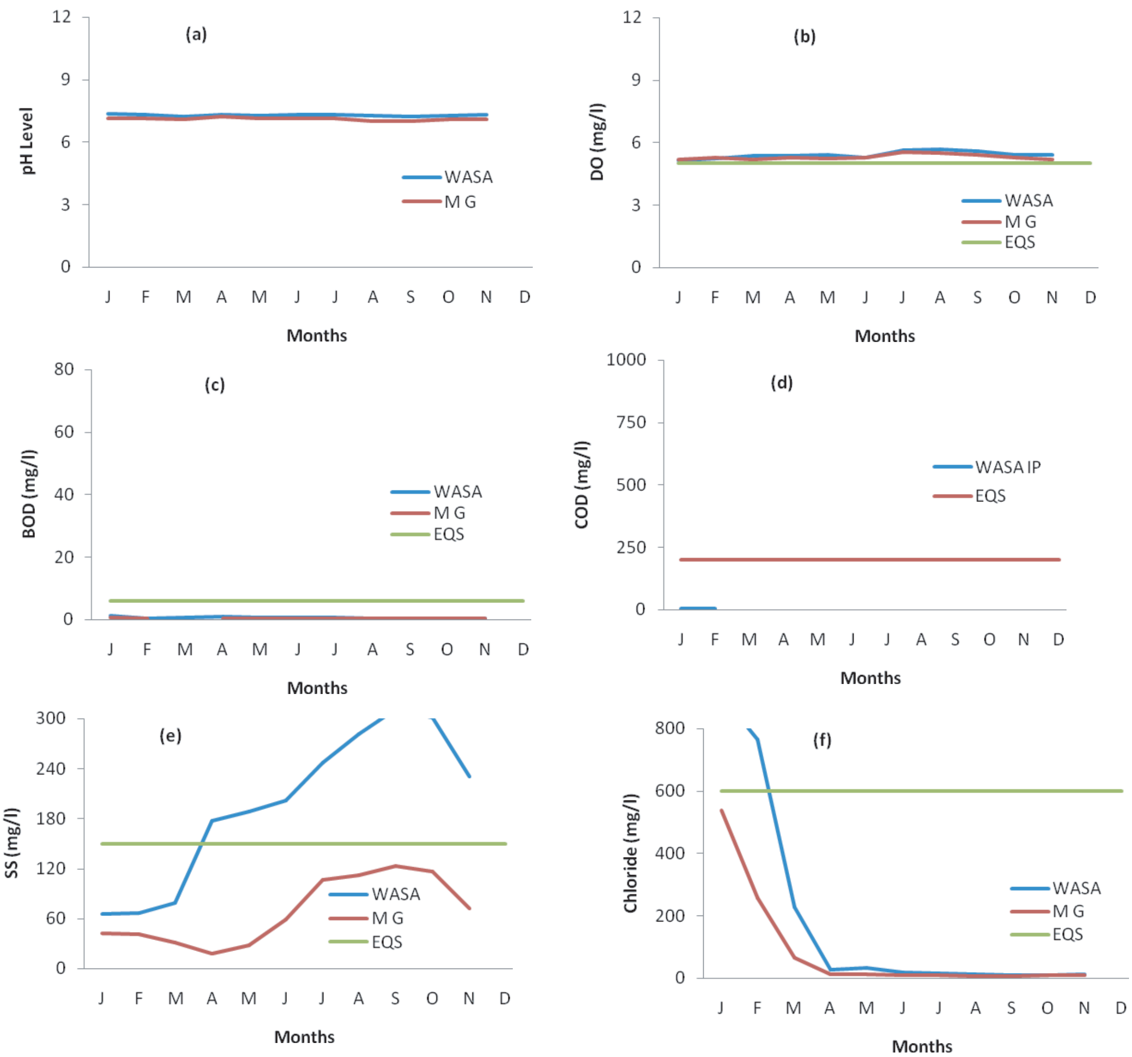


Fig.12. Graphical presentation of pH, BOD, COD, SS and TDS of Titas river in 2014

Table-18. Chloride of Titas river water in 2014

Sampling Locations	**Chloride (mg/l)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Bakail Bridge, B-Baria	72	-	73	-	-	-	-	-	-	-	-	-
EQS for wastewater after treatment from industrial units 600 mg/l												

Chloride concentration was below the EQS (600 mg/l) for treated wastewater from industrial units (Table-18). In 2013, Chloride concentration varied from 7.0 to 221 mg/l.

4.14 Moyuri River

For monitoring water quality of Moyuri River in 2014, water samples were collected from one station location named Gallamari Bridge comprising both of the banks and middle point of the river.

In 2014, pH level of Moyuri river water varied from 7.53 to 8.0 (Fig.13a) and was within the EQS limit. In 2013, pH level varied from 7.59 to 7.68. SS content of Moyuri river water was below the EQS (150 mg/l). SS level varied from 32 to 72 mg/l (Fig.13b). TDS level of the Moyuri river water varied from 633 to 1197 mg/l while EQS is 2100 mg/l (Fig.13c). In 2013, TDS range was from 382 to 1653 mg/l. Chloride range was from 232 to 832.68 mg/l (Fig.13d) while EQS is 600 mg/l. Highest Chloride value was found in April. In 2013, Chloride level varied from 122.73 to 910.98 mg/l. Turbidity level of Moyuri river was very high. It varied from 12.3 to 68.5 NTU while Turbidity for drinking water is 10 NTU (Fig.13e). In 2013, Turbidity level varied from 42.8 to 58.6 NTU. In 2014, Total alkalinity varied from 12.3 to 40.0 (Fig.13f) and was within the EQS limit.

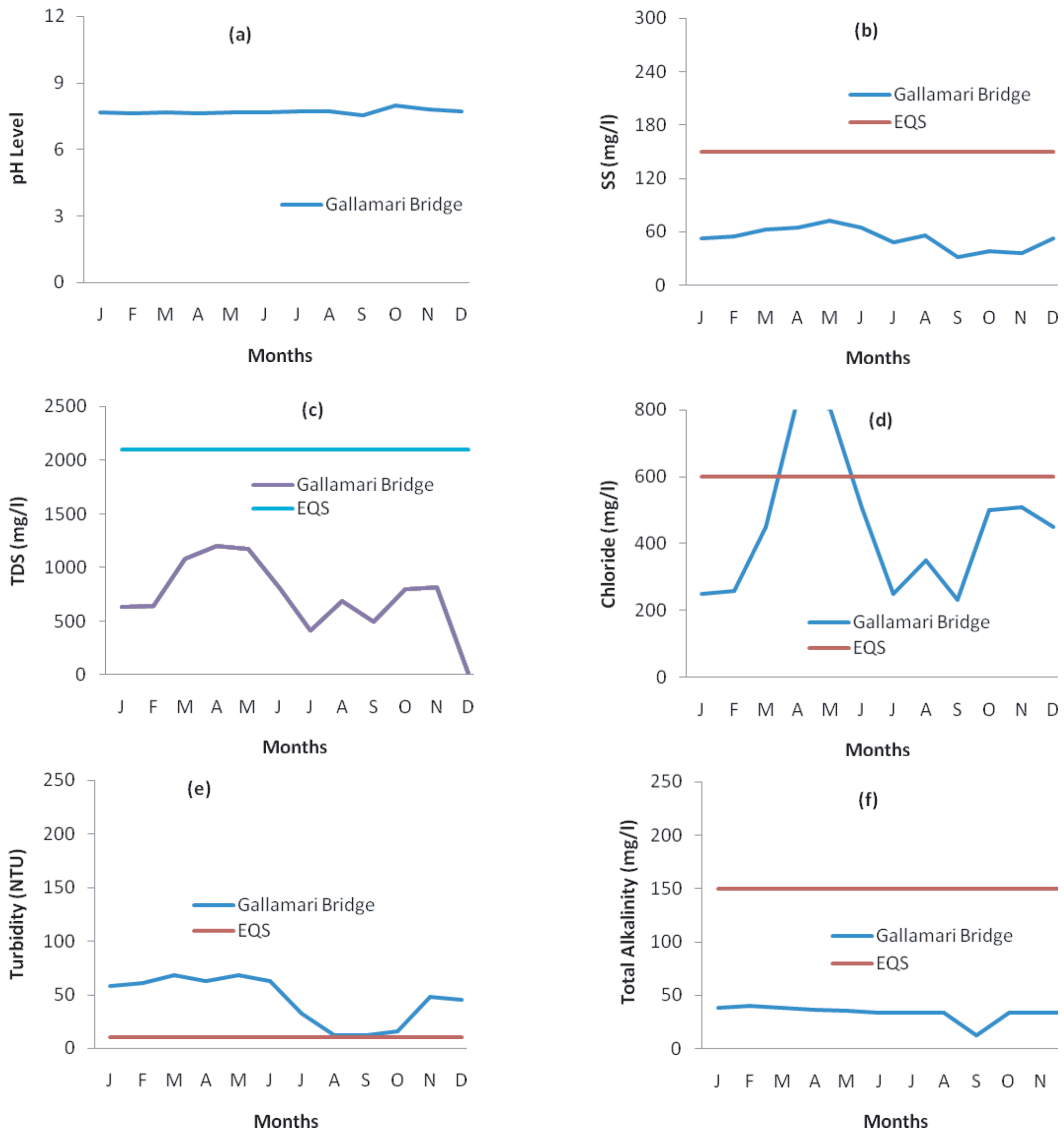


Fig.13. Graphical presentation of pH, SS, TDS, Chloride, Turbidity of Moyuri river in 2014

Table-19. EC of Moyuri river water in 2014

Sampling Locations	**EC (µmhos/cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Gallamari Bridge	1265	1280	2160	**2390**	2340	1604	820	1375	**926**	1594	1628	1580
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

EC varied from 926 µmhos/cm to 2390 µmhos/cm. The maximum and the minimum concentration was 2390 µmhos/cm in April and 926 µmhos/cm in September respectively (Table-19) while standard for treated wastewater from industrial unit EC is 1200 µmhos/cm. In 2013, EC was from730 µmhos/cm to 14081 µmhos/cm.

Table-20. Salinity of Moyuri river water in 2014

Sampling Locations	Salinity (ppt)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Gallamari Bridge	0.6	0.9	1.1	**1.2**	**1.2**	0.8	**0.3**	0.7	0.4	0.8	0.9	0.8
EQS for wastewater after treatment from industrial units 400 ppt												

Salinity level varied from 0.3 ppt to 1.2 ppt. The maximum and the minimum salinity was 8.6 and 0.0 mg/l respectively while standard salinity is 400 ppt for treated wastewater from industry (Table-20). In 2013, Salinity was from 0.0 ppt to 8.6 ppt.

4.15 Bhairab River

Bhairab river flows in the south of Bangladesh. The river is approximately 62 km long and 100m wide. Its average depth is 1.22 m to 1.53 m and with minimal water flow with plenty of silt. Water samples were collected from three locations comprising nine different points (e.g. Noapara Ghat Bank, Middle and Opposite bank, Fultala Ghat bank, Middle and Opposite bank and Charerhat Ghat bank Middle and Opposite bank) of Bhairab River for monitoring water quality in 2014. To simplify data analysis only middle point of all stations was considered. Because, no significant variation was found between bank, middle and opposite bank of a location of the river.

In 2014, pH at different locations of the Bhairab river varied from 7.63 to 8.3 (Fig.14a) while EQS for inland surface water is 6.5 to 8.5. In 2013, pH varied from 7.56 to 7.72. DO was around the EQS (($\geq$5 mg/l) for fisheries. In 2014, DO was 5.2 to 6.6 mg/l (Fig.14b) respectively. In 2013, DO varied from 4.8 to 7.2 mg/l. BOD level of Bhairab river water was below the EQS ($\leq$6 mg/l) for fisheries round the year of 2014. BOD varied from 0.8 to 1.1 mg/l (Fig.14c). In 2013, BOD level varied from 0.4 to 5.3 mg/l. In 2014, at all staion TDS level of Bhairab river was very high during March to June. The maximum and the minimum was 11850 and 119 mg/l (Fig.14d) respectively while EQS is 2100 mg/l. In 2013, TDS was from 114 to 4880 mg/l. In 2014, Chloride was varied from 18.23 to 2910.98 mg/l (Fig.14e) while EQS for Chloride is 600 mg/l. Highest Chloride (8898 mg/l) was found in May and lowest was (32 mg/l) in October. In 2013, Chloride level varied from 18.23 to 2910.98 mg/l. Turbidity of Bhairab river water at all locations was very high in 2014. It varied from 16.2 to 89.5 NTU while the EQS for drinking water is 10 NTU (Fig.14f). The prime reason may be of carrying huge silt by the river throughout the year. In 2013, Turbidity level varied from 28.1 to 75.28 NTU.

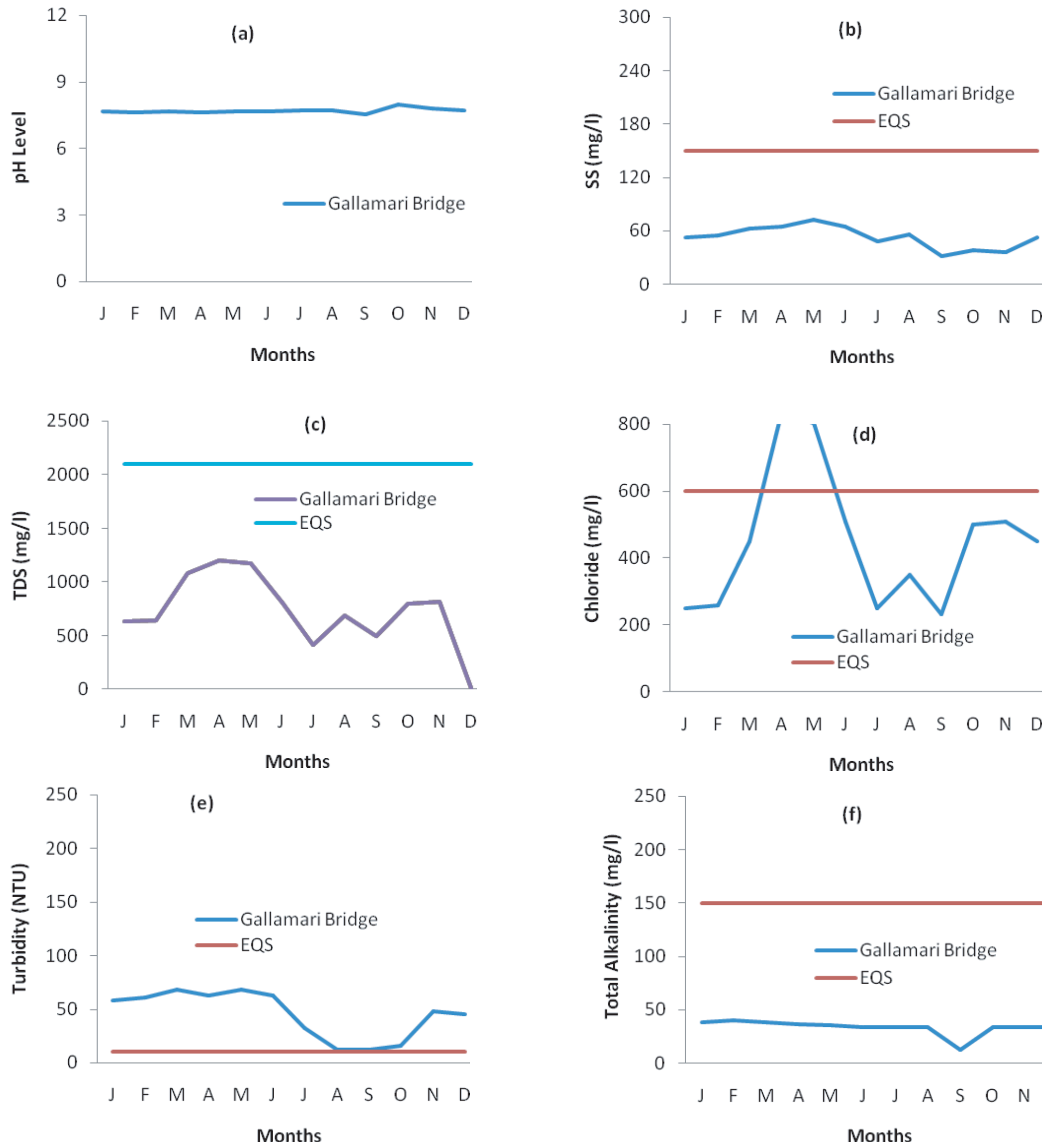


Fig.14. Graphical presentation of pH,DO,BOD,COD,TDS,Chloride and Turbidityof Bhairab river in 2014

Note: N G= Noapara Ghat, F G = Fultala Ghat, C G = harerhat Ghat

Table-21. Salinity of Bhairab river water in 2014

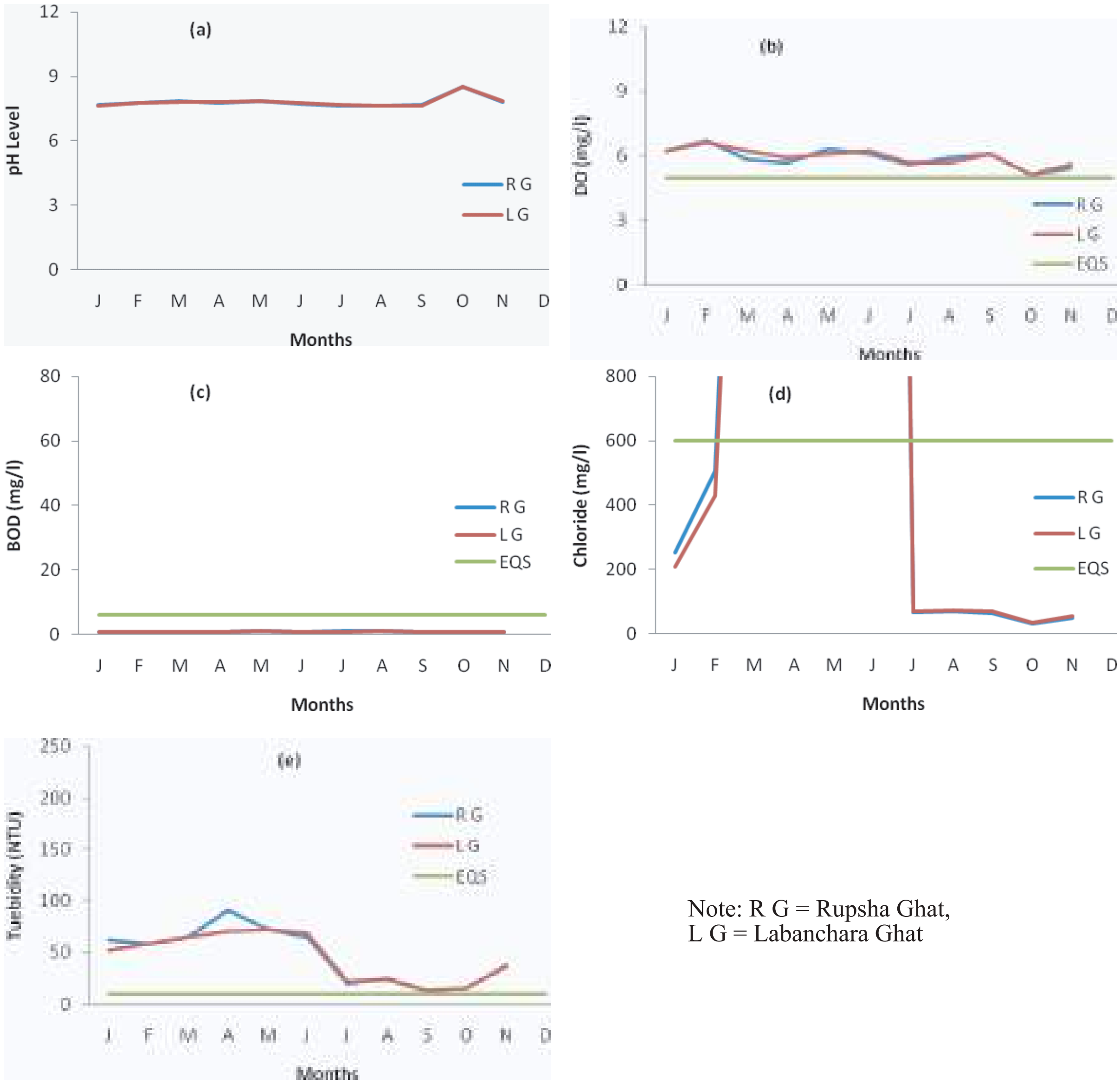
Sampling Locations	**Salinity (ppt)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Noapara Ghat	0.4	0.9	6	11.2	10.5	12.2	0.1		0.1	-	0.2	-
Fultala Ghat	0.4	0.8	5.8	9.4	13.6	13	0.1	0.1	0.1	-	0.2	-
Charerhat Ghat	0.4	0.9	4.9	11.9	**14.2**	**14.3**	**0.1**	0.1	0.1	0.1	0.1	-
EQS for wastewater after treatment from industrial units 400 ppt												

Salinity varied from 0.1 ppt to 14.3 ppt. The maximum and the minimum salinity was 14.3 ppt in June and 0.0 ppm in July respectively (Table-21). In 2013, salinity varied from 0.0 ppt to 3.9 ppt.

4.16 Rupsha River

Rupsha is an important river of Bangladesh that flows by the port city Khulna, and falls to the Bay of Bengal through Pashur River at Mongla channel. Water samples were collected from two different locations comprising six points (e.g. Rupsha Ghat Bank, Middle and Opposite bank and Labanchara Ghat Bank, Middle and Opposite bank) of Rupsha River for monitoring water quality in 2014. To ease analysis, only the middle point value of two locations were considered. Because, no significant variation was found among banks and middle points of both locations.

In 2014, pH varied from 7.62 to 7.84 (Fig.15a) while standard pH for inland surface water is 6.5 to 8.5. In 2013, pH level varied from 7.61 to 7.72.



Note: R G = Rupsha Ghat,
L G = Labanchara Ghat

Fig.15. Graphical presentation of pH, DO, BOD, Chloride and Turbidity of Rupsha River in 2014

In 2014, DO level was higher than EQS (≥5 mg/l) for fisheries. The maximum and the minimum DO content was 5.1 and 6.7 mg/l respectively (Fig.15b). In 2013, DO level varied from 3.8 and 8.0 mg/l. In 2014, the maximum and the minimum BOD was 1.0 and 0.7 mg/l respectively (Fig.15c). In 2013, BOD level was from 0.4 to 0.9 mg/l. Chloride level was much higher in March to June than the EQS (600 mg/l) for treated wastewater from industrial units. Chloride content varied from 32 to 10,159.70 mg/l (Fig.15d). In 2013, Chloride varied from 43.98 to 3598.57 mg/l. Turbidity level at both locations of Rupsha river was very high in 2014. Turbidity was highest in May and varied from 12.7 to 90.55 NTU (Fig.15e) while EQS for drinking water is 10 NTU. In 2013, Turbidity range was from 42.8 to 86.21 NTU.

Table-22. EC of Rupsha river water in 2014

Sampling Locations	**EC (µmhos/cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rupsha Ghat	947	2012	15230	17970	25400	24508	322	**212**	286	331	366	
Labanchara Ghat	1011	1758	13590	20090	**27600**	26200	345	220	292.6	342	440	
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

EC was high from February to June in 2014. EC level varied from 212 to 27600 mg/l (Table-22) while standard for treated wastewater from industrial units EC is 1200 µmhos/cm.

Table-23. Salinity of Rupsha river water in 2014

Sampling Locations	**Salinity (ppt)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rupsha Ghat	0.4	1.1	8.9	10.6	15.5	14.2	**0.1**	0.1	0.1	0.1	0.1	
Labanchara Ghat	0.5	1.1	7.8	12.4	**17**	16.1	0.1	0.1	0.1	0.1	0.2	
EQS for wastewater after treatment from industrial units 400 ppt												

Salinity level varied 0.1 ppt to 17 ppt. The maximum and the minimum salinity was 17 ppt in May and 0.1 ppt July to November (Table-23).

4.17 Mathavanga River

For monitoring water quality of Mathavanga river, water samples were collected from a single station comprising three diffeent points, Pipeghat, Pipeghat 200m upstream and Pipeghat 200m downstream of Darshana, Chuadanga.

In 2014, pH varied from 7.04 to 8.0 (Fig.16a) while standard pH for inland surface water is 6.61 to 7.68. In 2013, pH range was from 6.9 to 7.91. In 2014, DO level varied from 5.2 to 6.2 mg/l (Fig.16b) while standard DO for fisheries is ≥5 mg/l. In 2013, DO level varied from 5.2 to 8.5 mg/l. In 2014, BOD varied from 0.6 to 0.7 mg/l (Fig.16c). In 2013, BOD range was from 0.6 to 20 mg/l. Chloride of Mathavanga river water varied from 12 to 120.28 mg/l (Fig.16d) while EQS for Chloride is 600 mg/l. In 2013, Chloride content varied from 19.99 to 173 mg/l. Turbidity level was higher than EQS (10 NTU) for drinking water and varied from 10.3 to 20.4 NTU (Fig.16e). In 2013, Turbidity level varied from 14 to 27.1 NTU.

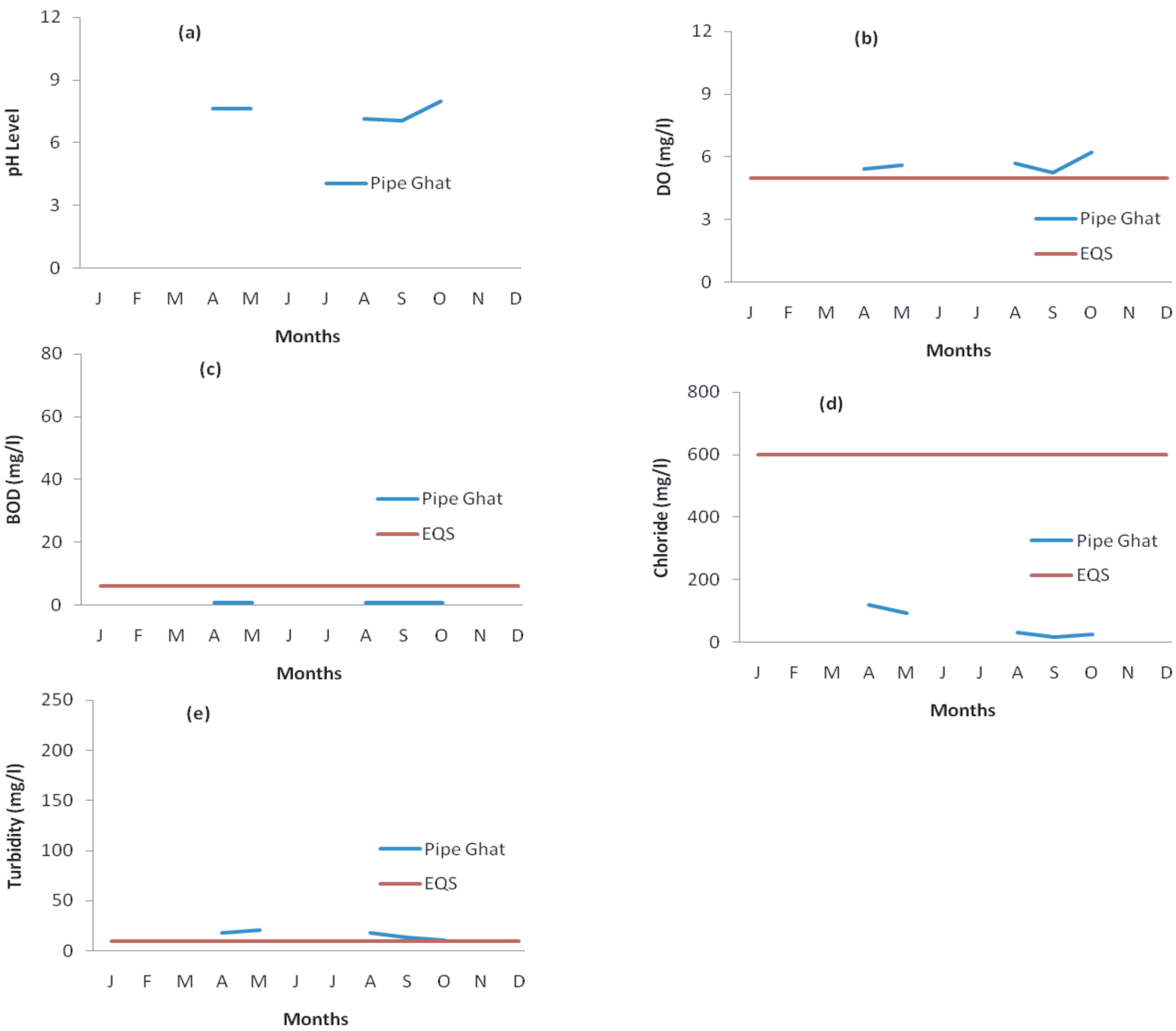


Fig.16.Graphical presentation of pH, DO, BOD, Chloride and Turbidity of Mathavanga river in 2014

4.18 Pashur River

For monitoring of water quality, water samples were collected from one location of Pashur river comprising three different points e.g. Monglaport Bank, Middle and Opposite bank. For analysis, only middle point was considered as there was no difference among banks and middlepoint.

In 2014, pH level varied from 7.62 to 8.2 (Fig.17a) and was within the EQS (6.5 to 8.5). In 2013, pH level varied from 7.65 to 7.78. DO level was above the EQS (≥5 mg/l) for fisheries all over the year. The maximum and the minimum concentration of DO was 6.7 and 5.2 mg/l respectively (Fig/17b). In 2013, DO varied from 8.1 and 5.5 mg/l. In 2014, BOD level was within the EQS (≤6 mg/l) for fisheries during the sampling period. The maximum and the minimum value of BOD was 1.1 and 0.8 mg/l respectively (Fig.17c). In 2013, BOD level varied from 0.4 and 0.8 mg/l. High level of TDS was found at Pipeghat compare to other points of the river. TDS varied from 256 to 15500 mg/l (Fig.17d). In 2013, TDS level varied from 149 to 13000 mg/l.

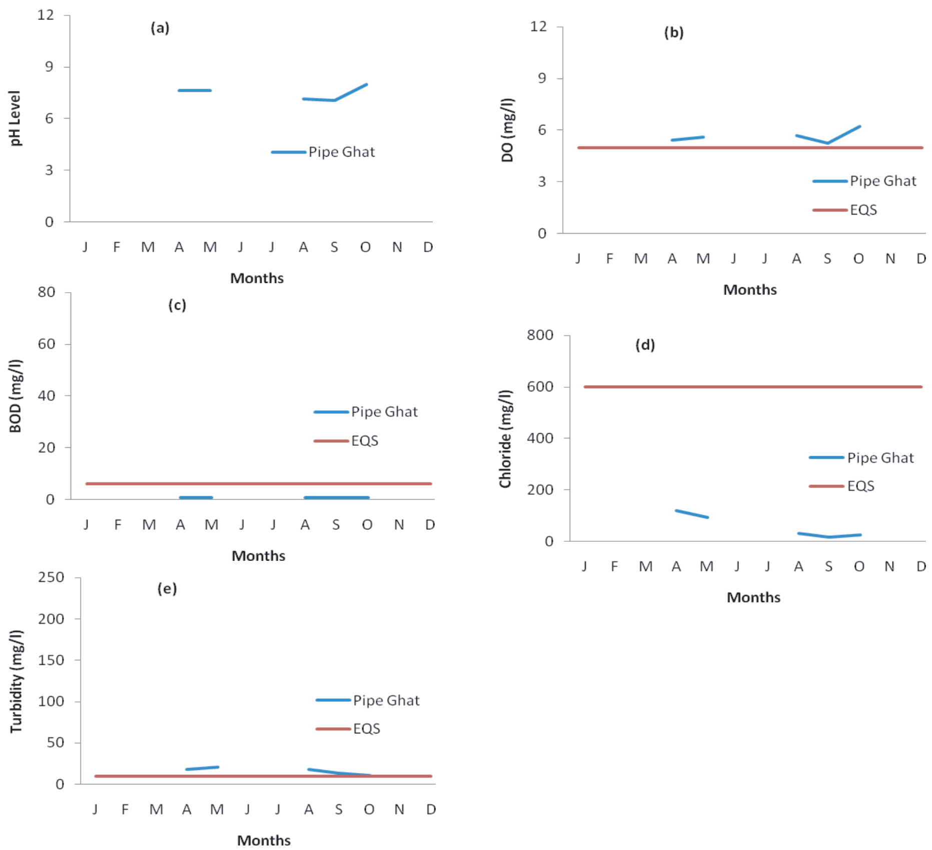


Fig.17. Graphical presentation of pH, DO, BOD, COD, TDS, Chloride, Turbidity of Pashur river in 2014

Chloride level of Pashur river water varied from 124 to 12646 mg/l. Chloride concentration was higher at all points during March to June compare to rest of the period (Fig.17e). In 2013, Chloride level varied from 72.28 to 8397.39 mg/l. Turbidity level varied from 28.3 to 128.3 NTU (Fig.17f) against the EQS(10 NTU) for drinking water. Turbidity concentration was very high all over the year. In 2013, Turbidity level varied from 66.6 to 136 NTU.

Table-24. Salinity of Pashur river water in 2014

Sampling Locations	**Salinity (ppt)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mongla Poart	2.7	6.2	12.6	16	**19.2**	16.7	1.1	0.5	0.8	**0.3**	0.3	
EQS for wastewater after treatment from industrial units 400 ppt												

Salinity varied from 0.3 ppt to 19.2 ppt. The maximum and the minimum salinity was 19.2 ppt in May and 0.3 ppt in October while EQS for Salinity is 400 ppt (Table-24).

4.19 Khakshiali River

To monitor water quality of Khakshiali river, water samples were collected from Kaliganj station comprising Kaliganj Bank, Middle and Opposite bank at Shatkhira in 2014. For analysis, only middle point was considered as there were insignificant differences among banks and the middle point.

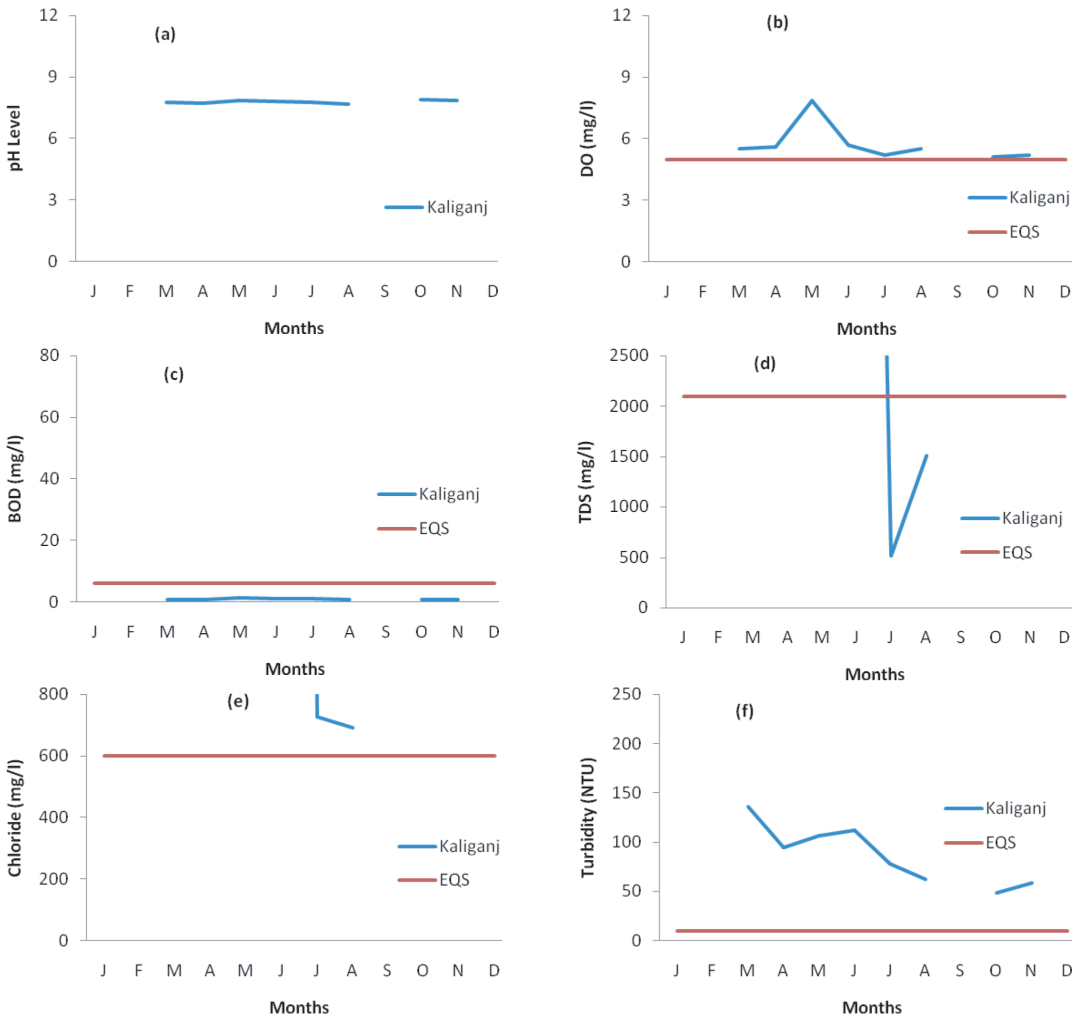


Fig.18. Graphical presentation of pH, DO, BOD, COD, TDS, Chloride, Turbidity of Khakshiali river in 2014

In 2014, pH level was within the EQS (6.5-8.5) for inland surface water and was varied from 7.65 to 7.9 (Fig.18a). In 2013, pH varied from 7.65 to 7.75. DO level varied from 5.1 to 7.85 mg/l (Fig.18b) throughout the year while EQS for fisheries is ≥5 mg/l. In 2013, DO level varied from 4.8 to 8.5 mg/l. BOD was far below the EQS (≤6 mg/l). It varied from 0.7 to 1.2 mg/l (Fig.18c). In 2013, BOD level varied from 0.6 to 0.8 mg/l. TDS level was very high all over the year of 2014. It varied from 514 to 16700 mg/l (Fig.18d). In 2013, TDS level varied from 2,200 to 14,000 mg/l.

In 2014, Chloride concentration was very high all over the year and varied from 692 to 13,045.95 mg/l (Fig.18e) while standard for treated wastewater from industrial units is 600 mg/l. The highest Chloride was found in May and the lowest value was in August. In 2013, Chloride level varied from 862.78 to 9,546.72 mg/l. Turbidity level was above the EQS (10 NTU) limit for drinking all over the year that varied from 48.2 to 136.3 NTU (Fig.18f). In 2013, Turbidity level varied from 76.2 to 129 NTU.

Table-25. Salinity of Khakshiali river water in 2014

Sampling Locations	**Salinity (ppt)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Kaliganj	-	-	8	16.1	**21.5**	18.3	1.5	**1.3**	-	2.8	3.6	-
EQS for wastewater after treatment from industrial units 400 ppt												

Salinity varied 1.3 ppt to 21.5 ppt. The maximum and the minimum salinity was 21.5 ppt in May and 1.3 ppt in August respectively. (Table-25)

4.20 Gorai River

Water samples were collected from two stations viz. Kamarkhali Ghat (KG), Magura and G K Ghat (GKG), Kustia comprising three points each. Only middle point of both station was considered for analyses because there was no significant difference between bank, middle and opposite bank of both stations.

In 2014, pH of Gorai river water varied from 7.41 to 8.4 (Fig.19a) and was within the EQS (6.5-8.5) for inland surface water. In 2013, pH level varied from 7.61 to 7.82. In 2014, DO was above the EQS (≥5 mg/l) limit for fisheries at both locations. Level of DO varied from 5.0 to 5.8 mg/l (Fig.19b). In 2013, DO level varied from 6.3 to 8.5 mg/l. In 2014, BOD level was far below the EQS (≤6 mg/l) and from 0.6 to 0.7 mg/l (Fig.19c). In 2013, BOD range was from 0.2 to 0.8 mg/l. TDS level of Gorai river water was very low throughout the year while comparing to the EQS (2100 mg/l) for treated wastewater from industrial units. It varied from 130 to 219 mg/l (Fig.19d). In 2013, TDS level varied from 115 to 226 mg/l. Chloride level was also within the EQS (600 mg/l) for treated wastewater from industrial units. The maximum and the minimum chloride values were 108.35 and 21 mg/l (Fig.19e). In 2013, Chloride level was from 10.8 to 125.58 mg/l. Turbidity level was relatively higher throughout the year than the EQS (10 NTU) for drinking water. It varied from 14.3 to 32.8 NTU (Fig.19f). In 2013, Turbidity level varied from 10.2 to 22.5 NTU.

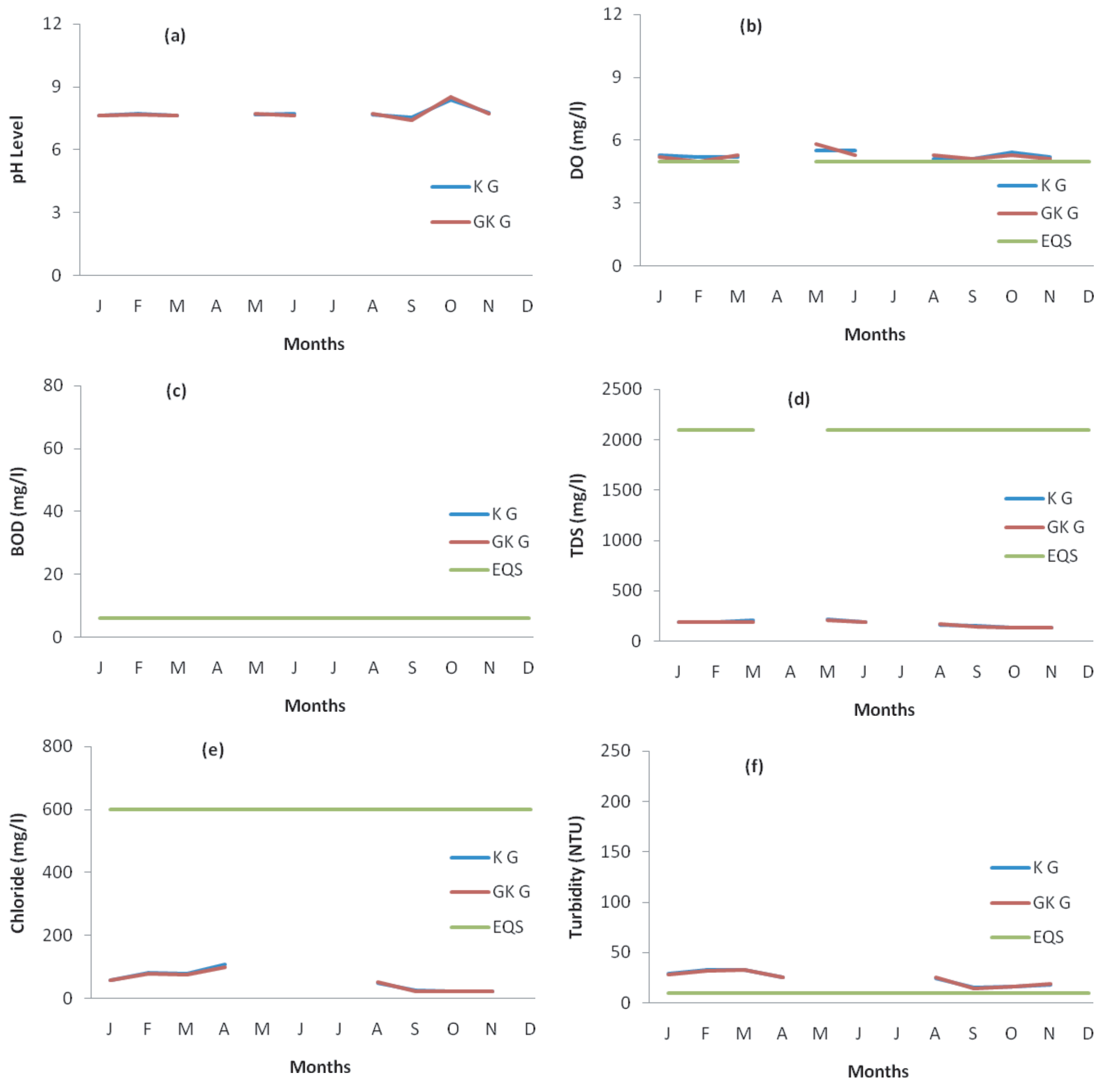


Fig.19. Graphical presentation of pH, DO BOD, COD, TDS, Chloride, Turbidity of Gorai river in 2014

Note: K G = Kamarkhali Ghat and GKG = G K Ghat

4. 21 Modhumoti River

To monitor water quality of Modhumoti river in 2014, samples were collected from one location comprising three different points (Mollarhat bank, middle and opposite bannk) of Bagerhat. For analysis, only middle point was considered.

In 2014, pH level of Modhumoti river was within the EQS and varied from 7.21 to 7.82 (Fig.20a). In 2013, pH level varied from 6.68 to 7.74. DO was varied from 4.5 to 5.6 mg/l while EQS is ≥5 mg/l for fisheries (Fig.20b). In 2013, DO level was varied from 5.2 to 7.3 mg/l. BOD of the river was below the EQS (≤6 mg/l) for fisheries. BOD varied from 0.8 mg/l all over the year (Fig.20c). In 2013, BOD varied from 0.4 to 1.0 mg/l. TDS of Modhumoti river water was within EQS (2100 mg/l). The maximum and the minimum value was 184 mg/l and 124 mg/l respectively (Fig.20d). In 2013, TDS level varied from 94 to 150 mg/l. In 2014, Chloride level varied from 58 to 102.25 mg/l while EQS for treated wastewater from industrial units is 600 mg/l (Fig.20e). In 2013, Chloride level varied from 22 to 99.96 mg/l. In 2014, EC varied from 248 to 367 µmohos/cm (Fig.20f). In 2013, EC varied from 188 to 347 µmohos/cm.

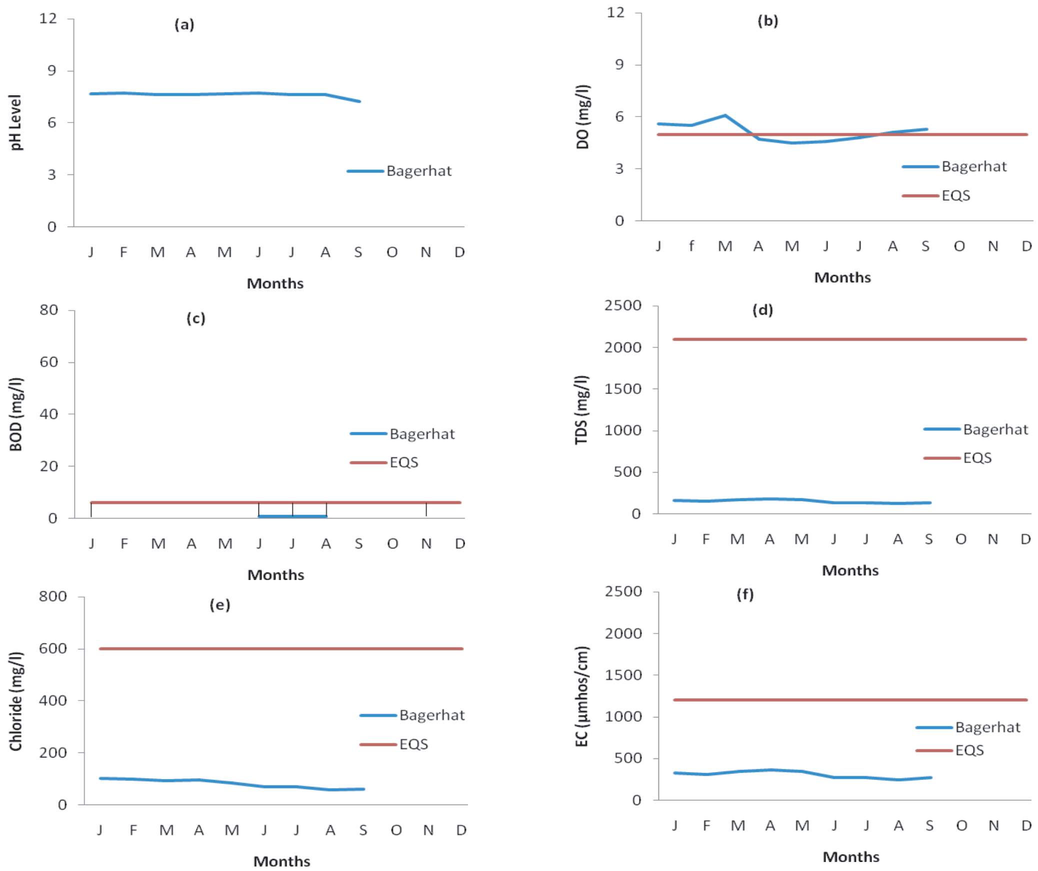


Fig.20. Graphical presentation of pH, DO, BOD COD, TDS, Chloride and EC of Modhumoti river in 2014

4.22 Beel Dakatia River

To monitor water quality of Beel Dakatia river in 2014, samples were collected from one station at Khulna comprising two points (bank and middle). For analysis, only the middle point was considered as there was no difference between river bank and middle point.

In 2014, pH level was within the EQS and varied from 7.48 to 7.75 (Fig.21a). In 2013, pH level varied from 7.61 to 7.72. DO varied from 3.4 to 5.6 mg/l (Fig.21b) and was closer to the EQS for fisheries (≥5 mg/l). In 2013, DO level varied from 2.1 to 6.3 mg/l. TDS was within the EQS (2100 mg/l) except the month of April to June. The maximum and the minimum TDS was 6155 and 115 mg/l respectively (Fig.21c). In 2013, TDS level varied from 323 to 1283 mg/l. In 2014, Chloride level varied from 52 mg/l to 3425 mg/l while EQS for treated wastewater from industrial units is 600 mg/l. The maximum value was found in May and the minimum was in July (Fig.21d). In 2013, Chloride level varied from 135.68 mg/l to 1258.82. Turbidity varied from 15.3 to 67.35 NTU (Fig.21e) and was higher than EQS (10 NTU) for dirking water. In 2013, Turbidity range was from 41.8 to 78.1 NTU. EC varied from 230 to 12310 µmohos/cm (Fig.21e) and was higher than EQS (1200 µmohos/cm) except the months of July, January and February. In 2013, EC range was from 7.71 to 3250 µmohos/cm.

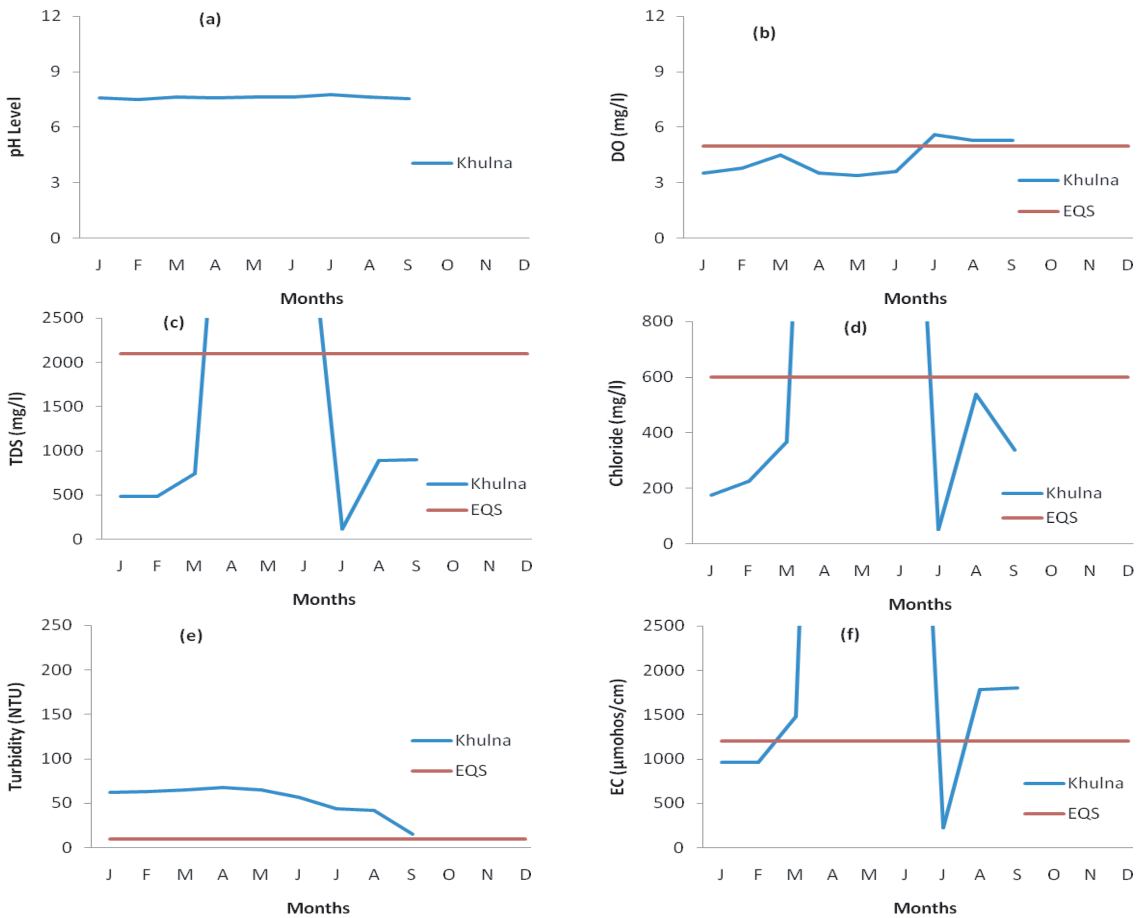


Fig.21.Graphical presentation of pH, DO, TDS, Chloride, Turbidity and EC of Beel Dakatia river in 2014

Table-26. Salinity of Beel Dakatia river water in 2014

Sampling Locations	Salinity (ppt)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Khulna	0.6	0.8	0.7	6.7	**6.8**	5.1	**0.1**	0.9	1.1	-	1	-
EQS for wastewater after treatment from industrial units 400 ppt												

Salinity varied 0.1 ppt to 6.8 ppt. The maximum and the minimum salinity was 6.8 ppt in May and 0.1 ppt in July (Table-26). In 2013, salinity varied from 0.3 ppt to 0.8 ppt.

4.23 Kirtankhola River

Kirtankhola river starts from Sayeshtabad in Barisal and ends at Gajalia near Gabkhan khal (Canal). This old river is now known as the Barisal river. The total length of the river is about 160 km (Murshed, 2006). For monitoring purpose water samples were collated from one location of the river at Launch ghat (at bank and in the middle). Samples were collected during low tide and high tide.

In 2014, pH level of Kirtankhola river water varied from 7.0 to 7.9 (Fig.22a) and was within the EQS. In 2013, pH range was from 6.0 to 8.2. DO level of Kirtankhola rive was above the EQS (≥5 mg/l) for fisheries. DO varied from 6.0 mg/l to 6.4 mg/l (Fig.22b). In 2013, DO level varied from 5.7 mg/l to 7.3 mg/l. In 2014, BOD was low round the year. The maximum and the minimum BOD was 2.4 mg/l and 1.8 mg/l respectively (Fig.22c). In 2013, BOD level varied from 1.1to 2.5 mg/l. In 2014, TDS of Kirtankhola rive water was also within the EQS (2100 mg/l) throughout the year and the range was from 34.5 to 72 mg/l (Fig.22d). In 2013, TDS level varied from 20 to 75.8 mg/l. Chloride content varied from 20 to 30 mg/l (Fig.22e). In 2013, Chloride level varied from 13 to 45 mg/l. SS of Kirtankhola river water was within EQS. The maximum and the minimum SS was 21.8 mg/l in June and 10.2 mg/l in May (Fig.22f). In 2013, the maximum and the minimum SS was 30.3 mg/l in March and 6.72 mg/l in July respectively.

Table-27. EC of Kirtankhola river water in 2014

Sampling Locations	EC (µmhos/cm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Barisal Launch Ghat	75.5	75.3	77.3	77.5	79.6	85.6	**321**	87.3	99.1	**51.55**	52.4	221
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

EC level of the Kirtankhola river varied from 51.55 to 321 µmhos/cm against the EQS for treated wastewater from industrial units is 1200 µmhos/cm (Table-27).

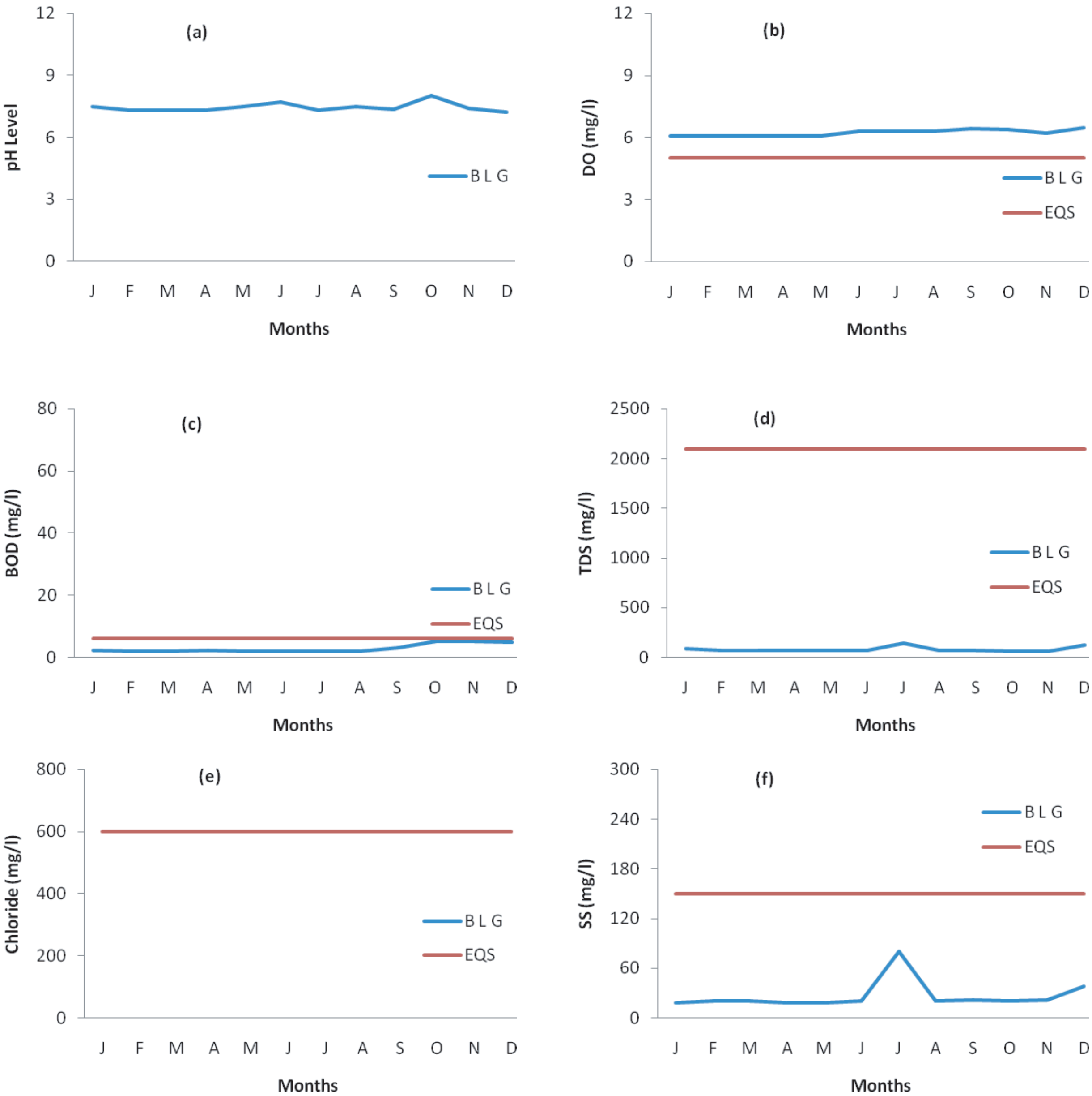


Fig.22.Graphical presentation of pH, DO, BOD, COD, TDS, Chloride and SS of Kirtankhola river in 2014

Note: B.L.G = Barisal Lanch Ghat.

4.24 Tetulia River

For monitoring of water quality of Tetulia river water samples was colleted from Vedhoria Feri Ghat (VFG) location (bank and middle point). Samples were collected in August during Low Tide (LT).

In 2014, pH level of the Tetulia river water ranged from 7.4 to 7.6 mg/l (Table-28) while in 2013, it varied from 6.5 to 7.7. DO varied from 7.0 to 7.2 mg/l (Table-28) while standard limit for fisheries is (≥5 mg/l). In 2013, DO level varied from 6.2 to 7.2 mg/l. BOD level of the Tetulia river was 2.0 mg/l (Table-28) against corresponding EQS (≤6 mg/l) for fisheries. In 2013, BOD level varied from 2.0 to 2.4 mg/l. TDS range was 90 mg/l (Table-28). In 2013, TDS level varied from 32.2 to 90 mg/l. Chloride level varied from 26 to 28 mg/l (Table-28) while EQS for treated wastewater from industrial units is 600 mg/l. In 2013, Chloride level varied from 30 to 132 mg/l. SS level varied from 22 to 24 mg/l (Table-28) and was below the EQS (150 mg/l). In 2013, SS level varied from 14.2 to 34 mg/l.

Table-28. Level of different parameters of Tetulia river water in 2014

Sampling Locations	Months	pH	DO	BOD	SS	TDS	Chloride	Total alkalinity
V. F. G (S), L.T	**August**	7.6	7.2	2	24	90	28	136
V. F. G (M), L.T		7.4	7	2	22	90	26	134
EQS		**6-9**	**5 mg/l**	**6 mg/l**	**150 mg/l**	**2100 mg/l**	**600 mg/l**	**150 mg/l**

4.25 Sughanda River

To monitor water quality of Sughanda River water samples were colleted for analysis from Launch Ghat, Jhalkathi (e.g. Side and middle point) of the river during high tide.

In 2014, pH level of the Sughanda river water varied from 7.4 to 7.8 mg/l (Table-29) while EQS for fisheries is 6.5 to 8.5. DO level varied from 6.0 to 7.2 mg/l (Table-29) and was above the EQS (≥5 mg/l) for fisheries. BOD range was from 2.0 to 2.2 mg/l (Table-29) while EQS for fisheries is ≤6 mg/l. Chloride was from 130 to 132 mg/l (Table-29) while corresponding EQS is 600 mg/l for treated wastewater from industrial units. SS level varied from 20 to 20.2 mg/l (Table-29) against EQS (150 mg/l) for treated wastewater from industrial units. Salinity level of the Sughanda river water varied from 11.0 ppt to 12.2 ppt (Table-29). EC varied from 136.4 to 164 µmhos/cm (Table-29) against EQS for waste water from industrial units is 1200 µmhos/cm. TDS level was from 66.4 to 94 mg/l (Table-29) while corresponding EQS is 2100 mg/l for treated wastewater from industrial units. Total alkalinity was from 130.4 to 136 mg/l (Table-29) while corresponding EQS is 150 mg/l for treated wastewater from industrial units.

Table-29. Level of different parameters of Sughanda river water in 2014

Sampling Locations	Months	pH	DO	BOD	T.Alka alinity	SS	TDS	Chloride	Salinity	EC
Jhalkathi LG (S)	**Jan**	**7.8**	7	2.2	**130.4**	**20**	92	132	11	164
Jhalkathi LG (M)		7.6	**7.2**	**2.2**	132.2	**20.2**	90	**130**	12.2	162
Jhalkathi LG (S)	**Apl**	7.4	7	2	132	20	**94**	132	11	162
Jhalkathi LG (M)		7.6	7.2	2.2	134	20	92	**134**	**12.2**	**164**
Jhalkathi LG (S)	**May**	7.6	6.2	2	**136**	20	68.6	134	0	138.2
Jhalkathi LG (M)		**7.4**	6	**2**	134	20	**66.4**	132	0	**136.4**
EQS		**6-9**	**5 mg/l**	**6 mg/l**	**150 mg/l**	**150 l mg/l**	**2100 mg/l**	**600 mg/l**	**400 ppt**	**1200 µmhos**

4.26 Surma River

The Surma river is a part of the Surma-Meghna river System. The average depth of this river is 86m and maximum depth is 170m. For monitoring purpose water samples were collected from five different a station of the river namely Shajalal Bridge, Knee Bridge, Shak Ghat, Chattak and Kazi Bazaar.

In 2014, pH level of the Surma river varied from 6.5 to 7.1 (Fig. 23a). In 2013, pH was from 6.2 to 7.8. In 2014, DO content was mostly above the EQS (≥5 mg/l). It varied from 4.4 to 7.0 mg/l (Fig. 23b). In 2013, DO level varied from 4.2 to 10.4 mg/l.

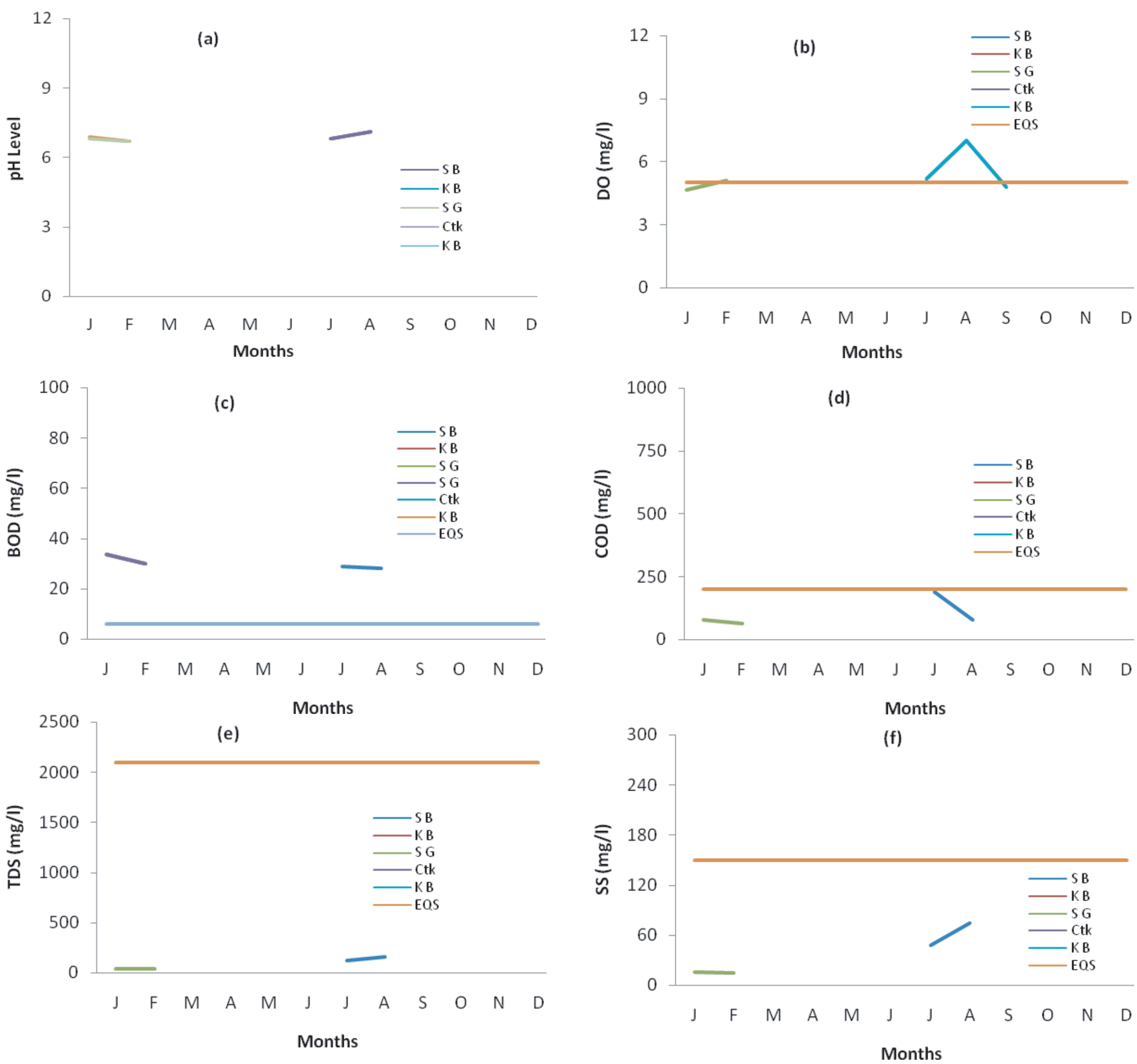


Fig.23. Graphical presentation of pH, DO, BOD, TDS, COD and SS of Surma river in 2014

Note: S B= Shajalal Bridge, K B = Knee Bridge, S G = Shak Ghat, Ctk = Chattak and K B = Kazi Bazaar

BOD value was also within the EQS at all stations. The maximum and the minimum BOD was 48 mg/l at Chattak in September and 26 mg/l at Shajalal Bridge in May (Fig. 23c). In 2013, BOD level varied from 0.3 to 3.9 mg/l. In 2014, COD content was within the EQS (200 mg/l) and varied from 58 to 188.5 mg/l (Fig. 23d). TDS range was from 37.22 to 160 mg/l (Fig. 23e) where EQS for TDS is 2100 mg/l for treated wastewater from industrial units. In 2013, TDS level was varied from 32 to 558 mg/l. SS level of Surma river was within the EQS limit for treated wastewater from industrial unit. It varied from 15.04 to 50.2 mg/l (Fig. 23f). In 2013, SS level varied from 13.2 to 102 mg/l.

Table-30. EC of Surma river water in 2014

Sampling stations	**E.C (µmhos/cm /cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Shajalal Bridge	-	-	-	-	232	-	268	171.7	-	-	-	172
Keen Bridge	-	-	-	-	-	-	-	-		-	-	-
Shak Ghat	-	-	-	-	-	-	-	-	-	-	-	-
Chattak	74.45	75.2	186	-	-	-	-	257	-	-	-	190
Kazir Bazar	-	-	-	-	-	-	268	-	290	-	-	-
EQS for wastewater after treatment from industrial units 1200 µmohos/cm												

EC level of Surma river was within the EQS limit. It varied from 69.9 to 327 µmhos/cm (Table-30).

4.27 Kushiara River

Kushiara river is one of the Trans-boundary rivers of Bangladesh. The total length of the Kushiara is about 161 km. The average width of the river is 250 m and in the rainy season the mean depth of the Kushiyara reaches upto 10m (Ahmed, 2006). Water samples were collected from two station (e.g. Jokigonj and near Fenchugonj Fertilizer Industry) of the river in 2014 for analysis of water quality. Sample was collected only in the month of November.

In 2014, pH level of Kushiara river was within EQS (6.5-8.5) for inland surface water. It varied from 6.5 to 7.4 (Fig. 24a). In 2013, pH level varied from 7.2 to 7.3. DO was above the EQS (≥ 5 mg/l) for fisheries and varied from 4.9 to 5.7 mg/l (Fig. 24b). In 2013, DO level varied from 5.8 to 5.9 mg/l. BOD level was from 28 to 36 mg/l while EQS for fisheries is ≤6 mg/l (Fig. 24c). In 2013, BOD level varied from 1.0 to 1.2 mg/l. In 2014, COD content was within the EQS (200 mg/l) and varied from 58 to 90 mg/l (Fig. 23d). In 2014, TDS level of Kushiara river water was below the EQS for treated wastewater from industrial unit and varied from 80.1 to 110 mg/l (Fig. 24e). In 2013, TDS level varied from 450 to 560 mg/l. SS was within the EQS limit and it varied from 10 to 37.4 mg/l (Fig. 24f). In 2013, SS level varied from 130 to 150 mg/l.

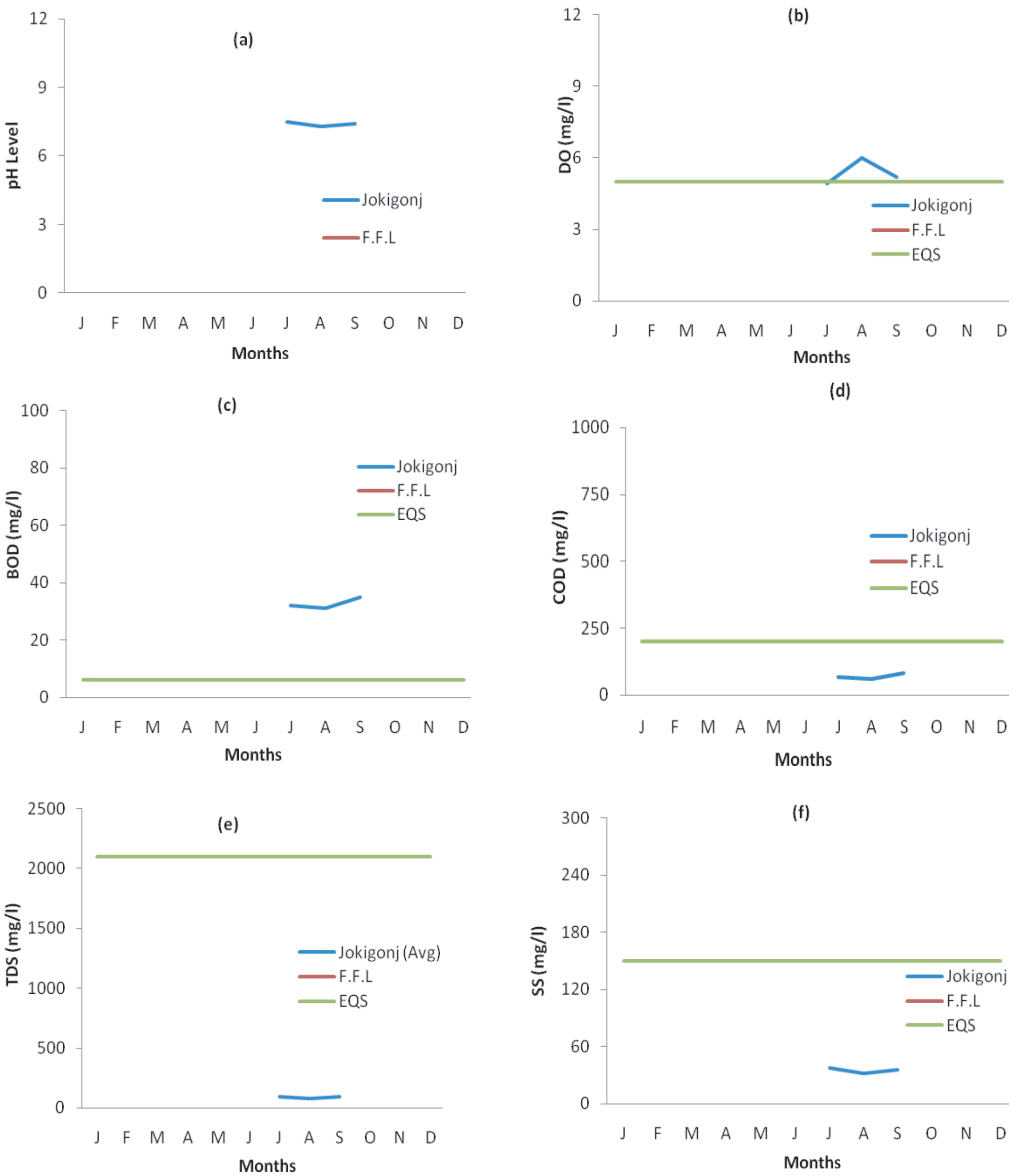


Fig 24. Graphical presentation of pH, DO, BOD, COD, TDS and SS of Kushiara River in 2014

Note : F.FI = Fenchugonj Fertilizer Industry.

Table-31. EC of Kushiara river water in 2014

Sampling locations	**EC (µmhos/cm)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Jokigong B.S.F Ghat	174	-	-	186	-	-	181.2	**160.2**	180	-	185	-
Fenchugonj Fertilizer Inds.	-	-	-	-	-	-	-	-	-	**220**	-	-
EQS for wastewater after treatment from industrial units 1200 µmhos/cm												

EC level of Kushiara river was within the EQS for treated wastewater from industrial units. It varied from 160.2 to 220 µmhos/cm (Table-31).

CHAPTER 5: RECOMMENDATIONS

5.1 Recommendations

To provide with concrete useful information for policy feedback, a continuous monitoring of a comprehensive set of parameters is essential. The following actions are recommended to get comprehensive data set and to get water quality improves as well

- Judicious selection of sampling stations.
- Collection of water samples and analyses must be in a consistent way and on regular basis for assessment of water quality.
- Increase skilled manpower at all level of water quality analysis including sample collection.
- A comprehensive set of parameters including microbial test (Fecal Coliform, E-Coli etc) of river water is essential to evaluate water quality of rivers.
- Use Global Positioning System (GPS) to represent monitoring results in global context.
- Establish Water Quality Index (WQI) to assess water quality analysis.
- Review and update surface water monitoring network.
- Need to collect supporting weather information while sampling.
- Need to collect data on river flow.
- Strengthening regional cooperation for the sustainable management of trans-boundary rivers, Integrated Watershed Management (IWM) approach can be implemented in this regard.
- For each river, sampling must be done from more than one sampling station.
- Intensify monitoring of ETP outlet water of Jamuna Fertilizer Factory at Bahadurpur and KAFCO at Chittagong to improve treatment efficiency.
- Ensure installation of ETP/CETP and their continuous operation to stop disposal of untreated wastewater into the rivers.
- Stop discharging untreated sewage into river water and improve sanitation system in the city areas.
- Stop dumping municipal waste and medical wastes in to rivers.
- Increase river flow epically during dry season.
- Water is the most important component of environment. To reduce ground water, environmental tax on ground water (industrial use only) use can be imposed.
- Need to identify pollution source of korotoa river around dutta bari bridge.
- Chloride conc ta downstream of karnaphuli Urea Fertilizer Ltd. was very high, pollution source should be identified

CHAPTER 6: COMPARATIVE ANALYSES OF RIVER WATER QUALITY BETWEEN THE PERIODS OF 1975 - 1979 AND 2010 - 2014

6.1 Buriganga River:

The Buriganga River (*Buṛigônga* "Old Ganges") flows pass the southwest outskirts of Dhaka city. In the distant past, a course of the Padma river used to reach the Bay of Bengal through the Dhaleshwari river. This course gradually shifted and ultimately lost its link with the main channel of the Ganges and it was renamed as Buriganga.

More than 60,000 cubic metres of toxic waste, including textile dying, printing, washing and pharmaceuticals are released into the main water bodies of Dhaka every day .(Ref. Majumdar, Dr. R.C., History of Ancient Bengal, First published 1971, Reprint 2005, pp. 3-4, Tulshi Prakashani, Kolkata, ISBN 81-89118-01-3). Currently Textile industries annually discharge nearly 56 million tonnes of waste and 0.5 million tonnes of sludge. Sewage is also released into the Buriganga. The Buriganga receives high amount of food waste including rotten fruits, vegetables, and fish. Different parameters of Buriganga River water are given in the following table.

Table-32. Level of different parameter of Buriganga river during 1975,1978,1979 and 2010 - 2014.

Name of River	Year	Season	pH	DO	BOD
Buriganga River	1975	Dry	7.8	6.55	3.1
		Wet	-	-	-
	1978	Dry	7.15	2.25	1.175
		Wet	-	-	-
	1979	Dry	6.87	6.43	3.42
		Wet	6.7	5.2	3.03
	2010	Dry	7.25	0.47	26.44
		Wet	7.31	3.83	8.23
	2011	Dry	7.27	1.35	26.06
		Wet	7.03	2.24	22.48
	2012	Dry	7.42	0.54	18.748
		Wet	7.19	2.55	15.90
	2013	Dry	7.38	2.3	21.18
		Wet	6.84	2.56	9.17
	2014	Dry	7.24	0.61	24.97
		Wet	7.27	2.58	10.29
EQS for fisgeries			**6.5-8.5**	**≥5 mg/l**	**≤6 mg/l**

Note: Value in each cell is seasonal (Dry: November – April, Wet: May-October) as well as average of sampling locations. EQS of pH, DO, BOD are for fisheries, as per ECR, 1997. Data for 1976, 1977 were unavailable.

During 1975, 1978, 1979 and 2010 - 2014, pH of Buriganga river water was within the EQS (6.5-8.5) for inland surface water for fisheries. DO of Buriganga river was more or less up to the EQS during 1975,1978and 1979. Direct discharge of untreated effluent from industries, domestic wastes, tannery wastes into the river and reduced flow of water are the proximate causes for depletion of DO in dry season of recent years. BOD content in dry season was higher than wet season. BOD of Buriganga river was lower than EQS (≤6 mg/l) and then increased towards 2010-2014.

With the passage of time tremendous human pressure on Buriganga river (in terms of plying motorized vessels, infrastructural development, encroachment, industrial and sewage waste dumping etc.) and dumping of ever increasing all sorts of wastes turned Buriganga a worst polluted and ecologically dysfunctional river.

6.2 Shitalakshya River:

The Shitalakhya is a branch of the Brahmaputra which has changed its course at least twice in the Bangladesh part in the fairly recent past. A portion of its upper course is known as Banar River. The Shitalakhya ran almost parallel to the Brahmaputra and joined with the Dhaleswari after passing by Narayanganj. There is a river port at Narayanganj. Numerous launches and mechanized vessels ply on this river. A lot of large, medium and small sized industries located on both banks of the river. Different parameters of Shitalakhya River water are given in the following table.

Table-33. Level of different parameter of Shitalakhya river during 1975 - 1979 and 2010 - 2014.

Name of river	Year	Season	pH	DO	BOD
Sitalakhya River	1975	Dry	6.9	7.1	1.85
		Wet	7.35	6	1.72
	1976	Dry	7.36	5.5	2.23
		Wet	7.2	6.5	2.2
	1977	Dry	7.1	3.8	2.3
		Wet	-	-	-
	1978	Dry	7.36	5.16	2.8
		Wet	7.05	3.8	1.35
	1079	Dry	7.02	6.1	3.8
		Wet	6.83	3.5	2.6
	2010	Dry	7.22	3.77	9.58
		Wet	7.05	5.53	4.67
	2011	Dry	7.14	3.80	10.62
		Wet	7.22	5.63	3.983
	2012	Dry	7.22	2.18	11.17
		Wet	7.37	3.56	5.21
	2013	Dry	7.7	2.69	22.83
		Wet	7.11	4.10	5.75
	2014	Dry	7.19	0.66	16.8
		Wet	7.43	3.86	6.64
EQS for fisheries			**6.5-8.5**	**≥5 mg/l**	**≤6 mg/l**

Note: Value in each cell is seasonal (Dry: November – April, Wet: May-October) as well as average of sampling locations.

During 1975-1979 and 2010 - 2014, pH of Shitalakhya river water was within the EQS (6.5-8.5) for inland surface water for fisheries. DO content was below the EQS (≤5 mg/l) and did not vary between 1975-79 and 2010-2014 period. BOD was lower than EQS during 1975-1975 but BOD was exceeded EQS during 2010-2014 though water quality slightly improved during wet season.

This may be due to increase of flow in the river. Direct discharge of untreated effluent from industries, loading/unloading construction materials, municipal and human wastes pollute river water. Some textile dyeing industries, consumer item producing industries and jute mills are located around the sampling location and all of those industries discharge wastes into river water.

6.3 Turag River:

The Turag River is the upper tributary of the Buriganga. The Turag originates from the Bangshi River, which is an important tributary of the Dhaleshwari River. Turag river flows through Gazipur and meet the Buriganga river at Mirpur in Dhaka District. Earlier this river was called as (Bengali: "Kohor Doriya"), "Kohor river". Different parameters of Turag River water are shown in the table below.

Table-34. Level of different parameter of Turag River during 1975 - 1979 and 2010 - 2014.

Sampling Location	Year	Season	pH	DO	BOD
Turag River	1975	Dry	6.9	5.1	2.15
		Wet	7.2	5.4	1.25
	1976	Dry	7.46	5.3	3.63
		Wet	6.75	4.8	2.35
	1977	Dry	7.3	2.7	1.7
		Wet	6.73	4.2	1.56
	1978	Dry	7.1	4.6	1.8
		Wet	6.87	3.75	1.6
	1979	Dry	6.77	6.4	2.97
		Wet	6.33	6.16	1.33
	2010	Dry	7.49	0	30.91
		Wet	6.39	3.73	9.5
	2011	Dry	7.74	0.47	22.33
		Wet	7.52	3.94	9.12
	2012	Dry	7.6	0.65	24.87
		Wet	7.48	2.67	12.95
	2013	Dry	7.46	0.742	31.96
		Wet	7.31	2.93	4.58
	2014	Dry	7.67	0.69	35.44
		Wet	7.36	2.75	7.21
EQS for fisheries			**6.5-8.5**	**≥5 mg/l**	**≤6 mg/l**

Note: Value in each cell is seasonal (Dry: November – April, Wet: May-October) as well as average of sampling locations. EQS of pH, DO, BOD is considered for fisheries.

During 1975-1979 and 2010 - 2014, pH of Turag river water was within the EQS (6.5-8.5) for inland surface water for fisheries. During 1975-1979 period, DO content in wet season met the EQS but in dry season DO content declined. During 2010-2014 period DO content was below the EQS irrespective of seasons. Sometimes, DO reached to zero especially in dry season. BOD load was low

Many industries and markets discharge their treated/untreated wastes (solid and liquid) into the Turag river. There are many industries dotting the banks of this river those dispose their wastes into the river. During the Bishwa Ijtema, Muslims pilgrims coming from all over the world stay at the riverside for several days. Unfortunately the site is lacking of proper accommodation and an adequate sanitation system. As a result, human waste and garbage generated are disposed into the river. This also pollutes the river heavily. Encroachment, sand/earth filling, dumping of industrial, municipal and medical waste, etc. turned its water pitch black and unfit for any use.

CHAPTER 7: GLOSSARY

pH :

Power of Hydrogen - or more completely, power of the concentration of the Hydrogen ion .The is abbreviated as pH. The mathematical definition of pH is a bit less intuitive but in general more useful. It says that the pH is equal to the negative logarithmic value of the Hydrogen ion (H^+) concentration. In chemistry, pH is the negative log of the activity of the hydrogen ion in an aqueous solution. Solution with a pH less than seven is said to be acidic and solution with a pH greater than seven is basic or alkaline. pH of Pure water is seven. Contrary to popular belief, this value can be extended from 0 to 14 for sufficiently concentrated acids and bases.

Dissolved Oxygen (DO):

Amount of oxygen dissolved (and hence available to sustain marine life) in a body of water such as a lake, river, or stream. DO is the most important indicator of the health of a water body and its capacity to support a balanced aquatic ecosystem of plants and animals. Wastewater containing organic (oxygen consuming) pollutants depletes the dissolved oxygen and may lead to the death of marine organisms. The DO is usually express as mg/l (or ppm)

Precaution: Using a dissolved oxygen meter, need to be calibrated immediately prior to use. Check the cable connection between the probe and the meter. Make sure that the probe is filled with electrolyte solution, that the membrane has no wrinkles, and that there are no bubbles trapped on the face of the membrane. You can do a field check of the meter's accuracy by calibrating it in saturated air according to the manufacturer's instructions. Or, you can measure a water sample that is saturated with oxygen, as follows. (NOTE: Use this procedure for testing the accuracy of the Winkler method.) Fill a l-liter beaker or bucket of tap water. (May want to bring a gallon jug with water in it for this purpose.) Mark the bottle number as "tap" on the lab sheet. Pour this water back and forth into another beaker 10 times to saturate the water with oxygen. Use the meter to measure the water temperature and record it in the water temperature column on the field data sheet. Use the meter to compare the dissolved oxygen concentration of your sample with the maximum concentration at that temperature in the table. Sample should be within 0.5 mg/L. If it is not, repeat the check and if there is still an error, check the meter's batteries and follow the troubleshooting procedures in the manufacturer's manual.

Interference due to nitrite can be eliminated by adding sodium azide to the alkaline potassium iodide solution.

$MnSO_4 + 2\ KOH \rightarrow Mn(OH)_2 + K2SO4$

$2\ Mn(OH)_2 + O_2$ (from DO) $\rightarrow 2MnO(OH)_2$
Basic manganic oxide

$MnO(OH)_2 + 2\ H_2SO_4 \rightarrow Mn(SO_4)_2 + 3H_2O$
Manganic sulphate

$Mn(SO4)2 + 2\ Kl \rightarrow MnSO_4 + K_2SO_4 + I_2$

$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$
Sodium thiosulpate → Sodium tetrathionate

Biochemical Oxygen Demand (BOD):

Biochemical oxygen demand is the amount of dissolved oxygen needed by aerobic biological organisms in a water body to break down organic material present in a given water body at certain temperature over a specific time period. This is not a precise quantitative test, although it is widely used as an indication of the organic quality of water. The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water.

BOD_5 is calculated by: $\text{Seeded}: BOD_5 = \frac{(D_0 - D_5) - (B_0 - B_5)f}{P}$ $\quad \text{Unseeded}: BOD_5 = \frac{(D_0 - D_5)}{P}$
where:
D_0 is the dissolved oxygen (DO) of the diluted solution after preparation (mg/l)
D_5 is the DO of the diluted solution after 5 day incubation (mg/l)
P is the decimal dilution factor
B_0 is the DO of diluted seed sample after preparation (mg/l)
B_0 is the DO of diluted seed sample after 5 day incubation (mg/l)
$f_0$is the ratio of seed volume in dilution solution to seed volume in BOD test on seed

Chemical Oxygen Demand (COD):

In environmental chemistry, the chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of is to COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution.

Using potassium dichromate: Potassium dichromate is a strong oxidizing agent under acidic conditions. (Acidity is usually achieved by the addition of sulfuric acid.) Most commonly, a 0.25 N solution of potassium dichromate is used for

$$C_nH_aO_bN_c + dCr_2O_7^{2-} + (8d + c)H^+ \rightarrow nCO_2 + \frac{a + 8d - 3c}{2}H_2O + cNH_4^+ + 2dCr^{3+}$$

COD determination, although for samples with COD below 50 mg/L, a lower concentration of potassium dichromate is preferred. In the process of oxidizing the organic substances found in the water sample, potassium dichromate is reduced (since in all redox reactions, one reagent is oxidized and the other is reduced), forming Cr^{3+}. The amount of Cr^{3+} is determined after oxidization is complete, and is used as an indirect measure of the organic contents of the water sample.

Total Dissolved Solid (TDS):

Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometer (nominal size, or smaller) pores. Total dissolved solids are normally discussed only for freshwater systems, as salinity includes some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. TDS is measured in ppm (parts per million) or in mg/l.

Measurement

The two principal methods of measuring total dissolved solids are gravimetry and conductivity. Gravimetric methods are the most accurate and involve evaporating the liquid solvent and measuring the mass of residues left. This method is generally the best, although it is time-consuming. If inorganic salts comprise the great majority of TDS, gravimetric methods are appropriate. Electrical conductivity of water is directly related to the concentration of dissolved ionized solids in the water. Ions from the dissolved solids in water create the ability for that water to conduct an electrical current, which can be measured using a conventional conductivity meter or TDS meter. When correlated with laboratory TDS measurements, conductivity provides an approximate value for the TDS concentration, usually to within ten-percent accuracy. The relationship of TDS and specific conductance of groundwater can be approximated by the following equation:

$TDS = k_e EC$, where TDS is expressed in mg/L and EC is the electrical conductivity in microsiemens per centimeter at 25 °C. The correlation factor k_e varies between 0.55 and 0.8.

Electrical Conductivity (EC):

The electrical conductivity of water estimates the total amount of solids dissolved in water -TDS, which stands for Total Dissolved Solids.

The electrical conductivity of the water depends on the water temperature: the higher the temperature, the higher the electrical conductivity would be. The electrical conductivity of water increases by 2-3% for an increase of 1 degree Celsius of water temperature. Many EC meters nowadays automatically standardize the readings to 25°C. While the electrical conductivity is a good indicator of the total salinity, it still does not provide any information about the ion composition in the water. The same electrical conductivity values can be measured in low quality water (e.g. water rich with Sodium, Boron and Fluorides) as well as in high quality irrigation water (e.g. adequately fertilized water with appropriate nutrient concentrations and ratios).

The commonly used units for measuring EC of water are: µS/cm (microSiemens/cm) or dS/m (deciSiemens/m), Where: 1000 µs/cm = 1 dS/m

Relationship between TDS and EC:

Since the electrical conductivity is a measure to the capacity of water to conduct electrical current, it is directly related to the concentration of salts dissolved in water, and therefore to the Total Dissolved Solids (TDS). Salts dissolve into positively charged ions and negatively charged ions, which conduct electricity.

Since it is difficult to measure TDS in the field, the electrical conductivity of the water is used as a measure. The electrical conductivity of the water can be determined in a quick and inexpensive way, using portable meters. Distilled water does not contain dissolved salts and, as a result, it does not conduct electricity and has an electrical conductivity of zero.
Nevertheless, when the salt concentration reaches a certain level, electrical conductivity is no longer directly related to salts concentration. This is because ion pairs are formed. Ion pairs weaken each other's charge, so that above this level, higher TDS will not result in equally higher electrical conductivity.

EC can be converted to TDS using the following calculation:
TDS (ppm) = 0.64 X EC (µS/cm) = 640 X EC (dS/m)
This relation provides an estimate only.

Suspended Solids (SS):

Suspended solids is the amount of tiny solid particles that remain suspended in water and act as a colloid. The measurement of suspended solids is one way of gauging water quality. Suspended solids are common in wastewater applications and should not be mistaken for settleable solids, which are also abbreviated as SS. When suspended solids are left untreated, these can contribute to sewer pipe blockage and cause damage to other systems.
Suspended solids are important as pollutants and pathogens are carried on the surface of particles. The smaller the particle size, the greater the total surface area per unit mass of particle, and so the higher the pollutant load that is likely to be carried.

The use of a very simple cloth filter, consisting of a folded cotton sari, drastically reduces the load of cholera carried in the water, and is suitable for use by the very poor; in this case, an appropriate technology method of disinfection might be added, such as solar water disinfection.
A major exception to this generalization is arsenic contamination of groundwater, as arsenic is a very serious pollutant which is soluble, and thus not removed when suspended solids are removed. This makes it very difficult to remove, and finding an alternative water source is often the most realistic option.
Removal of suspended solids is generally achieved through the use of sedimentation and/or water filters (usually at a municipal level). By eliminating most of the suspended solids in a water supply, the significant water is usually rendered close to drinking quality. This is followed by disinfection to ensure that any free floating pathogens, or pathogens associated with the small remaining amount of suspended solids, are rendered ineffective.

Total Suspended Solids (TSS) is a water quality parameter used for example to assess the quality of wastewater after treatment in a wastewater treatment plant. It is listed as a conventional pollutant in the U.S. Clean Water Act.[1] This parameter was at one time called non-filterable residue (NFR), a term that refers to the identical measurement: the dry-weight of particles trapped by a filter, typically of a specified pore size. However, the term "non-filterable" suffered from an odd (for science) condition of usage: in some circles (Oceanography, for example) "filterable" meant the material retained on a filter, so non-filterable would be the water and particulates that passed through the filter. In other disciplines (Chemistry and Microbiology for examples) and dictionary definitions, "filterable" means just the opposite: the material passed by a filter, usually called "Total dissolved solids" or TDS. Thus in chemistry the non-filterable solids are the retained material called the residue.

TSS in mg/L can be calculated as:

(dry weight of residue and filter - dry weight of filter alone, in grams)/ mL of sample * 1,000,000

TSS of a water or wastewater sample is determined by pouring a carefully measured volume of water (typically one litre; but less if the particulate density is high, or as much as two or three litres for very clean water) through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. Filters for TSS measurements are typically composed of glass fibres.[2] The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered (typically milligrams per litre or mg/L).

If the water contains an appreciable amount of dissolved substances (as certainly would be the case when measuring TSS in seawater), these will add to the weight of the filter as it is dried. Therefore it is necessary to "wash" the filter and sample with deionized water after filtering the sample and before drying the filter. Failure to add this step is a fairly common mistake made by inexperienced laboratory technicians working with sea water samples, and will completely invalidate the results as the weight of salts left on the filter during drying can easily exceed that

Although turbidity purports to measure approximately the same water quality property as TSS, the latter is more useful because it provides an actual weight of the particulate material present in the sample. In water quality monitoring situations, a series of more labor-intensive TSS measurements will be paired with relatively quick and easy turbidity measurements to develop a site-specific correlation. Once satisfactorily established, the correlation can be used to estimate TSS from more frequently made turbidity measurements, saving time and effort. Because turbidity readings are somewhat dependent on particle size, shape, and color, this approach requires calculating a correlation equation for each location. Further, situations or conditions that tend to suspend larger particles through water motion (e.g., increase in a stream current or wave action) can produce higher values of TSS not necessarily accompanied by a corresponding increase in turbidity. This is because particles above a certain size (essentially anything larger than silt) are not measured by a bench turbidity meter (they settle out before the reading is taken), but contribute substantially to the TSS value.

Chloride:

The chloride ion is the anion (Cl^-). It is formed when the element chlorine (a halogen) gains an-electron or when a compound such as hydrogen chloride is dissolved in water or other polar solvents. Chloride salts such as sodium chloride are often very soluble in water. It is an essential electrolyte located in all body fluids responsible for maintaining acid/base balance, transmitting nerve impulses and regulating fluid in and out of cells. The word *chloride* can also form part of the name of chemical compounds in which one or more chlorine atoms are covalently bonded. For example, methyl chloride, more commonly called chloromethane, (CH_3Cl) is an organic compound with a covalent C-Cl bond. It is not a source of chloride ion.

Alkalinity:

Alkalinity is the name given to the quantitative capacity of an aqueous solution to neutralize an acid. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. It is one of the best measures of the sensitivity of the stream to acid inputs. There can be long-term changes in the alkalinity of rivers and streams in response to human disturbances. Alkalinity does not measure the same property as the pH (namely basicity).

Alkalinity can be measured by titrating a sample with a strong acid until all the buffering capacity of the aforementioned ions above the pH of bicarbonate or carbonate is consumed. This point is functionally set to pH 4.5. At this point, all the bases of interest have been protonated to the zero level species, hence they no longer cause alkalinity. For example, the following reactions take place during the addition of acid to a typical seawater solution:

$B(OH)_4^- + H^+ \rightarrow B(OH)_3 + H_2O$
$OH^- + H^+ \rightarrow H_2O$
$PO_4^{-3} + 2H^+ \rightarrow H_2PO_4^-$
$HPO_4^{-2} + H^+ \rightarrow H_2PO_4^-$
$[SiO(OH)_3^-] + H^+ \rightarrow [Si(OH)_4^0]$

It can be seen from the above protonation reactions that most bases consume one proton (H^+) to become a neutral species, thus increasing alkalinity by one per equivalent. CO_3^{-2} however, will consume two protons before becoming a zero level species (CO_2), thus it increases alkalinity by two per mole of CO_3^{-2}. $[H^+]$ and $[HSO_4^-]$ decrease alkalinity, as they act as sources of protons. They are often represented collectively as $[H^+]_T$. Alkalinity is typically reported as mg/L *as* $CaCO_3$. (The conjunction "as" is appropriate in this case because the alkalinity results from a mixture of ions but is reported "as if" all of this is due to $CaCO_3$.) This can be converted into milli Equivalents per Liter (mEq/L) by dividing by 50 (the approximate MW of $CaCO_3/2$).

Turbidity:

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. Turbidity (or haze) is also applied to transparent solids such as glass or plastic. In plastic production haze is defined as the percentage of light that is deflected more than 2.5° from the incoming light direction.

The propensity of particles to scatter a light beam focused on them is now considered a more meaningful measure of turbidity in water. Turbidity measured this way uses an instrument called a nephelometer with the detector set up to the side of the light beam. More light reaches the detector if there are lots of small particles scattering the source beam than if there are few. The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU). To some extent, how much light reflects for a given amount of particulates is dependent upon properties of the particles like their shape, color, and reflectivity. For this reason (and the reason that heavier particles settle quickly and do not contribute to a turbidity reading), a correlation between turbidity and total suspended solids (TSS) is somewhat unique for each location or situation.

Salinity:

Salinity is the saltiness or dissolved salt content of a water body. Salinity is an important factor in determining many aspects of the chemistry of natural waters and of biological processes within it, and is a thermodynamic state variable that, along with temperature and pressure, governs physical characteristics like the density and heat capacity of the water.

Seawater typically has a salinity of around 35 g/kg, although lower values are typical near coasts where rivers enter the ocean. Rivers and lakes can have a wide range of salinities, from less than 0.01 g/kg to a few g/kg, although there are many places where higher salinities are found. The Dead Sea has a salinity of more than 200 g/kg.

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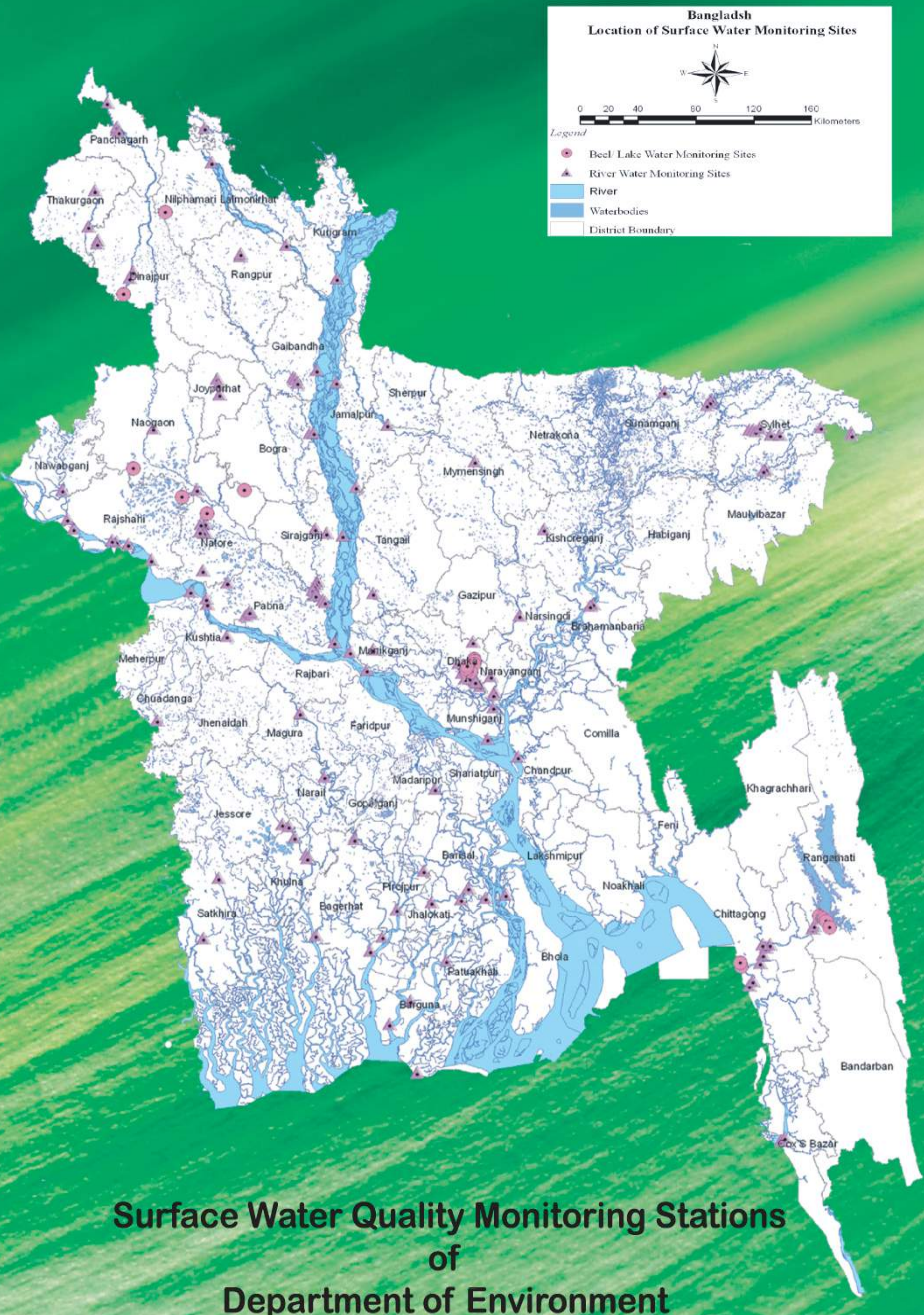

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