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Physicochemical Assessment of Water Quality of the Karnafuli River and Its Impact on the Environment of Chittagong, Bangladesh

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***Abstract**: The present study was conducted to assess the physicochemical characteristics of water quality parameters concentrations in water at different locations of the Karnafuli River. The assessment was carried out for various physicochemical parameters in three seasons during pre-monsoon, monsoon and post-monsoon seasons for various continuous monitoring during the hydrological year 2014-2015. The statistical methods of sampling were used for collecting samples from different points of Karnafuli River. The samples were collected in high and low tide conditions. Since the water quality is expected to vary with season, multiple samples were collected at an interval of 2 to 3 weeks. The work has been carried out by traveling to the sampling sites for collection required water samples and the estimation of water discharge and determination of basic parameters of the sites. Samples were preserved with suitable preservation and transported to the laboratory. Standard methods were followed to determine the physicochemical water quality parameters. In the present study, seasonal variation hydro-chemical character of Karnafuli River water has been evaluated and assessed the suitability of water for human & animal's consumption, irrigation and industrial purposes. The study stress to access various essential physical and chemical parameters including pH, conductivity, salinity, total dissolved solid (TDS), total suspended solid (TSS), turbidity, alkalinity, acidity, dissolved oxygen (DO), sulfate, biological oxygen demand (BOD), Chemical demand oxygen (COD), nitrate, phosphate, chloride, total- hardness. The average of maximum parameters studied both physical and chemical were found higher than those of the World Health Organization(WHO), Department of Environment (DoE) and BSTI drinking water guidelines. The laboratory finding of water quality parameters were also compared with the recommended values set by DoE and BSTI. From Pearson correlation program, significant positive and negative correlations were found in different parameters. These assessment data indicated that the water quality of Karnafuli River are highly polluted which are continuously polluting the coastal zone, sea and the Halda River of Chittagong. The environmental impact of water quality of Karnafuli River has been discussed. The result provided data to understand and quantify the threat of the impact of climate change on river water resources of greater Chittagong region. The result also provided data for water quality of Karnafuli River water resources of greater Chittagong region to*

match national and international standard for drinking, agriculture, industrial and livestock requirements. The assessment data can be used to help the determination the efficacy of existing water quality policies to help analysts determine the need for and likely consequences of new policies. The assessment data can be supplied to the proper Govt. authority for making new national and appropriate preventive measures. The assessment can be increased the awareness of the people of the risk and affected areas so that they could ready to face the disaster due to climate change, from the investigation it can be concluded that the water quality of Karnafuli River is being affected by pollution hazard. The delay of the application of the legal frame work as well as stakeholder awareness aggravates the situation by continually reducing the water quality in the river. A strategic water quality management plan has been proposed.”Wise decision must be based on sound information”

Keywords: *Physicochemical water pollution assessment, Karnafuli River, water quality parameters, seasonal variations, environmental impact, Chittagong, Bangladesh*

Introduction

Water is a universal solvent an absolute necessity of life. It contains dissolved materials and suspended particles even in its natural state. Due to very good solvent property, it produce water pollution problems because it can dissolve toxic and hazardous substances **[1].**Various investigations indicate that most of the communicable diseases are water born and these diseases cause morbidity and mortality. In Bangladesh, the mortality rate especially in the infants is very high because of Bangladesh is a developing country **[2].** The prime objective of literature survey was to review basic water quality parameters to be used as an indicator of water pollution assessment. The standard analytical procedures were adopted for the determination of water quality parameters. Water pollution is the contamination of water by foreign matter that deteriorates the quality of the water **[3-4].** Water pollution covers pollutions in liquid forms like ocean pollution and river pollution. As the term applies, liquid pollution occurs in the oceans, lakes, streams, rivers, underground water and bays, in short liquid-containing areas **[5].** Determination of the physical, bacteriological and chemical quality of water is essential for assessing the suitability of water for various purposes like drinking, domestic use, industries and agriculture **[6].** The pH is of importance in determining the corrosively of water but the relationship with a number of other parameters is complex. Natural waters contain gases, colloidal matter and a variety of electrolyte and non-electrolyte material, and these, together with pH, determine the extent of corrosion in a system. However in general the lower is the pH, the higher the potential level of corrosion **[7].** Electrical conductivity is a measure of water’s ability to conduct electricity, and therefore a measure of the water’s ionic activity and content. The higher the concentration of ionic (dissolved) constituents was the higher the conductivity **[8].** Biochemical oxygen demand (BOD) is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water

sample at certain temperature over a specific time period **[9].** The DO level requirement for most of the aquatic organism is around 5.00-mgL^{-1}. The amount of DO in water depends upon three major factors, namely, rate of photosynthesis, respiration by aquatic organisms oxidation of wastes, and rate of reparation of water. Water is considered to be polluted when its DO concentration drops below the level to sustain normal biota. Water gets deoxygenated due to the presence of substances, collectively known as oxygen demanding wastes **[10].** The chemical oxygen demand (COD) is widely used as a means of measuring pollution strength of industrial effluents. COD unfortunately cannot differentiate between biologically oxidizable and inert organic matter. The rate of oxidation is not precisely understood in COD analysis. The outstanding feature of COD in comparison to BOD is short-time required for valuation **[10].**

The general public of these countries is not well aware of water quality impacts on human health. Hence, they are not conscious about drinking water quality due to low literacy rate and lack of monitoring facilities of drinking water quality. Uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. 97% of water on the Earth is salt water, leaving only 3% as fresh water of which slightly over two thirds is frozen in glaciers and polar ice caps **[11].** The remaining unfrozen fresh water is mainly found as groundwater, with only a small fraction present above ground or in the air **[12].** But in general surface water is impure and become contaminated where the river flow through thickly populated and industrial area. Lakes, natural and artificial, also show similar quantities as rivers and streams but they, being quiescent, show less pollution both physically and bacteriologically **[13].** Quality of surface water depends upon the season of the year, nature of soil and the habitation in the catchments area. But in general surface water is impure and become contaminated where the river flow through thickly populated and industrial area. Karnafuli River the largest and most important river in Chittagong region and the Chittagong Hill Tracts, is a 667-metre (2,188 ft) wide river in the southern -eastern part of Bangladesh **[14-15].** Originating from the Lushai Hills in Mizoram Province of India, it flows 270 kilometers (170 miles) Cement west through Chittagong Hill Tracts and Chittagong into the Bay of Bengal. Water pollution is a phenomenon that is characterized by the deterioration of the quality of water as a result of various human activities. The Karnafuli River is called the mother of Chittagong city because it is feeding the city in many ways and also contains all kinds of garbage of this city and plays an important role in the communication system of the whole region. The main industries of Chittagong are concentrated at Kalurghat, Patenga, Nasirabad, Sholashahar, Kaptai, Bhatiary, Barabkunda, Anwara and Fauzderhat industrial areas. From, the huge quantities of liquid waste of the Karnafuli Paper Mills to the thousands of tonnages of dirt and garbage from Chittagong Municipal area and different Mills and Factories from Kaptai to Chittagong are dumped indiscriminately into the Karnafuli River. Due to this she is nearly facing biological death. The areas between the Kalurghat to Patenga is the most polluted due to the presence of many chemical, fertilizers, iron and steel, leather, paint,

garments, food, cosmetics, toiletries and pharmaceutical industries. All these industries discharge their untreated toxic waste water directly or indirectly into this river, which not only degraded the water quality of this river water to a large extent but also destroyed the habitats of the water body. A large hydroelectric power plant using Karnafuli River was built in the Kaptai region during the 1960s. Karnafuli is heavily polluted by Industrial discharge and agricultural runoff **[16-21].** There are more than 140 industries in Kalurghat, Nasirabad, Patenga, Kaptai, Bhatiary, Barabkunda, Fauzdarhat, and Sholashahar in Chittagong. All their wastes fall in the waters of the Karnafuli and the Bay of Bengal. Chittagong has 19 Tanneries, 1 Rayon Mill, 26 Textile Mills, 1 Refinery, 2 Chemical, 1 TSP Fertilizer, 5 Fish processing, 2 Cement Factories, 5 Steel mills, 2 Insecticide factories, 4 Dyeing Factories and about 75 other small Industries [22]. Which are Polluting the water of Karnafuli River? These are the some images of pollution

Fig. 1. Effluent flowing to the Karnafuli River at Kalurghat (Source: The Daily Star)

Fig. 2. Standing Open Toilet on Karnafuli River

Sampling Areas

Our present work focused on the water quality status of stagnant and open river water resources in the Karnafuli River of the Greater Chittagong district [13]. A total number of **100** water quality monitoring stations were identified (**Fig. 1**) and water samples were collected in the middle month of three seasons namely pre-monsoon (January-March), monsoon (July-September), and post-monsoon (October-December) of the hydrological years 2014-2015 for continuous monitoring of water quality parameters. Water samples from different points or spots of Karnafuli River region were collected for this study. A brief discussion of study area of Karnafuli River is given in **Figure 3**.

Materials and Methods

Surface samples from different points of Karnafuli River Chittagong districts were collected for this study. Samples were collected in amber color polyethylene bottle cleaned by rinsing thoroughly with 8 M HNO_3, followed by repeated washing with distilled water. Multiple samples were collected from the same spot in different seasons to study the seasonal variation of the results. The surface water samples were collected in the boat if possible in the middle of the flow. Two to four equal volumes were collected from vertical section. The water samples were collected within 3-18 inches from the surface of the water. The samples were mixed well and a sample of 1.0-1.5 L was transferred for analysis in the laboratory. A large number of separate sample taken at different times and location were some physical quantities, semi-quantities and quantitative test were done at the sampling sport such as Temperature, pH, DO, EC, TDS, Salinity, As etc. Acidity, Alkalinity, Carbon dioxide was measured immediately after sample collection at the laboratory **[23].**

Freshwater sample were used for analyzing Nitrate, Sulfate, Phosphate immediately after sample collection at the laboratory. A glass thermometer was used for the measurement of temperature. Transparency was measured by Sacchi disc. pH, EC and TDS were measured at the sampling site by Portable Multi-parameters, Model-HI9828, HANNA. Measurement of DO was done by Jenway 970 DO meter at the sampling site. Biochemical oxygen demand (BOD) was measured from the differences of initial and 5 days DO by DO meter **[24].** Chemical oxygen demand (COD) was determined by titrimetric method after 2 hours open reflux. Acidity and dissolved carbon dioxide were measured by titrimetric method using standard 0.02M NaOH **[25]**. Total and phenolphthalein alkalinity were measured by titrimetric method using methyl orange and phenolphthalein, respectively as indicators. Hardness was measured by complexometric titration method **[26].**

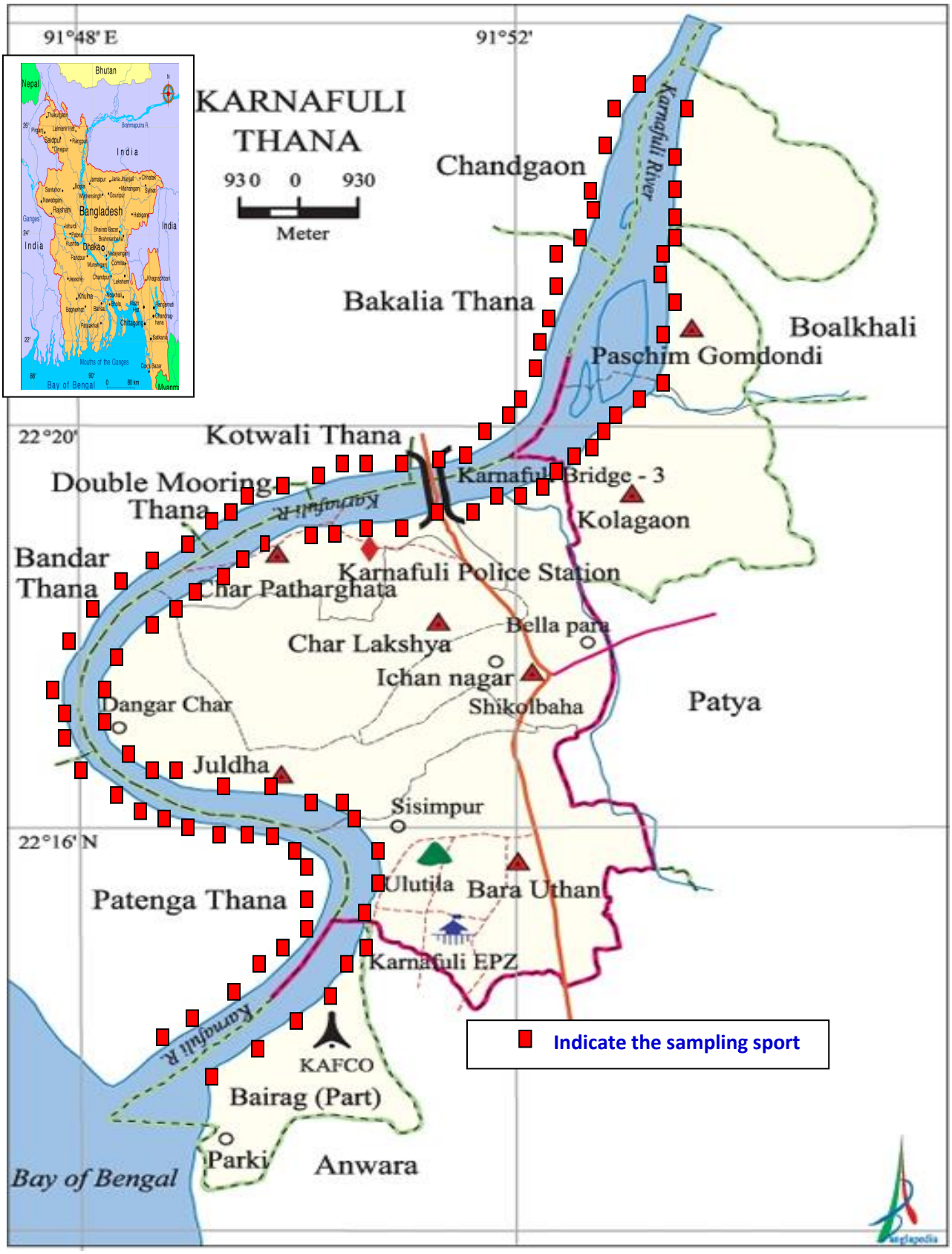

Fig. 3. Map showing the Sample Collection points of Karnafuli River

Results and Discussion

Results

Karnafuli River water resources quality are shown in Table 1, Karnafuli River water quality at different tide conditions, Karnafuli River water quality at different seasons, comparative study with WHO, BSTI, and also inter country rivers and the results of Pearson Correlations among the different parameters of Karnafuli River are shown in **Table 2, 3,4 and 5**, respectively..

Table1.1. Karnafuli River water resources quality from Sikolbaha canal to Anumajhirghat

Parameters	Units	1. SikolBaha canal	2. Raja khali canal	3. Chakti canal	4. Fisharighat canal	5. Jalilgang canal	6. Bangobari canal	7. Firingibazar canal	8. Karnafulighat	9. Majhirghat	10. Anumajhirghat
Temp	(°C)	28.9	28.6	28.2	28.8	28.4	28.7	28.7	28.8	30.1	28.8
pH		8.2	7.5	7.5	7.5	7.7	7.6	7.7	7.6	7.6	7.5
DO	mgL^{-1}	6.9	1.7	1.0	1.0	0.9	1.0	1.4	1.8	3.1	1.3
EC	μscm^{-1}	112	230	556	600	442	408	300	204	155	782
TDS	mgL^{-1}	56	115	278	300	221	204	150	102	78	391
Salinity	mgL^{-1}	0.1	0.1	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Turbidity	NTU	95	120	20	46	37	156	41.2	62	103	40
Phosphate	mgL^{-1}	1.9	1.41	1.34	0.28	0.28	0.9	1.01	2.0	2.1	2.14
Nitrate	mgL^{-1}	1.3	1.7	1.2	6.6	6.4	1.3	1.4	0.4	0.9	2.14
Sulfate	mgL^{-1}	20	27	61	25	28	9.4	17	2.9	3.4	17
Hardness	mgL^{-1}	60	80	140	200	100	120	60	60	80	140
Alkalinity	mgL^{-1}	86.1	88.9	111.1	86.1	77.8	80.6	75	55.6	77.8	66.7
Acidity	mgL^{-1}	1	1	10	10	6	8	10	8	12	16
CO_2	mgL^{-1}	5	7	9	10	10	6	8	16	8	10
Cl^-	mgL^{-1}	1.67	6.11	7.03	11.6	3.5	4.1	2.78	2.4	2.22	8.34
BOD	mgL^{-1}	1.3	2.9	4.1	3.4	3.4	3.4	2.8	2.3	2.4	2.8
COD	mgL^{-1}	56	235	336	302	358	347	268	224	202	180

Table 1.2. Karnafuli River water resources quality from Banglabazarghat to Power Point.

Parameters	Units	11.Banglabazarghat	12. Sadorghat	13. Current centre	14. Boalkhali Kalago canal	15. BoalkhaliTeksho canal	16. Boalkhali Kalago canal	17. Ajgajjapara	18. Ship Yard	19. Western Marine Ship Yard	20. Power point
Temp	(ºC)	29.4	28.7	28.4	28.7	28.8	28.8	28.7	28.6	28.8	28.7
pH		7.8	7.5	7.2	7.4	7.5	7.4	7.5	7.5	7.5	7.5
DO	mgL^{-1}	5	5.7	6.6	6.4	6.7	6.7	6.7	6.5	6.4	6.5
EC	μscm^{-1}	144	266	164	166	134	148	154	154	181	116
TDS	mgL^{-1}	72	133	82	83	67	74	77	77	91	58
Salinity	mgL^{-1}	0.1	0.1	0.1	0.10	0.1	0.1	0.07	0.08	0.05	0.07
Turbidity	NTU	59	57	78	70	86	79	90	126	59	120
Phosphate	mgL^{-1}	1.4	3.4	0.30	0.05	0.8	0.17	0.31	0.29	0.01	0.31
Nitrate	mgL^{-1}	1.7	2.9	1.9	3.7	2.7	0.4	0.2	0.5	0.2	0.5
Sulfate	mgL^{-1}	45	16	22	17	11	9	9	27	27	15
Hardness	mgL^{-1}	40	40	40	40	60	40	40	60	60	60
Alkalinity	mgL^{-1}	63.8	94.4	86.9	59.7	58.3	61.1	51.6	44.4	46.1	66.6
Acidity	mgL^{-1}	32	10	8	6	40	12	8	10	10	8
CO_2	mgL^{-1}	12	60	10	8	8	36	2	6	4	2
Cl^-	mgL^{-1}	2.78	3.52	1.85	0.93	0.93	2.78	0.93	1.85	2.4	3.14
BOD	mgL^{-1}	0.7	1.4	2.2	2.1	2.3	2.3	2.4	2.0	2.1	2.3
COD	mgL^{-1}	146	134	134	235	134	134	120	115	124	156

Table 1.3. Karnafuli River water resources quality from Under Karnafuli Bridge to JD No. 1.

Parameters	Units	21. Under Karnafuli bridge	22. East Mastuhara	23. West Mastuhara	24. Under Tower of mastuhara	25. North side bridge	26. New chaktai	27. Boalkhalikolago village (East)	28. Boalkhali village (West)	29. Talmarighat	30. JD No. 1
Temp	(ºC)	28.8	28.8	28.9	28.7	28.9	28.3	28.6	28.8	28.9	28.9
pH		7.6	7.2	7.3	7.3	7.4	7.5	7.2	7.1	7.4	7.4
DO	mgL^{-1}	6.9	6.9	6.6	6.9	7.1	6.7	6.9	6.8	6.6	6.8
EC	μscm^{-1}	456	178	108	219	202	126	150	124	337	343
TDS	mgL^{-1}	228	89	54	109	101	63	62	112	167	172
Salinity	mgL^{-1}	0.15	0.06	0.03	0.06	0.03	0.11	0.06	0.07	0.08	0.12
Turbidity	NTU	62	66	78	104	74	68	62	80	104	62
Phosphate	mgL^{-1}	0.2	0.25	0.6	0.4	0.6	0.04	0.03	0.10	2.9	0.2
Nitrate	mgL^{-1}	0.03	0.4	0.33	0.35	.34	1.2	0.9	1.6	0.03	1.18
Sulfate	mgL^{-1}	15	14	15	15	11	15	16	13	38	20
Hardness	mgL^{-1}	40	80	60	60	60	40	40	40	60	40
Alkalinity	mgL^{-1}	58.3	55.5	55.5	48.1	52.7	77.7	36.1	76	70.6	70
Acidity	mgL^{-1}	12	16	14	8	12	16	10	8	12	10
CO_2	mgL^{-1}	2	6	8	10	8	6	4	12	12	10
Cl^-	mgL^{-1}	5.37	0.93	0.93	0.55	3.33	3.33	2.04	0.93	0.93	2.78
BOD	mgL^{-1}	2.5	2.4	2.4	2.5	2.3	2.	2.3	1.8	2	2.29
COD	mgL^{-1}	130	141	156	138	156	146	134	156	224	146

Table 1.4. Karnafuli River water resources quality from JD No. 2 to JD No. 10.

Parameters	Units	31. JD No. 2	32. JD No. 3	33. Janar canal	34..JD No. 4	35. JD No. 5	36. JD No. 6	37. JD No. 7	38. JD No. 8	39. JD No. 9	40. JD No. 10
Temp	(ºC)	28.9	28.9	28.9	28.8	28.7	28.7	28.8	28.9	28.8	28.8
pH		7.4	7.6	7.6	7.3	7.5	7.3	7.4	7.3	7.3	7.3
DO	mgL^{-1}	6.8	6.7	6.8	6.9	6.7	6.7	6.6	6.8	6.9	6.7
EC	μscm^{-1}	318	342	379	398	518	602	1013	1483	1950	948
TDS	mgL^{-1}	159	171	189	1199	259	301	507	742	975	474
Salinity	mgL^{-1}	0.11	0.18	0.13	0.12	014	0.21	0.25	036	0.42	0.52
Turbidity	NTU	64	46	36	64	57	68	67	74	84	57
Phosphate	mgL^{-1}	0.8	0.82	0.14	0.16	0.32	.4	0.19	0.18	0.17	0.68
Nitrate	mgL^{-1}	0.9	1.0	0.8	0.8	0.7	0.9	0.8	1.6	2.5	2.6
Sulfate	mgL^{-1}	19	55	58	28	27	24	34	30	12	66
Hardness	mgL^{-1}	20	40	40	20	40	20	60	40	80	40
Alkalinity	mgL^{-1}	70.6	75	73.4	70.6	51.6	2.7	68	70.6	77	73
Acidity	mgL^{-1}	10	12	10	8	12	14	16	10	8	10
CO_2	mgL^{-1}	8	10	10	16	12	10	18	8	10	12
Cl^-	mgL^{-1}	2.96	6.11	6.18	7.03	7.41	12	13	15.6	52.8	23
BOD	mgL^{-1}	2.3	1.5	2.3	1.6	2.4	2.4	2.1	2.3	2.3	2.4
COD	mgL^{-1}	134	120	201	156	202	212	156	146	112	201

Table 1.5. Karnafuli River water resources quality from Super Petrochemical to Dhanar canal **North.**

Parameters	Units	41. Super Petrochemical	42. Super Petrochemical (North)	44. BNK Nirvik	43. Star Cement	45. Star Cement (North)	46. KhatGhor North	47. KhatGhor	48. Star Cement (East)	49. Canal in between Star Cement	50.Dhanar canal (North)
Temp	(°C)	28.	28.7	28.9	28.8	28.8	28.8	28.8	28.7	28.6	28.7
pH		7.6	7.6	.3	7.5	7.4	7.5	7.5	7.4	7.5	7.5
DO	mgL^{-1}	6.7	6.6	6.6	6.6	6.7	6.8	6.7	6.6	6.6	6.7
EC	μscm^{-1}	769	1012	948	314	651	769	702	620	648	540
TDS	mgL^{-1}	384	506	474	157	460	384	351	310	324	270
Salinity	mgL^{-1}	0.98	0.41	0.36	0.43	0.44	0.12	0.32	0.31	0.15	0.32
Turbidity	NTU	68	55	74	60	66	48	70	72	48	61
Phosphate	mgL^{-1}	0.38	0.06	0.24	0.4	0.19	0.17	0.19	.21	2.7	0.2
Nitrate	mgL^{-1}	0.7	0.72	0.5	0.8	0.6	0.52	0.4	0.06	0.7	0.7
Sulfate	mgL^{-1}	75	53	40	49	35	39	41	32	34	37
Hardness	mgL^{-1}	80	100	60	60	40	40	60	40	20	40
Alkalinity	mgL^{-1}	130.5	77.8	70.8	73.4	73.4	72.2	75.1	70.7	77.78	81.6
Acidity	mgL^{-1}	12	10	12	10	8	8	10	8	8	10
CO_2	mgL^{-1}	10	8	10	10	6	8	10	8	8	10
Cl^-	mgL^{-1}	23.8	23.1	2.96	1.85	6.11	5.38	5.74	6.11	29.1	22.1
BOD	mgL^{-1}	2.2	2.1	2.0	2.1	2.2	2.0	2.7	2.8	2.8	2.8
COD	mgL^{-1}	122	112	146	156	120	56.8	46	49	67.2	56

Table 1.6. Karnafuli River water resources quality from Dhanar canal to Aminpara.

Parameters	Units	51. Dhanar canal	52. In between Dhanar canal and Diamond factory	53. Diamond factory	54. S.Alam refined sugar (North)	55. S.Alam refined sugar	56.Coast guard	57. Coast guardd (North)	58. Moilarchor	59. Polyhard	60. Aminpara
Temp	(°C)	28.6	28.8	28.9	28.9	28.8	28.9	29.1	26.1	25.8	25.8
pH		7.5	7.2	7.5	7.4	7.4	7.4	7.4	7.4	7.3	7.1
DO	mgL^{-1}	6.5	6.4	6.5	6.6	6.7	6.6	7.1	7.2	7.1	7.1
EC	μscm^{-1}	1012	646	314	384	746	450	471	1608	1565	1338
TDS	mgL^{-1}	506	323	157	192	373	275	236	804	780	669
Salinity	mgL^{-1}	0.53	0.12	0.14	0.15	0.12	0.13	0.14	0.82	0.84	0.74
Turbidity	NTU	54	48	44	51	61	41	44	40	51	46
Phosphate	mgL^{-1}	0.19	0.18	0.17	0.21	0.17	0.24	0.30	0.12	0.08	0.13
Nitrate	mgL^{-1}	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.8	0.5	0.9
Sulfate	mgL^{-1}	35	36	39	34	32	19	21	45	59	42
Hardness	mgL^{-1}	60	40	40	60	40	60	80	220	180	160
Alkalinity	mgL^{-1}	87	76.1	76.1	70	78.9	86.1	83.4	66.7	77.8	97.2
Acidity	mgL^{-1}	12	12	8	12	14	16	10	8	12	6
CO_2	mgL^{-1}	12	12	10	14	14	18	12	10	12	6
Cl^-	mgL^{-1}	29.6	29.1	30.9	28.6	27.9	31.8	28.9	29.8	35.7	40.2
BOD	mgL^{-1}	2.2	2.1	2.1	2	2.2	2	2.7	2.8	2.8	2.8
COD	mgL^{-1}	46	37	72.8	37	42	56	67	56	41	72.8

Table 1.7 Karnafuli River water resources quality from Jelepara Khal to Khoudhurypara.

Parameters	Units	61. Jeleparakhal	62. Ispahani	63. Kalurghat (South)	64. Kalurghat Bridge	65. Kalurghat (North)	66. Ramurhat (South para)	67. Ramurhat (middle para)	68. Bagrar canal	69. Roujan canal	70. Choudhurypara
Temp	(°C)	26.2	26.3	25.8	25.9	25.8	25.8	26	25.9	25.8	26.1
pH		7.4	7.5	7.6	7.5	7.4	7.5	7.7	7.6	7.6	7.7
DO	mgL^{-1}	7.1	6.9	6.8	6.7	6.8	6.6	6.7	6.6	6.8	6.9
EC	μscm^{-1}	890	1160	863	413	278	240	174	164	204	189
TDS	mgL^{-1}	445	580	432	206	137	120	87	82	102	95
Salinity	mgL^{-1}	0.14	0.12	0.14	0.12	0.19	0.12	0.14	0.15	0.13	0.13
Turbidity	NTU	72	42	60	52	34	30	18	24	20	30
Phosphate	mgL^{-1}	0.15	0.28	0.13	0.18	0.15	0.23	0.13	0.08	0.14	0.10
Nitrate	mgL^{-1}	1.2	1.0	1.1	0.8	1.4	0.9	1.1	0.8	0.7	0.8
Sulfate	mgL^{-1}	33	28	43	32	22	20	13	18	22	30
Hardness	mgL^{-1}	200	160	120	80	40	200	80	20	40	40
Alkalinity	mgL^{-1}	75	72	76	75	73.4	72.2	72.3	73.4	77.8	72.2
Acidity	mgL^{-1}	8	10	12	4	16	10	18	10	12	16
CO_2	mgL^{-1}	8	12	10	36	18	12	18	10	12	14
Cl^-	mgL^{-1}	40.2	40.6	8.5	5.3	2.2	2.2	0.37	0.21	0.24	0.23
BOD	mgL^{-1}	2.8	2.6	2.5	2.3	2.4	1.9	2.1	2.2	2.5	2.5
COD	mgL^{-1}	72.8	56	37	78.9	41	78.9	34	56	72.8	37

Table 1.8. Karnafuli River water resources quality from Amurhat (South para) to Choudhuryhat Koutoli.

Parameters	Units	71. Amurhat (South para)	72. Amurhat (North para)	73. Amurhat (West para)	74. Fakirakhali (North)	75. Fakirakhali (middle para)	76. Fakirakhali(South	77. Boalkhali (Sourth)	78. Boalkhali (middle para)	79. Boalkhali (North)	80. ChoudhuryhatKouto
Temp	(ºC)	26	26	26.1	26.1	26.3	26.1	25.8	25.8	25.8	25
pH		7.7	7.8	7.8	7.4	7.4	7.5	7.5	7.7	7.7	7.9
DO	mgL^{-1}	7.1	6.8	6.9	6.8	6.7	6.7	6.7	6.8	6.6	6.9
EC	μscm^{-1}	174	103	119	106	100	96	108	120	116	306
TDS	mgL^{-1}	87	52	60	53	50	48	54	60	58	153
Salinity	mgL^{-1}	016	0.14	0.14	0.12	0.14	0.13	0.05	0.05	0.05	0.06
Turbidity	NTU	40	20	22	185	13	8	10	12	20	25
Phosphate	mgL^{-1}	0.14	0.11	0.20	0.12	0.08	0.07	1.2	0.8	0.7	1.0
Nitrate	mgL^{-1}	1.4	1.3	1.0	1.8	0.8	0.7	1.2	0.8	0.7	1.0
Sulfate	mgL^{-1}	20	10	5	8	13	10	5	7	18	20
Hardness	mgL^{-1}	20	20	80	40	40	60	20	40	60	20
Alkalinity	mgL^{-1}	72.2	68	77.8	70.7	75.2	77.7	75	77.8	73.4	77.8
Acidity	mgL^{-1}	14	18	8	140	125	16	10	14	18	12
CO_2	mgL^{-1}	14	18	8	10	12	14	8	12	16	14
Cl^-	mgL^{-1}	032	0.36	0.72	0.04	0.12	0.22	0.18	0.36	3.38	3.78
BOD	mgL^{-1}	2.2	2.2	2.4	2.3	2.4	2.3	1.8	2.2	2.1	2.4
COD	mgL^{-1}	41	66	72.8	23	37	89.4	78	67	72.8	56

Table 1.9. Karnafuli River water resources quality from Koutoli (South) to Kumirar Chor (North).

Parameters	Units	81. koutoli (South)	82. Kajibari (North)	83. Kajibari (South)	84.kalurghat (East)	85. Water supplier	86. Soyabin factory	87. Soyabin factory (South)	88. Kumirarchor (South)	89. KumirarChor	90. KumirarChor (North)
Temp	(ºC)	26	26	26	26.1	26.1	25.9	26	25.8	25.9	26.1
pH		7.8	7.7	7.8	7.8	7.6	7.3	7.6	7.5	7.7	7.7
DO	mgL^{-1}	6.6	6.8	7.31	6.9	7.0	6.8	6.6	6.7	6.9	6.8
EC	μscm^{-1}	860	1861	1054	658	524	525	1858	1500	1620	1640
TDS	mgL^{-1}	430	930	527	329	262	262	929	750	810	820
Salinity	mgL^{-1}	0.14	0.44	0.82	.092	0.35	0.26	0.26	0.92	0.84	0.07
Turbidity	NTU	30	52	58	46	62	58	56	42	12	11
Phosphate	mgL^{-1}	0.07	0.12	0.12	0.12	0.09	0.08	0.15	0.18	0.2	0.15
Nitrate	mgL^{-1}	0.9	1.2	1.3	1.0	0.9	1.4	1.2	0.8	1.0	1.2
Sulfate	mgL^{-1}	30	45	75	75	24	31	26	40	42	8
Hardness	mgL^{-1}	40	60	240	120	80	80	80	140	240	60
Alkalinity	mgL^{-1}	80.5	80.5	78.9	73.4	83.3	76.1	77.8	81.6	76.1	78.9
Acidity	mgL^{-1}	8	10	6	12	20	12	8	12	16	10
CO_2	mgL^{-1}	10	10	6	12	55	14	10	14	16	10
Cl^-	mgL^{-1}	3.88	3.68	0.54	0.54	14.8	9.12	9.67	48.1	1.68	1.68
BOD	mgL^{-1}	2.3	2.4	2.7	2.5	2.7	2.4	2.4	2.3	2.4	2.6
COD	mgL^{-1}	67	56	76	78.4	47	37	72.8	63	56	47

Table 1.10. Karnafuli River water resources quality from Karnafuli Paper Mill to Meshinghat and Air port to Navy Gait.

Parameters	Units	91. Karnafuli Paper Mill	92. 250m South of Karnafuli Paper Mill	93. Kola bagan	94. 400m South from Karnafuli Paper Mill	95. 250m Karnafuli Paper Mill from North	96. Meshinghat	97. Air port	98. Merine Academy	99. KAFCO	100. Navy Gait
Temp	(ºC)	26	25.8	25.6	25.9	26.1	26	26.1	25.9	25.8	26
pH		7.4	7.3	7.4	7.7	7.7	7.7	7.7	7.6	7.7	7.6
DO	mgL^{-1}	6.	6.5	6.4	6.5	6.4	6.5	6.6	6.7	6.8	6.7
EC	μscm^{-1}	210	204	179	173	174	200	190	180	174	200
TDS	mgL^{-1}	105	102	89.5	86.5	87	100	95	90	87	100
Salinity	mgL^{-1}	0.06	0.02	0.06	0.07	0.08	0.05	0.05	0.04	0.06	0.13
Turbidity	NTU	14	10	18	20	24	20	16	22	18	20
Phosphate	mgL^{-1}	0.036	0.11	0.15	0.22	0.12	0.09	0.1	0.09	0.308	0.12
Nitrate	mgL^{-1}	1.3	0.9	1.4	1.1	0.7	1.2	0.8	1.0	0.9	1.1
Sulfate	mgL^{-1}	10	8	12	13	22	20	12	14	10	16
Hardness	mgL^{-1}	80	80	40	60	60	80	60	60	80	60
Alkalinity	mgL^{-1}	106	111.5	119	130.5	122.2	97.9	108	108.8	119.8	122.7
Acidity	mgL^{-1}	12	16	10	8	16	18	22	16	10	16
CO_2	mgL^{-1}	14	18	10	8	18	16	20	16	10	16
Cl^-	mgL^{-1}	1.48	1.11	1.11	1.11	1.48	1.29	1.29	1.48	1.29	1.29
BOD	mgL^{-1}	2.4	2.1	2	2	2	2.2	2.1	2.7	2.4	2.1
COD	mgL^{-1}	212	156	212	218	202	212	224	202	156	212

Table 2.1. Karnafuli River water quality resources from Sikolbaha canal to Anumajhirghat at different tide conditions.

Parameters	Units	Tide conditions	1. SikolBaha canal	2. Raja khali canal	3. Chakti canal	4. Fisharighat canal	5. Jalilgang canal	6. Bangobari canal	7. Firingibazar canal	8. Karnafulighat	9. Majhirghat	10. Anumajhirghat
Temp.	(°C)	Low tide	28.1	28.6	28.2	28.9	28.4	28.7	28.3	28.3	29.8	28.1
		High tide	28.4	28.9	28.6	29.2	28.2	28.5	28.7	28.8	30.1	28.5
pH		Low tide	7.5	7.3	7.4	7.6	7.7	7.5	7.6	7.6	7.6	7.5
		High tide	7.2	7.5	7.5	7.5	7.6	7.6	7.6	7.5	7.5	7.4
DO	mgL^{-1}	Low tide	6.9	1.7	1.0	1.0	0.9	1.0	1.8	1.4	3.1	1.3
		High tide	7.0	2.5	2.2	1.3	1.2	1.8	2.4	1.8	3.8	2.6
EC	μscm^{-1}	Low tide	112	150	267	407	442	600	204	300	155	782
		High tide	120	230	556	430	464	625	230	320	164	810
TDS	mgL^{-1}	Low tide	56	75	133	204	221	300	102	150	78	391
		High tide	60	115	278	215	232	317	215	160	82	405
Salinity	mgL^{-1}	Low tide	0.1	0.1	0.1	0.2	0.2	0.4	0.1	0.1	0.1	0.1
		High tide	0.18	0.19	0.3	0.28	0.25	0.52	0.16	0.18	0.18	0.14
Turbidity	NTU	Low tide	95	120	20	156	37	46	62	41.2	103	40
		High tide	102	130	50	126	42	48	68	38	110	45
PO_4^{2-}	mgL^{-1}	Low tide	1.9	1.9	1.7	.9	.28	0.28	2.0	1.01	2.1	2.14
		High tide	1.6	1.41	1.34	0.65	.31	0.27	2.5	1.3	1.8	2.05
NO_3^{1-}	mgL^{-1}	Low tide	1.3	1.7	1.2	1.3	6.4	6.6	0.4	1.4	0.9	5.8
		High tide	1.3	1.2	1.3	1.4	6.8	6.2	0.52	1.2	0.8	6.2
SO_4^{2-}	mgL^{-1}	Low tide	20	12	21	9.4	28	28	2.9	17	3.4	17
		High tide	19	27	61	10	33	25	8	22	4.2	15
Hardness	mgL^{-1}	Low tide	60	80	140	120	100	200	60	60	80	140
		High tide	70	100	180	140	110	220	80	70	90	160
Alkalinity	mgL^{-1}	Low tide	86.1	68	76	80.5	77.7	86.11	55.5	75.0	77.7	66.6
		High tide	91	88.9	111	86.5	82.2	80	60.2	78.5	75.2	65.2
Acidity	mgL^{-1}	Low tide	1	1	10	8	6	10	8	10	12	16
		High tide	1.1	4	17	10	8	8	8	12	12	12
CO_2	mgL^{-1}	Low tide	0.88	9	12	6	10	10	16	8	8	10
		High tide	0.85	7	9	8	10	12	12	10	10	12
Cl^-	mgL^{-1}	Low tide	1.67	6.11	7.03	4.08	3.51	11.64	2.40	2.78	2.22	8.34
		High tide	1.70	6.78	8.2	4.12	3.7	10.56	2.6	3.2	2.42	8.69
BOD	mgL^{-1}	Low tide	1.5	3.1	4.3	3.5	3.6	3.5	3	2.7	2.7	2.9
		High tide	1.3	2.9	4.1	3.4	3.4	3.4	2.8	2.3	2.4	2.8
COD	mgL^{-1}	Low tide	56	235	336	302	358	347	268	224	202	180
		High tide	34	134	234	212	231	223	126	120	89	98

Table 2.2.Karnafuli River water resources quality from Banglabazarghat to Power point at different tide conditions.

Parameters	Units	Tide conditions	11.Banglabazarghat	12. Sadorghat	13. Current centre	14. Boalkhali Kalago	15. Boalkhali Teksho canal	16. Boalkhali Kalago canal	17. Ajgaijjapara	18. Ship Yard	19. Western Marine Ship Yard	20. Power point
Temp.	(°C)	Low tide	26.9	26.30	26	26.3	26.4	26.4	26.3	26.2	26.4	26.3
		High tide	29.4	28.7	28.4	28.7	28.8	28.8	28.7	28.6	28.8	28.7
pH		Low tide	7.4	7.1	6.8	7.1	7.1	7.03	7.1	7.1	7.1	7.1
		High tide	7.8	7.5	7.2	7.4	7.5	7.4	7.5	7.5	7.5	7.5
DO	mgL^{-1}	Low tide	4.7	5.4	6.2	6.1	6.3	6.3	6.3	6.1	6.1	6.1
		High tide	5	5.7	6.6	6.4	6.7	6.7	6.7	6.5	6.4	6.5
EC	µs/cm	Low tide	129.6	239.4	147.6	149.4	120.6	133.2	138.6	138.6	162.9	104.4
		High tide	144	266	164	166	134	148	154	154	181	116
TDS	mgL-1	Low tide	64.8	119.7	73.8	74.7	60.3	66.6	69.3	69.3	81.9	52.2
		High tide	72	133	82	83	67	74	77	77	91	58
Salinity	mgL^{-1}	Low tide	0.1	0.1	0.1	0.1	0.1	0.1	0.07	0.08	0.05	0.07
		High tide	0.15	0.15	0.15	0.15	0.15	0.15	0.11	0.12	0.07	0.11
Turbidity	NTU	Low tide	50.5	48.84	66.8	60	73.7	67.7	77.1	108	50.5	102.8
		High tide	59	57	78	70	86	79	90	126	59	120
PO_4^{2-}	mgL^{-1}	Low tide	1.2	2.9	0.25	0.04	0.68	0.14	0.26	0.24	0.008	0.26
		High tide	1.4	3.4	0.3	0.05	0.8	0.17	0.31	0.29	0.01	0.31
NO_3^{1-}	mgL^{-1}	Low tide	1.45	2.48	1.62	3.17	2.31	0.342	0.17	0.42	0.17	0.42
		High tide	1.7	2.9	1.9	3.7	2.7	0.4	0.2	0.5	0.2	0.5
SO_4^{2-}	mgL^{-1}	Low tide	38.57	13.71	18.8	14.57	9.42	7.714	7.71	23.14	23.14	12.85
		High tide	45	16	22	17	11	9	9	27	27	15
Hardness	mgL^{-1}	Low tide	34.2	34.2	34.2	34.2	51.4	34.2	34.2	51.47	51.4	51.42
		High tide	40	40	40	40	60	40	40	60	60	60
Alkalinity	mgL^{-1}	Low tide	54.6	80.9	74.4	51.1	49.9	52.37	44.22	38.05	39.51	57.08
		High tide	63.8	94.4	86.9	59.7	58.3	61.1	51.6	44.4	46.1	66.6
Acidity	mgL^{-1}	Low tide	27.42	8.57	6.85	5.14	34.28	10.28	6.85	8.57	8.57	6.85
		High tide	32	10	8	6	40	12	8	10	10	8
CO_2	mgL^{-1}	Low tide	10.28	51.42	8.57	6.85	6.85	30.85	1.71	5.14	3.42	1.71
		High tide	12	60	10	8	8	36	2	6	4	2
Cl^-	mgL^{-1}	Low tide	2.38	3.01	1.5	0.79	0.79	2.38	0.79	1.58	2.05	2.69
		High tide	2.78	3.52	1.85	0.93	0.93	2.78	0.93	1.85	2.4	3.14
BOD	mgL^{-1}	Low tide	0.7	1.4	2.2	2.1	2.3	2.3	2.4	2	2.1	2.3
		High tide	0.6	1.2	1.88	1.8	1.97	1.97	2.05	1.71	1.8	1.97
COD	mgL^{-1}	Low tide	146	134	134	235	134	134	120	115	124	156
		High tide	116.8	107.2	107.2	188	107.2	107.2	96	92	99.2	124.8

Table 2.3. Karnafuli River water resources quality from Under Karnaphulli Bridge to JD No. 1 at tide different conditions.

Parameters	Units	Tide conditions	21. Under Karnafuli Bridge	22. East Mastuhara	23. West Mastuhara	24. Under Tower of mastuhara	25. North side bridge	26. New chaktai	27. Boalkhalikolago village(East)	28. Boalkhali village (West)	29. Talmarighat	30. JD No. 1
Temp.	(°C)	Low tide	27.3	27.3	27.4	27.2	27.4	26.8	27.1	27.3	27.4	27.4
		High tide	28.8	28.8	28.9	28.7	28.9	28.3	28.6	28.8	28.9	28.9
pH		Low tide	7.3	7.0	7.1	7.1	7.1	7.2	7.0	7.0	7.1	7.2
		High tide	7.6	7.2	7.3	7.3	7.4	7.5	7.2	7.1	7.4	7.4
DO	mgL^{-1}	Low tide	6.6	6.6	6.3	6.6	6.8	6.4	6.6	6.5	6.3	6.5
		High tide	6.9	6.9	6.6	6.9	7.1	6.7	6.9	6.8	6.6	6.8
EC	µs/cm	Low tide	410.4	160.2	97.2	197.1	181.8	113.4	135	111.6	303.3	308.7
		High tide	456	178	108	219	202	126	150	124	337	343
TDS	mgL^{-1}	Low tide	205.2	80.1	48.6	98.1	90.9	56.7	55.8	100.8	150.3	154.8
		High tide	228	89	54	109	101	63	62	112	167	172
Salinity	mgL^{-1}	Low tide	0.15	0.06	0.03	0.06	0.03	0.11	0.06	0.07	0.08	0.12
		High tide	0.225	0.09	0.045	0.09	0.04	0.165	0.09	0.12	0.12	0.18
Turbidity	NTU	Low tide	55.8	59.4	70.2	93.6	66.6	61.2	55.8	72	93.6	55.8
		High tide	62	66	78	104	74	68	62	80	104	62
PO_4^{2-}	mgL^{-1}	Low tide	0.18	0.225	0.54	0.36	0.54	0.036	0.027	0.09	2.61	0.18
		High tide	0.2	0.25	0.6	0.4	0.6	0.04	0.03	0.1	2.9	0.2
NO_3^{1-}	mgL^{-1}	Low tide	0.02	0.36	0.29	0.31	0.306	1.08	0.81	1.44	0.02	1.06
		High tide	0.03	0.4	0.33	0.35	0.34	1.2	0.9	1.6	0.03	1.18
SO_4^{2-}	mgL^{-1}	Low tide	13.5	12.6	13.5	13.5	9.9	13.5	14.4	11.7	34.2	18
		High tide	15	14	15	15	11	15	16	13	38	20
Hardness	mgL^{-1}	Low tide	36	72	54	54	54	36	36	36	54	36
		High tide	40	80	60	60	60	40	40	40	60	40
Alkalinity	mgL^{-1}	Low tide	52.4	49.9	49.9	43.2	47.4	69.9	32.4	68.4	63.5	63
		High tide	58.3	55.5	55.5	48.1	52.7	77.7	36.1	76	70.6	70
Acidity	mgL^{-1}	Low tide	10.8	14.4	12.6	7.2	10.8	14.4	9	7.2	10.8	9
		High tide	12	16	14	8	12	16	10	8	12	10
CO_2	mgL^{-1}	Low tide	1.8	5.4	7.2	9	7.2	5.4	3.6	10.8	10.8	9
		High tide	2	6	8	10	8	6	4	12	12	10
Cl^-	mgL^{-1}	Low tide	4.8	0.8	0.8	0.5	2.9	2.9	1.8	0.8	0.8	2.5
		High tide	5.37	0.93	0.93	0.55	3.33	3.33	2.04	0.93	0.93	2.78
BOD	mgL^{-1}	Low tide	2.75	2.64	2.64	2.75	2.53	2.2	2.53	1.98	2.2	2.5
		High tide	2.5	2.4	2.4	2.5	2.3	2	2.3	1.8	2	2.29
COD	mgL^{-1}	Low tide	130	141	156	138	156	146	134	156	224	146
		High tide	113.7	123.3	136.5	120.7	136.5	127.7	117.2	136.5	196	127.7

Table 2.4. Karnafuli River water resources quality from JD No. 2to JD No. 10 at different tide conditions.

Parameters	Units	Tide conditions	31. JD No. 2	32. JD No. 3	33. Janar canal	34..JD No. 4	35. JD No. 5	36. JD No. 6	37. JD No. 7	38. JD No. 8	39. JD No. 9	40. JD No. 10
Temp.	(°C)	Low tide	27.7	27	27.7	27.6	27.5	27.5	27.6	27.7	27.6	27.6
		High tide	28.9	28.9	28.9	28.8	28.7	28.7	28.8	28.9	28.8	28.8
pH		Low tide	7.1	7.2	7.2	7.1	7.2	7.1	7.1	7.1	7.1	7.1
		High tide	7.4	7.6	7.6	7.3	7.5	7.3	7.4	7.3	7.3	7.3
DO	mgL^{-1}	Low tide	6.5	6.4	6.5	6.6	6.4	6.4	6.3	6.5	6.6	6.4
		High tide	6.8	6.7	6.8	6.9	6.7	6.7	6.6	6.8	6.9	6.7
EC	µs/cm	Low tide	286.2	307	341	358	466	541	911	1334	1755	853
		High tide	318	342	379	398	518	602	1013	1483	1950	948
TDS		Low tide	143	153	170	1079	233	270	456	667	877	426
		High tide	159	171	189	1199	259	301	507	742	975	474
Salinity	mgL^{-1}	Low tide	0.11	0.18	0.13	0.12	14	0.21	0.25	0.36	0.42	0.52
		High tide	0.16	0.27	0.19	0.18	21	0.31	0.375	0.54	0.63	0.78
Turbidity	NTU	Low tide	58.6	42.16	33	58.66	52.25	62.33	61.41	67.83	77	52.25
		High tide	64	46	36	64	57	68	67	74	84	57
PO_4^{2-}	mgL^{-1}	Low tide	0.73	0.75	0.13	0.146	0.29	0.34	0.17	0.16	0.15	0.62
		High tide	0.8	0.82	0.14	0.16	0.32	0.4	0.19	0.18	0.17	0.68
NO_3^{1-}	mgL^{-1}	Low tide	0.82	0.91	0.73	0.73	0.64	0.82	0.73	1.46	2.29	2.38
		High tide	0.9	1	0.8	0.8	0.7	0.9	0.8	1.6	2.5	2.6
SO_4^{2-}	mgL^{-1}	Low tide	17.41	50.41	53.16	25.66	24.75	22	31.16	27.5	11	60.5
		High tide	19	55	58	28	27	24	34	30	12	66
Hardness	mgL^{-1}	Low tide	18.3	36.6	36.6	18.3	36.6	18.3	55	36.6	73.3	36.6
		High tide	20	40	40	20	40	20	60	40	80	40
Alkalinity	mgL^{-1}	Low tide	64.7	68.7	67.2	64.7	47.3	2.4	62.3	64.71	70.5	66.9
		High tide	70.6	75	73.4	70.6	51.6	2.7	68	70.6	77	73
Acidity	mgL^{-1}	Low tide	9.2	11	9.2	7.3	11	12.8	14.6	9.1	7.3	9.1
		High tide	10	12	10	8	12	14	16	10	8	10
CO_2	mgL^{-1}	Low tide	7.3	9.2	9.2	14. 67	11	9.17	16.5	7.33	9.17	11
		High tide	8	10	10	16	12	10	18	8	10	12
Cl^-	mgL^{-1}	Low tide	2.73	5.6	5.6	6.4	6.79	11	11.9	14.3	48.4	21.1
		High tide	2.96	6.11	6.18	7.03	7.41	12	13	15.6	52.8	23
BOD	mgL^{-1}	Low tide	2.3	1.5	2.3	1.6	2.4	2.4	2.1	2.3	2.3	2.4
		High tide	1.84	1.2	1.84	1.28	1.92	1.92	1.68	1.84	1.84	1.92
COD	mgL^{-1}	Low tide	134	120	201	156	202	212	156	146	112	201
		High tide	107	96	160	124	161	169	124	116	89	160

Table 2.5. Karnafuli River water resources quality from Super Petrochemical to Dhanar canal North at tide different conditions.

Parameters	Units	Tide conditions	41. Super Petrochemical	42. Super Petrochemical (North)	43. Star Cement	44. BNK Nirvik	45. Star Cement (North)	46. KhatGhor North	47. KhatGhor	48. Star Cement (East)	49. Canal in between Star Cement	50.Dhanar canal North
Temp.	(°C)	Low tide	26.6	27.2	27.3	27.4	27.3	27.3	27.3	27.2	27.1	27.2
		High tide	28	28.7	28.8	28.9	28.8	28.8	28.8	28.7	28.6	28.7
pH		Low tide	7.22	7.2	7.1	7	7.0	7.1	7.1	7.0	7.1	7.1
		High tide	7.6	7.6	7.5	7.3	7.4	7.5	7.5	7.4	7.5	7.5
DO	mgL^{-1}	Low tide	6.3	6.2	6.2	6.2	6.3	6.4	6.3	6.2	6.2	6.3
		High tide	6.7	6.6	6.6	6.6	6.7	6.8	6.7	6.6	6.6	6.7
EC	µs/cm	Low tide	692	910	28	853	585	692	631	562	583	486
		High tide	769	1012	314	948	651	769	702	625	648	540
TDS	mgL^{-1}	Low tide	345	455	141	426	414	345	315	279	291	243
		High tide	384	506	157	474	460	384	351	310	324	270
Salinity	mgL^{-1}	Low tide	0.65	0.27	0.28	0.24	0.29	0.08	0.21	0.21	0.1	0.21
		High tide	0.98	0.41	0.43	0.36	0.44	0.12	0.32	0.31	0.15	0.32
Turbidity	NTU	Low tide	61.2	49.5	54	66.6	59.4	43.2	63	64.8	43.2	54.9
		High tide	68	55	60	74	66	48	70	72	48	61
PO_4^{2-}	mgL^{-1}	Low tide	0.34	0.05	0.36	0.22	0.17	0.15	0.17	0.19	2.43	0.18
		High tide	0.38	0.06	0.4	0.24	0.19	0.17	0.19	0.21	2.7	0.2
NO_3^{1-}	mgL^{-1}	Low tide	0.63	0.64	0.72	0.45	0.54	0.46	0.36	0.05	0.63	0.63
		High tide	0.7	0.72	0.8	0.5	0.6	0.52	0.4	0.06	0.7	0.7
SO_4^{2-}	mgL^{-1}	Low tide	67.5	47.7	44.1	36	31.5	35.1	36.9	28.8	30.6	33.3
		High tide	75	53	49	40	35	39	41	32	34	37
Hardness	mgL^{-1}	Low tide	72	90	54	54	36	36	54	36	18	36
		High tide	80	100	60	60	40	40	60	40	20	40
Alkalinity	mgL^{-1}	Low tide	117.4	70	66	63	66	64.9	67.5	63.6	70	73.4
		High tide	130.5	77.8	73.4	70.8	73.4	72.2	75.1	70.7	77.78	81.6
Acidity	mgL^{-1}	Low tide	10.8	9	9	10.8	7.2	7.2	9	7.2	7.2	9
		High tide	12	10	10	12	8	8	10	8	8	10
CO^1	mgL^{-1}	Low tide	9	7.2	9	9	5.4	7.2	9	7.2	7.2	9
		High tide	10	8	10	10	6	8	10	8	8	10
Cl^-	mgL^{-1}	Low tide	21.4	20.7	1.6	2.66	5.49	4.84	5.16	5.49	26.19	19.89
		High tide	23.8	23.1	1.85	2.96	6.11	5.38	5.74	6.11	29.1	22.1
BOD	mgL^{-1}	Low tide	2.2	2.1	2.1	2	2.2	2	2.7	2.8	2.8	2.8
		High tide	1.98	1.89	1.89	1.8	1.98	1.8	2.43	2.52	2.52	2.52
COD	mgL^{-1}	Low tide	122	112	156	146	120	56.8	46	49	67.2	56
		High tide	101	93	130	121	100	47	38	40	56	46

Table 3.1. Karnafuli River water resources quality from Dhanar canal to Aminpara at different seasons.

Parameters	Units	Seasons	51. Dhanar canal	52. In between Dhanar canal and Diamond factory	53. Diamond factory	54. S.Alam refined sugar (North)	55. S.Alam refined sugar	56. Coast guard	57. Coast guardd (North)	58. Moilarchor	59. Polyhard	60. Aminpara
Temp.	(ºC)	PRM	28.6	28.8	28.9	28.9	28.8	28.9	29.1	26.1	25.8	25.8
		POM	25.0	25.2	25.2	25.2	25.2	25.2	25.4	22.8	22.5	22.5
		Monsoon	30.6	30.8	30.9	30.9	30.8	30.9	31.1	27.9	27.6	27.6
pH		PRM	7.1	6.8	7.1	7	7.1	7	7	7.1	6.9	7
		POM	7.5	7.2	7.5	7.4	7.4	7.4	7.4	7.4	7.3	7.1
		Monsoon	6.7	6.4	6.7	6.6	6.6	6.6	6.6	6.6	6.5	6.3
DO	mgL-1	PRM	5.85	5.76	5.85	5.94	6.03	5.94	6.39	6.48	6.39	6.39
		POM	6.5	6.4	6.5	6.6	6.7	6.6	7.1	7.2	7.1	7.1
		Monsoon	6.1	6.08	6.	6.2	6.3	6.2	6.7	6.8	6.7	6.7
EC	µscm-1	PRM	910	581	282	345	671	405	423	1447	1408	1204
		POM	809	516	251	307	596	360	376	1286	1252	1070
		Monsoon	1012	646	314	384	746	450	471	1608	1565	1338
TDS	mgL-1	PRM	455	290	141	172	335	247	212	726	702	602
		POM	404	258	125	153	298	220	188	643	624	535
		Monsoon	506	323	157	192	373	275	236	804	780	669
Salinity	mgL-1	PRM	0.70	0.16	0.18	0.2	0.16	0.17	0.18	1.09	1.12	0.98
		POM	0.53	0.12	0.14	0.15	0.12	0.13	0.14	0.82	0.84	0.74
		Monsoon	0.47	0.11	0.12	0.13	0.11	0.12	12.6	0.73	7.6	0.666
Turbidity	NTU	PRM	59.4	52.8	48.4	56.1	67.1	45.1	48.4	44	56.1	50.6
		POM	54	48	44	51	61	41	44	40	51	46
		Monsoon	47.2	42	38.5	44.6	53.3	35.	38.5	35	44.6	40.2
Phosphate	mgL-1	PRM	0.21	0.2	0.18	0.23	0.18	0.26	0.333	0.133	0.08	0.14
		POM	0.19	0.18	0.17	0.21	0.17	0.24	0.3	0.12	0.08	0.13
		Monsoon	0.16	0.16	0.14	0.18	0.15	0.21	0.26	0.10	0.07	0.113
Nitrate	mgL-1	PRM	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.8	0.5	0.9
		POM	0.8	0.66	0.666	0.66	0.8	0.66	0.8	1.06	0.66	1.2
		Monsoon	0.48	0.4	0.4	0.4	0.48	0.4	0.48	0.64	0.4	0.72
Sulfate	mgL-1	PRM	35	36	39	34	32	19	21	45	59	42
		POM	46.66	48	52	45.33	42.6	25.33	28	60	78.66	56
		Monsoon	28	28.8	31.2	27.2	25.6	15.2	16.8	36	47.2	33.6
Hardness	mgL-1	PRM	60	40	40	60	40	60	80	220	180	160
		POM	80	53.33	53.3	80	53.3	80	106.6	293.3	240	213.3
		Monsoon	48	32	32	48	32	48	64	176	144	128
Alkalinity	mgL-1	PRM	69.6	60.8	60.8	56	63.1	68.8	66.7	53.3	62.2	77.
		POM	87	76.1	76.1	70	78.9	86.1	83.4	66.7	77.8	97.2
		Monsoon	76.1	66.5	66.5	61.2	69	75.3	72.9	58.5	68.5	85
Acidity	mgL-1	PRM	9.6	9.6	6.4	9.6	11.2	12.8	8	6.4	9.6	4.8
		POM	12	12	8	12	14	16	10	8	12	6
		Monsoon	10.5	10.5	7	10.5	12.2	14	8.5	7	10.5	5.2
Chloride	mgL-1	PRM	28.1	27.6	29.3	27.	26.5	30.2	27.4	28.3	33.5	38.2
		POM	29.6	29.1	30.9	28.6	27.9	31.8	28.9	29.8	35.7	40.2
		Monsoon	26.6	26.2	27.8	25.7	25.1	28.6	26	26.8	32.1	36.1
BOD	mgL-1	PRM	1.98	1.89	1.89	1.8	1.98	1.8	2.43	2.52	2.52	2.52
		POM	2.2	2.1	2.1	2	2.2	2	2.7	2.8	2.8	2.8
		Monsoon	2.1	1.9	1.9	1.9	2.1	1.9	2.5	2.6	2.6	2.6
COD	mgL-1	PRM	41.4	33.3	65.52	33.3	37.8	50.4	60.3	50.4	36.9	65.5
		POM	46	37	72.8	37	42	56	67	56	41	72.8
		Monsoon	51.1	41.1	80.8	41.1	46.7	62.2	74.4	62.2	45.6	80.9

Table 3.2. Karnafuli River water resources quality from Jeleparakhal to Choudhurypara at different seasons.

Parameters	Units	Seasons	61. Jeleparakhal	62. Ispahani	63. Kalurghat (South)	64. Kalurghat Breeze	65. Kalurghat (North)	66. Ramurhat (South para)	67. Ramurhat (middle	68. Bagrar canal	69. Roujan canal	70. Choudhurypara
Temp.	(°C)	PRM	26.2	26.3	25.8	25.9	25.8	25.8	26	25.9	25.8	26.1
		POM	22.9	23	22.5	22.6	22.5	22.5	22.7	22.6	22.5	22.8
		Monsoon	28	28.1	27.6	27.7	27.6	27.6	27.8	27.7	27.6	27.9
pH		PRM	7.1	7.1	7.22	7.1	7.1	7.1	7.3	7.2	7.2	7.3
		POM	7.4	7.5	7.6	7.5	7.4	7.5	7.7	7.6	7.6	7.7
		Monsoon	6.6	6.7	6.8	6.7	6.6	6.7	6.9	6.8	6.8	6.9
DO	mgL^{-1}	PRM	6.3	6.2	6.1	6	6.1	5.9	6	5.9	6.1	6.2
		POM	7.1	6.9	6.8	6.7	6.8	6.6	6.7	6.6	6.8	6.9
		Monsoon	6.7	6.5	6.4	6.3	6.4	6.2	6.3	6.2	6.4	6.5
EC	μscm^{-1}	PRM	801	1044	776.7	371.7	250.2	216	156.6	147.6	183.6	170.1
		POM	712	928	690.4	330.4	222.4	192	139.2	131.2	163.2	151.2
		Monsoon	890	1160	863	413	278	240	174	164	204	189
TDS	mgL^{-1}	PRM	400.5	522	388.8	185.4	123.3	108	78.3	73.8	91.8	85.5
		POM	356	464	345.6	164.8	109.6	96	69.6	65.6	81.6	76
		Monsoon	445	580	432	206	137	120	87	82	102	95
Salinity	mgL^{-1}	PRM	0.18	0.16	0.1	0.16	0.25	0.16	0.18	0.2	0.17	0.17
		POM	0.14	0.12	0.14	0.12	0.19	0.12	0.14	0.15	0.13	0.13
		Monsoon	0.12	0.11	0.12	0.11	0.17	0.11	0.12	0.13	0.11	0.11
Turbidity	NTU	PRM	79.2	46.2	66	57.2	37.4	33	19.8	26.4	22	33
		POM	72	42	60	52	34	30	18	24	20	30
		Monsoon	63	36.75	52.5	45.5	29.75	26.25	15.75	21	17.5	26.25
Phosphate	mgL^{-1}	PRM	0.16	0.31	0.14	0.2	0.16	0.25	0.14	0.08	0.15	0.11
		POM	0.15	0.28	0.13	0.18	0.15	0.23	0.13	0.08	0.14	0.1
		Monsoon	0.13	0.25	0.11	0.16	0.13	0.20	0.11	0.07	0.12	0.08
Nitrate	mgL^{-1}	PRM	1.2	1	1.1	0.8	1.4	0.9	1.1	0.8	0.7	0.8
		POM	1.6	1.33	1.46	1.06	1.86	1.2	1.46	1.06	0.93	1.06
		Monsoon	0.96	0.8	0.88	0.64	1.12	0.72	0.88	0.64	0.56	0.64
Sulfate	mgL^{-1}	PRM	33	28	43	32	22	20	13	18	22	30
		POM	44	37.33	57.33	42.66	29.33	26.66	17.33	24	29.33	40
		Monsoon	26.4	22.4	34.4	25.6	17.6	16	10.4	14.4	17.6	24
Hardness	mgL^{-1}	PRM	200	160	120	80	40	200	80	20	40	40
		POM	266.6	213.3	160	106.66	53.3	266.7	106.6	26.6	53.3	53.3
		Monsoon	160	128	96	64	32	160	64	16	32	32
Alkalinity	mgL^{-1}	PRM	60	57.6	60.8	60	58.7	57.7	57.8	58.7	62.2	57.7
		POM	75	72	76	75	73.4	72.2	72.3	73.4	77.8	72.2
		Monsoon	65.6	63	66.5	65.6	64.2	63.1	63.2	64.25	68	63.1
Acidity	mgL^{-1}	PRM	8	9.6	3.2	12.8	8	14.4	8	9.6	12.8	4.8
		POM	10	12	4	16	10	18	10	12	16	6
		Monsoon	8.75	10.5	3.5	14	8.75	15.75	8.75	10.5	14	5.25
Chloride	mgL^{-1}	PRM	38.2	38.5	8.07	5.1	2.09	2.09	0.35	0.19	0.228	0.21
		POM	40.2	40.6	8.5	5.3	2.2	2.2	0.37	0.21	0.24	0.23
		Monsoon	36.18	36.54	7.65	4.77	1.98	1.98	0.333	0.189	0.21	0.21
BOD	mgL^{-1}	PRM	2.25	2.07	2.16	1.71	1.89	1.98	2.25	2.25	2.52	2.52
		POM	2.5	2.3	2.4	1.9	2.1	2.2	2.5	2.5	2.8	2.8
		Monsoon	2.3	2.1	2.28	1.8	1.9	2	2.3	2.3	2.6	2.6
COD	mgL^{-1}	PRM	65.5	50.4	33.3	71	36.9	71	30.6	50.4	65.5	33.3
		POM	72.8	56	37	78.9	41	78.9	34	56	72.8	37
		Monsoon	80.8	62.2	41.1	87.6	45.5	87.6	37.7	62.2	80.8	41.1

PRM= Pre-monsoon, POM= Post-monsoon

Table 3.3. Karnafuli River water resources quality from Amurhat (South para) to Choudhuryhat Koutoli at different seasons.

Parameters	Units	Seasons	71. Amurhat (South para)	72. Amurhat (North para)	73. Amurhat (West para)	74. Fakirakhali (North)	75. Fakirakhali (middle para)	76. Fakirakhali (South para)	77. Boalkhali (Sourth)	78. Boalkhali (middle para)	79. Boalkhali (North)	80.Choudhury hat Koutoli
‘./	(ºC)	PRM	26	26	26.1	26.1	26.3	26.1	25.8	25.8	25.8	25
		POM	22.7	22.75	22.8	22.8	23	22.8	22.5	22.5	22.5	21.8
		Monsoon	27.85	27.8	27.9	27.9	28.1	27.9	27.6	27.6	27.6	26.7
pH		PRM	7.3	7.4	7.4	7.1	7.1	7.1	7.1	7.3	7.3	7.5
		POM	7.7	7.8	7.8	7.4	7.4	7.5	7.5	7.7	7.7	7.9
		Monsoon	6.9	7.1	7.1	7	7	7	7	7	7	7.11
DO	mgL^{-1}	PRM	6.3	6.1	6.21	6.1	6	6	6	6.1	5.9	6.2
		POM	7.1	6.8	6.9	6.8	6.7	6.7	6.7	6.8	6.6	6.9
		Monsoon	6.7	6.4	6.5	6.4	6.3	6.3	6.3	6.4	6.2	6.5
EC	μscm^{-1}	PRM	156.6	92.7	107.1	95.4	90	86.4	97.2	108	104.4	275.4
		POM	174	103	119	106	100	96	108	120	116	306
		Monsoon	193.3	114.4	132.2	117.7	111.1	106.6	120	133.3	128	340
TDS	mgL^{-1}	PRM	78.3	46.8	54	47.7	45	43.2	48.6	54	52.2	137.7
		POM	87	52	60	53	50	48	54	60	58	153
		Monsoon	96.6	57.7	66.6	58.8	55.5	53.3	60	66.6	64.4	170
Salinity	mgL^{-1}	PRM	0.21	0.18	0.18	0.16	0.18	0.17	0.06	0.06	0.06	0.21
		POM	0.16	0.14	0.14	0.12	0.14	0.13	0.05	0.05	0.05	0.16
		Monsoon	0.14	0.12	0.12	0.11	0.12	0.11	0.04	0.04	0.04	0.14
Turbidity	NTU	PRM	44	22	24.2	203.5	14.3	8.8	11	13.2	22	27.5
		POM	40	20	22	185	13	8	10	12	20	25
		Monsoon	35	17.5	19.2	161.8	11.3	7	8.75	10.5	17.5	21.8
Phosphate	mgL^{-1}	PRM	0.16	0.31	0.14	0.2	0.16	0.25	0.14	0.08	0.15	0.11
		POM	0.15	0.28	0.13	0.18	0.15	0.23	0.13	0.08	0.14	0.1
		Monsoon	0.13	0.25	0.15	0.15	0.15	0.20	0.11	0.07	0.12	0.08
Nitrate	mgL^{-1}	PRM	1.4	1.3	1	1.8	0.8	0.7	1.2	0.8	0.7	1
		POM	1.75	1.65	1.25	2.25	1	0.87	1.5	1	0.87	1.25
		Monsoon	1.26	1.17	0.9	1.62	0.72	0.63	1.08	0.72	0.63	0.9
Sulfate	mgL^{-1}	PRM	20	10	5	8	13	10	5	7	18	20
		POM	26.6	13.3	6.66	10.66	17.33	13.33	6.66	9.33	24	26.6
		Monsoon	16	8	4	6.4	10.4	8	4	5.6	14.4	16
Hardness	mgL^{-1}	PRM	20	20	80	40	40	60	20	40	60	20
		POM	26.6	26.6	106.6	53.3	53.3	80	26.6	53.3	80	26.6
		Monsoon	16	16	64	32	32	48	16	32	48	16
Alkalinity	mgL^{-1}	PRM	60	57.6	60.8	60	58.72	57.76	57.84	58.72	62.24	57.76
		POM	75	72	76	75	73.4	72.2	72.3	73.4	77.8	72.2
		Monsoon	65.625	63	66.5	65.6	64.2	63.1	63.2	64.2	68	63.1
Chloride	mgL^{-1}	PRM	30.4	0.34	0.68	0.03	0.11	0.2	0.17	0.34	3.21	3.59
		POM	32	0.36	0.72	0.04	0.12	0.22	0.18	0.36	3.38	3.78
		Monsoon	28.8	0.32	0.64	0.036	0.11	0.19	0.16	0.32	3.04	3.42
Acidity	mgL^{-1}	PRM	11.2	14.4	6.4	112	100	12.8	8	11.2	14.4	9.6
		POM	14	18	8	140	125	16	10	14	18	12
		Monsoon	12.2	15.7	7	122.5	109.3	14	8.7	12.2	15.7	10.5
BOD	mgL^{-1}	PRM	1.98	1.98	2.16	2.07	2.16	2.07	1.62	1.98	1.89	2.16
		POM	2.2	2.2	2.4	2.3	2.4	2.3	1.8	2.2	2.1	2.4
		Monsoon	2.09	2.09	2.28	2.18	2.28	2.18	1.71	2.09	1.99	2.28
COD	mgL^{-1}	PRM	36.9	59.4	65.52	20.7	33.3	80.46	70.2	60.3	65.52	50.4
		POM	41	66	72.8	23	37	89.4	78	67	72.8	56
		Monsoon	45.5	73.3	80.8	25.5	41.1	99.3	86.6	74.4	80.8	62.2

Table 3.4. Karnafuli River water resources quality from koutoli (South) to KumirarChor (North) at different seasons.

Parameters	units	Seasons	81. koutoli (South)	82. Kajibari (North)	83. Kajibari (South)	84.kalurghat (East)	85. Water supplier	86. Soyabin factory	87. Soyabin factory (South)	88. Kumirar chor (South)	89. Kumirar Chor	90. Kumirar Chor (North)
Temp.	(ºC)	PRM	26	26	26	26.1	26.1	25.9	26	25.8	25.9	26.1
		POM	23.8	23.8	23.8	23.9	23.9	23.7	23.	23.6	23.7	23.9
		Monsoon	28	28	28	28.1	28.	27.8	28	27.7	27.8	28.1
pH		PRM	7.4	7.3	7.4	7.4	7.2	6.9	7.2	7.1	7.3	7.3
		POM	7.8	7.7	7.8	7.8	7.6	7.3	7.6	7.5	7.7	7.7
		Monsoon	7.1	7	7.1	7.1	7	7	7	7	7	7
DO	mgL^{-1}	PRM	5.9	6.	6.5	6.	6.3	6.1	5.9	6	6.2	6.1
		POM	6.6	6.8	7.31	6.9	7	6.8	6.6	6.7	6.9	6.8
		Monsoon	6.2	6.4	6.9	6.5	6.6	6.4	6.2	6.3	6.5	6.4
EC	μscm^{-1}	PRM	774	1674.9	948.6	592.2	471.6	472.5	1672	1350	1458	1476
		POM	860	1861	1054	658	524	525	1858	1500	1620	1640
		Monsoon	955.5	2067.7	1171	731.1	582.2	583.3	2064.4	1666	1800	1822
TDS	mgL^{-1}	PRM	387	837	474.3	296.1	235.8	235.8	836.1	675	729	738
		POM	430	930	527	329	262	262	929	750	810	820
		Monsoon	477.7	1033.3	585.5	365.5	291	291.1	1032	833.3	900	911.1
Salinity	mgL^{-1}	PRM	0.18	0.58	1.1	0.12	0.46	0.34	0.34	1.2	1.12	0.093
		POM	0.14	0.44	0.82	0.092	0.35	0.26	0.26	0.92	0.84	0.07
		Monsoon	0.126	0.39	0.7	0.08	0.315	0.23	0.23	0.82	0.75	0.06
Turbidity	NTU	PRM	33	57.2	63.8	50.6	68.2	63.8	61.6	46.2	13.2	12.1
		POM	30	52	58	46	62	58	56	42	12	11
		Monsoon	26.2	45.5	50.7	40.2	54.2	50.7	49	36.7	10.5	9.6
Phosphate	mgL^{-1}	PRM	0.07	0.13	0.13	0.13	0.1	0.08	0.16	0.2	0.22	0.17
		POM	0.07	0.12	0.12	0.12	0.09	0.08	0.1	0.18	0.2	0.15
		Monsoon	0.06	0.10	0.10	0.10	0.07	0.07	0.13	0.15	0.17	0.13
Nitrate	mgL^{-1}	PRM	0.9	1.2	1.3	1	0.9	1.4	1.2	0.8	1	1.2
		POM	1.12	1.5	1.6	1.2	1.12	1.75	1.5	1	1.2	1.5
		Monsoon	0.81	1.08	1.17	0.9	0.81	1.26	1.08	0.72	0.9	1.08
Sulfate	mgL^{-1}	PRM	30	45	75	75	24	31	26	40	42	8
		POM	40	60	100	100	32	41.3	34.6	53.3	56	10.6
		Monsoon	24	36	60	60	19.2	24.8	20.8	32	33.6	6.4
Hardness	mgL^{-1}	PRM	40	60	240	120	80	80	80	140	240	60
		POM	53.33	80	320	160	106.6	106.	106.6	186. 7	320	80
		Monsoon	32	48	192	96	64	64	64	112	192	48
Alkalinity	mgL^{-1}	PRM	64.4	64.4	63.1	58.7	66.6	60.8	62.2	65.2	60.8	63.1
		POM	80.5	80.5	78.9	73.4	83.3	76.1	77.8	81.6	76.1	78.9
		Monsoon	70.4	70.4	69	64.2	72.8	66.5	68	71.4	66.5	69
Acidity	mgL^{-1}	PRM	6.4	8	4.8	9.6	16	9.6	6.4	9.6	12.8	8
		POM	8	10	6	12	20	12	8	12	16	10
		Monsoon	7	8.75	5.25	10.5	17.5	10.5	7	10.5	14	8.75
Chloride	mgL^{-1}	PRM	3.6	3.49	0.51	0.51	14.06	8.66	9.18	45.69	1.59	1.59
		POM	3.88	3.68	0.54	0.54	14.8	9.12	9.67	48.1	1.68	1.68
		Monsoon	3.49	3.33	0.48	0.48	13.32	8.20	8.70	43.29	1.51	1.51
BOD	mgL^{-1}	PRM	2.07	2.16	2.43	2.25	2.43	2.16	2.16	2.07	2.16	2.34
		POM	2.3	2.4	2.7	2.5	2.7	2.4	2.4	2.3	2.4	2.6
		Monsoon	2.18	2.28	2.56	2.37	2.56	2.28	2.28	2.18	2.28	2.47
COD	mgL^{-1}	PRM	60.3	50.4	68.4	70.56	42.3	33.3	65.52	56.7	50.4	42.3
		POM	67	56	76	78.4	47	37	72.8	63	56	47
		Monsoon	74.4	62.2	84.4	87.1	52.2	41.1	80.9	70	62.2	52.2

PRM= Pre-monsoon, POM= Post-monsoon

Table 3.5. Karnafuli River water resources quality from (Karnafuli Paper Mill to Meshinghat) and (Air port to Navy Gait) at different seasons.

Parameters	Units	Seasons	91. KPM	92. 250m South of KPM	93. Kola bagan	94. 400m South from	95. 250m KPM from	96. eshinghat	97. Air port	98. Merine Academy	99. KAFCO	100. Navy Gait
Temp.	(°C)	PRM	25.8	25.6	25.9	26.1	26	26.1	25.9	25.8	26	26.1
		POM	23.6	23.4	23.7	23.9	23.8	23.9	23.7	23.6	23.8	23.9
		Monsoon	27.7	27.5	27.8	28.1	28	28.1	27.8	27.7	28	28.1
pH		PRM	6.9	7.1	7.3	7.3	7.3	7.3	7.	7.3	7.2	7.5
		POM	7.3	7.4	7.7	7.7	7.7	7.7	7.6	7.7	7.6	7.7
		Monsoon	6.57	6.6	6.9	6.9	6.9	6.9	6.8	6.9	6.8	6.9
DO	mgL^{-1}	PRM	5.8	5.7	5.8	5.7	5.8	5.9	6.2	6.1	6	6.1
		POM	6.5	6.4	6.5	6.4	6.5	6.6	6.7	6.8	6.7	6.8
		Monsoon	6.1	6.1	6.1	6.1	6.1	6.2	6.3	6.4	6.3	6.4
EC	μscm^{-1}	PRM	183.6	161.1	155.7	156.6	180	171	162	156.6	180	1476
		POM	204	179	173	174	200	190	180	174	200	1640
		Monsoon	226.6	198.8	192.2	193.3	222.2	211	200	193.	222.2	1822
TDS	mgL^{-1}	PRM	91.8	80.55	77.85	78.3	90	85.5	81	78.3	90	738
		POM	102	89.5	86.5	87	100	95	90	87	100	820
		Monsoon	113.3	99.4	96.11	96.6	111.1	105.5	100	96.6	111	911.1
Salinity	mgL^{-1}	PRM	0.026	0.08	0.093	0.11	0.06	0.06	0.05	0.08	0.17	0.09
		POM	0.02	0.06	0.07	0.08	0.05	0.05	0.04	0.06	0.13	0.07
		Monsoon	0.018	0.054	0.063	0.072	0.045	0.045	0.03	0.054	0.11	0.06
Turbidity	NTU	PRM	11	19.8	22	26.4	22	17.6	24.2	19.8	22	12.1
		POM	10	18	20	24	20	16	22	18	20	11
		Monsoon	8.75	15.75	17.5	21	17.5	14	19.2	15.7	17.5	9.6
Phosphate	mgL^{-1}	PRM	0.12	0.16	0.24	0.13	0.1	0.11	0.1	0.34	0.13	0.17
		POM	0.11	0.15	0.22	0.12	0.09	0.1	0.09	0.3	0.12	0.15
		Monsoon	0.09	0.13	0.19	0.105	0.078	0.087	0.07	0.26	0.10	0.13
Nitrate	mgL^{-1}	PRM	0.9	1.4	1.1	0.7	1.2	0.8	1	0.9	1.1	1.2
		POM	1.125	1.75	1.375	0.875	1.5	1	1.25	1.125	1.3	1.5
		Monsoon	0.81	1.26	0.99	0.63	1.08	0.72	0.9	0.81	0.99	1.08
Sulfate	mgL^{-1}	PRM	8	12	13	22	20	12	14	10	16	8
		POM	10.6	16	17.3	29.3	26.6	16	18.6	13.3	21.3	10.6
		Monsoon	6.4	9.6	10.4	17.6	16	9.6	11.2	8	12.8	6.4
Hardness	mgL^{-1}	PRM	80	40	60	60	80	60	60	80	60	60
		POM	106.6	53.3	80	80	106.6	80	80	106.6	80	80
		Monsoon	64	32	48	48	64	48	48	64	48	48
Alkalinity	mgL^{-1}	PRM	89.2	95.52	104.4	97.76	78.32	86.64	87	95.8	98.1	63.1
		POM	111.5	119.4	130.5	122.2	97.9	108.3	108.8	119.8	122.7	78
		Monsoon	97.5	104.4	114	106	85.6	94.7	95.2	104.8	107.3	69
Acidity	mgL^{-1}	PRM	12.8	8	6.4	12.8	14.4	17.6	12.8	8	12.8	8
		POM	16	10	8	16	18	22	16	10	16	10
		Monsoon	14	8.75	7	14	15	19.2	14	8.7	14	8.7
Chloride	mgL^{-1}	PRM	1.4	1.	1.0	1.1	1.4	1.2	1.2	1.4	1.2	1.2
		POM	1.4	1.1	1.1	1.1	1.4	1.2	1.2	1.4	1.2	1.2
		Monsoon	1.3	0.9	0.9	0.9	1.3	1.1	1.1	1.3	1.16	1.16
BOD	mgL^{-1}	PRM	2.1	1.8	1.8	1.8	1.8	1.9	1.8	2.4	2.1	1.89
		POM	2.4	2.1	2	2	2	2.2	2.1	2.7	2.4	2.1
		Monsoon	2.28	1.9	1.9	1.9	1.9	2	1.9	2.5	2.28	1.9
COD	mgL^{-1}	PRM	190.8	140.4	190.8	196.2	181.8	190.8	201.6	181	140.4	190.8
		POM	212	156	212	218	202	212	224	202	156	212
		Monsoon	235.5	173.3	235.5	242.2	224.4	235	248.8	224.4	173.3	235.5

PRM= Pre-monsoon, POM= Post-monsoon, KPM=Karnafuli Paper Mill

Table 4.1. Comparative study of Karnafuli River water resources quality (Sikolbaha canal to Anumajhirghat) with inter country rivers (Halda, Meghna and Sangu) and standard value (WHO and BSTI).

Parameters	Units	Min	Max	Mean	Halda	Sangu	Meghna	WHO	BSTI
Temp	(°C)	28.2	30.1	28.8 ± 0.5*	30	28	31.50		
pH		7.5	8.2	7.59 ± 0.2	6.5	6.8	7.61	6.5-8.5	6.4-7.4
DO	mgL^{-1}	0.9	6.9	2.01 ± 0.1	6.25	5.4	6.85	Max. 6.5-8.5	Min. 6
EC	μscm^{-1}	112	782	378.9 ± 5.6	133	240	415.00		
TDS	mgL^{-1}	56	391	189.5 ± 1.08	66.5	120	207.40	Max1000	Max. 500
Salinity	mgL^{-1}	0.1	0.4	0.14 ± 0.02	0.06	0.15			
Turbidity	NTU	37	120	72.02 ± 4.4	105	70		Max. 5	5
Phosphate	mgL^{-1}	0.28	2.14	1.336 ± 0.07	1.3	1.1	3.68		Max 66
Nitrate	mgL^{-1}	0.8	6.6	2.334 ± 0.25	4	6	4.76	Max. 4.5	Max.10
Sulfate	mgL^{-1}	2.9	61	21.07 ± 1.6	17	20	12.50	Max. 400	Max 400
Hardness	mgL^{-1}	60	200	104 ± 4.6	80	140	92.00	Max. 500	Max 500
Alkalinity	mgL^{-1}	55.56	111.1	80.57 ± 1.6	55	72	50.75		Max 500
Acidity	mgL^{-1}	1	16	8.2 ± 0.56	9	14	15.47		
CO_2	mgL^{-1}	0.88	16	8.9 ± 0.8	8	12			
Cl^-	mgL^{-1}	1.67	8.34	4.975 ± 0.2	4.5	8	36.59	Max. 600	Max. 250
BOD	mgL^{-1}	4.1	1.3	2.88± 0.77	1.3	1.2	1.68		Max. 4
COD	mgL^{-1}	56	358	143.2 ± 3.1	37	50	6.38		Max. 0.2

*** The measure of precision is the standard deviation (s)**
WHO= World Health Organization
BSTI= Bangladesh Standards and Testing Institute
Max= Maximum.
Min= Minimum.

Table 4.2. Comparative study of Karnafuli River water resources quality from Banglabazarghat to Power point with inter country rivers (Halda, Meghna and Sangu) and standard value (WHO and BSTI).

Parameters	Units	Min	Max	Mean	Halda	Sangu	Meghna	WHO	BSTI
Temp	(ºC)	28.4	29.4	28.76 ± 0.25*	30	28	31.50		
pH		7.2	7.8	7.48 ± 0.15	6.5	6.8	7.61	6.5-8.5	6.4-7.4
DO	mgL^{-1}	5	6.7	6.32 ± 0.55	6.25	5.4	6.85	Max. 6	Min. 6
EC	μscm^{-1}	116	266	162.7 ± 2.5	133	240	415.00		
TDS	mgL^{-1}	58	133	81.4 ± 1.3	66.5	120	207.40	Max1000	Max. 500
Salinity	mgL^{-1}	0.05	0.1	0.087 ± 0.018	0.06	0.15			
Turbidity	NTU	57	126	82.4 ± 2.3	105	70		Max. 5	5
Phosphate	mgL^{-1}	0.01	3.4	0.704 ± 0.013	1.3	1.1	3.68		Max 66
Nitrate	mgL^{-1}	0.2	3.7	1.47 ± 0.3	4	6	4.76	Max. 4.5	Max.10
Sulfate	mgL^{-1}	9	45	19.8 ± 1.2	17	20	12.50	Max. 400	Max 400
Hardness	mgL^{-1}	40	60	48 ± 1.32	80	140	92.00	Max. 500	Max 500
Alkalinity	mgL^{-1}	44.4	94.4	63.29 ± 1.2	55	72	50.75		Max 500
Acidity	mgL^{-1}	6	40	14.4 ± 1.65	9	14	15.47		
CO_2	mgL^{-1}	2	40	14.8 ± 1.67	8	12			
Cl^-	mgL^{-1}	0.93	3.52	2.111 ± 0.096	4.5	8	36.59	Max. 600	Max. 250
BOD	mgL^{-1}	0.7	2.4	1.98 ± 0.053	1.3	1.2	1.68		Max. 4
COD	mgL^{-1}	115	235	143.2 ± 3.1	37	50	6.38		Max. 0.2

*** The measure of precision is the standard deviation (s)**
WHO= World Health Organization
BSTI= Bangladesh Standards and Testing Institute
Max= Maximum.
Min= Minimum.

Table 4.3. Comparative study with Karnafuli River water resources quality from under Karnafuli Bridge to JD No. 1.with inter country rivers (Halda,Meghna and Sangu) and standard value (WHO and BSTI).

Parameters	Units	Min	Max	Mean	Halda	Sangu	Meghna	WHO	BSTI
Temp	(ºC)	28.7	28.9	28.76± 0.19*	30	28	31.50		
pH		7.2	7.6	7.34 ± 0.15	6.5	6.8	7.61	6.5-8.5	6.4-7.4
DO	mgL^{-1}	6.6	7.1	6.82 ± 0.15	6.25	5.4	6.85	Max. 6	Min. 6
EC	μscm^{-1}	108	456	224.3 ± 11.4	133	240	415.00		
TDS	mgL^{-1}	54	228	115.7 ± 1.2	66.5	120	207.40	Max1000	Max. 500
Salinity	mgL^{-1}	0.03	0.15	0.077 ± 0.004	0.06	0.15			
Turbidity	NTU	62	104	76 ± 1.13	105	70		Max. 5	5
Phosphate	mgL^{-1}	0.03	2.9	0.532 ± 0.028	1.3	1.1	3.68		Max 66
Nitrate	mgL^{-1}	0.03	1.6	0.636 ± 0.073	4	6	4.76	Max. 4.5	Max.10
Sulfate	mgL^{-1}	11	38	17.2 ± 0.5	17	20	12.50	Max. 400	Max 400
Hardness	mgL^{-1}	40	80	52 ± 1.96	80	140	92.00	Max. 500	Max 500
Alkalinity	mgL^{-1}	48.1	77.7	60.05 ± 1.54	55	72	50.75		Max 500
Acidity	mgL^{-1}	8	16	11.8 ± 0.53	9	14	15.47		
CO_2	mgL^{-1}	2	12	7.8 ± 0.27	8	12			
Cl^-	mgL^{-1}	0.93	5.37	2.112 ± 0.025	4.5	8	36.59	Max. 600	Max. 250
BOD	mgL^{-1}	1.8	2.5	152.7 ± 3.23	37	50	6.38		Max. 4
COD	mgL^{-1}	130	224	2.249 ± 0.022	1.3	1.2	1.68		Max. 0.2

*** The measure of precision is the standard deviation (s)**
WHO= World Health Organization
BSTI= Bangladesh Standards and Testing Institute
Max= Maximum.
Min= Minimum.

Table 4.4. Comparative study with Karnafuli River water resources quality from JD No. 2 to JD No.10.with inter country Rivers (Halda,Meghna and Sangu) and standard value (WHO and BSTI).

Parameters	Units	Min	Max	Mean	Halda	Sangu	Meghna	WHO	BSTI
Temp	(°C)	28.8	28.9	28.82 ± 0.19*	30	28	31.50		
pH		7.3	7.6	7.4 ± 0.15	6.5	6.8	7.61	6.5-8.5	6.4-7.4
DO	mgL^{-1}	6.6	6.9	6.76 ± 0.15	6.25	5.4	6.85	Max. 6	Min. 6
EC	μscm^{-1}	318	1950	795.1 ± 11.4	133	240	415.00		
TDS	mgL^{-1}	159	975	497.6 ± 6.2	66.5	120	207.40	Max1000	Max. 500
Salinity	mgL^{-1}	0.11	0.42	0.244 ± 0.04	0.06	0.15			
Turbidity	NTU	36	74	61.7 ± 1.13	105	70		Max. 5	5
Phosphate	mgL^{-1}	0.14	0.82	0.386 ± 0.028	1.3	1.1	3.68		Max 66
Nitrate	mgL^{-1}	0.8	2.6	1.26 ± 0.073	4	6	4.76	Max. 4.5	Max.10
Sulfate	mgL^{-1}	12	58	35.3 ± 1.05	17	20	12.50	Max. 400	Max 400
Hardness	mgL^{-1}	80	220	40 ±0.96	80	140	92.00	Max. 500	Max 500
Alkalinity	mgL^{-1}	51.6	77	68.25 ± 0.54	55	72	50.75		Max 500
Acidity	mgL^{-1}	8	16	11 ± 0.53	9	14	15.47		
CO_2	mgL^{-1}	8	18	11.4 ± 0.27	8	12			
Cl^-	mgL^{-1}	2.96	52.8	14.60 ± 1.61	4.5	8	36.59	Max. 600	Max. 250
BOD	mgL^{-1}	1.5	2.4	164 ± 3.23	37	50	6.38		Max. 4
COD	mgL^{-1}	112	202	2.16 ± 0.022	1.3	1.2	1.68		Max. 0.2

*** The measure of precision is the standard deviation (s)**
WHO= World Health Organization,
BSTI= Bangladesh Standards and Testing Institute
Max= Maximum.
Min= Minimum.

Table 4.5 Comparative study with Karnafuli River water resources quality from Super Petrochemical to Dhanar canal (North) with inter country rivers (Halda, Meghna and Sangu) and standard value (WHO and BSTI).

Parameters	Units	Min	Max	Mean	Halda	Sangu	Meghna	WHO	BSTI
Temp	(°C)	28.7	28.9	28.68 ± 0.09*	30	28	31.50		
pH		7.4	7.6	7.48 ± 0.11	6.5	6.8	7.61	6.5-8.5	6.4-7.4
DO	mgL^{-1}	6.6	6.8	6.66 ± 0.67	6.25	5.4	6.85	Max. 6	Min. 6
EC	μscm^{-1}	620	1012	697.3 ± 2.09	133	240	415.00		
TDS	mgL^{-1}	310	506	362 ± 1.04	66.5	120	207.40	Max1000	Max. 500
Salinity	mgL^{-1}	0.12	0.98	0.384 ± 0.023	0.06	0.15			
Turbidity	NTU	48	74	62.2 ± 0.46	105	70		Max. 5	5
Phosphate	mgL^{-1}	0.06	2.7	0.57 ± 0.01	1.3	1.1	3.68		Max 66
Nitrate	mgL^{-1}	0.06	0.8	0.478 ± 0.02	4	6	4.76	Max. 4.5	Max.10
Sulfate	mgL^{-1}	32	75	43.5 ± 1.0	17	20	12.50	Max. 400	Max 400
Hardness	mgL^{-1}	40	100	54 ± 2.2	80	140	92.00	Max. 500	Max 500
Alkalinity	mgL^{-1}	70.7	130.5	80.328 ± 1.98	55	72	50.75		Max 500
Acidity	mgL^{-1}	8	12	9.6 ± 0.57	9	14	15.47		
CO_2	mgL^{-1}	6	10	8.8 ± 0.39	8	12			
Cl^-	mgL^{-1}	1.85	29.1	12.625 ± 1.49	4.5	8	36.59	Max. 600	Max. 250
BOD	mgL^{-1}	2	2.8	93.1 ± 0.02	37	50	6.38		Max. 4
COD	mgL^{-1}	46	146	2.37 ± 0.02	1.3	1.2	1.68		Max. 0.2

*** The measure of precision is the standard deviation (s)**
WHO= World Health Organization
BSTI= Bangladesh Standards and Testing Institute
Max= Maximum.
Min= Minimum.

Table 5. Pearson Correlations among the different parameters of Karnafuli River**.**

	Temperature	pH	DO	EC	TDS	Salinity	Turbidity	PO_4^{3-}	NO_3^-	SO_4^{2-}	Hardness	Alkalinity	Acidity	CO2	Cl^-	BOD	COD
Temperature	**1**	**-.289 (**)**	**-.298 (**)**	**-.102**	**-.096**	**-.125**	**.661 (**)**	**.428 (**)**	**.123**	**.074**	**-.280 (**)**	**-.340 (**)**	**-.092**	**-.200 (*)**	**.060**	**-.027**	**.336 (**)**
pH	**-.289 (**)**	**1**	**-.137**	**-.149**	**-.148**	**-.031**	**-.232 (*)**	**.087**	**.043**	**-.064**	**-.054**	**.088**	**.103**	**.102**	**-.326 (**)**	**-.097**	**-.043**
DO	**-.298 (**)**	**-.137**	**1**	**.099**	**.102**	**.078**	**-.173**	**-.534 (**)**	**-.527 (**)**	**.078**	**-.208 (*)**	**-.077**	**.111**	**.066**	**.120**	**-.438 (**)**	**-.666 (**)**
EC	**-.102**	**-.149**	**.099**	**1**	**.999 (**)**	**.667 (**)**	**.020**	**-.151**	**.067**	**.483 (**)**	**.462 (**)**	**-.064**	**-.188**	**-.069**	**.591 (**)**	**.111**	**-.263 (**)**
TDS	**-.096**	**-.148**	**.102**	**.999 (**)**	**1**	**.665 (**)**	**.021**	**-.153**	**.061**	**.480 (**)**	**.464 (**)**	**-.068**	**-.183**	**-.071**	**.593 (**)**	**.116**	**-.264 (**)**
Salinity	**-.125**	**-.031**	**.078**	**.667 (**)**	**.665 (**)**	**1**	**.014**	**-.137**	**.074**	**.713 (**)**	**.553 (**)**	**.137**	**-.113**	**-.031**	**.428 (**)**	**.127**	**-.203 (*)**
Turbidity	**.661 (**)**	**-.232 (*)**	**-.173**	**.020**	**.021**	**.014**	**1**	**.321 (**)**	**-.018**	**.060**	**-.039**	**-.345 (**)**	**-.216 (*)**	**-.185**	**.081**	**.058**	**.203 (*)**
Phosphate	**.428 (**)**	**.087**	**-.534 (**)**	**-.151**	**-.153**	**-.137**	**.321 (**)**	**1**	**.271 (**)**	**-.070**	**-.001**	**-.011**	**-.016**	**.202 (*)**	**-.135**	**-.058**	**.325 (**)**
Nitrate	**.123**	**.043**	**-.527 (**)**	**.067**	**.061**	**.074**	**-.018**	**.271 (**)**	**1**	**.009**	**.205 (*)**	**.087**	**.010**	**.014**	**-.026**	**.223 (*)**	**.417 (**)**
Sulfate	**.074**	**-.064**	**.078**	**.483 (**)**	**.480 (**)**	**.713 (**)**	**.060**	**-.070**	**.009**	**1**	**.345 (**)**	**.115**	**-.119**	**-.077**	**.367 (**)**	**.075**	**-.133**
Hardness	**-.280 (**)**	**-.054**	**-.208 (*)**	**.462 (**)**	**.464 (**)**	**.553 (**)**	**-.039**	**-.001**	**.205 (*)**	**.345 (**)**	**1**	**.124**	**-.102**	**-.051**	**.327 (**)**	**.387 (**)**	**.012**
Alkalinity	**-.340 (**)**	**.088**	**-.077**	**-.064**	**-.068**	**.137**	**-.345 (**)**	**-.011**	**.087**	**.115**	**.124**	**1**	**.003**	**.184**	**.076**	**-.034**	**.222 (*)**
Acidity	**-.092**	**.103**	**.111**	**-.188**	**-.183**	**-.113**	**-.216 (*)**	**-.016**	**.010**	**-.119**	**-.102**	**.003**	**1**	**.222 (*)**	**-.133**	**-.199 (*)**	**-.042**
CO2	**-.200 (*)**	**.102**	**.066**	**-.069**	**-.071**	**-.031**	**-.185**	**.202 (*)**	**.014**	**-.077**	**-.051**	**.184**	**.222 (*)**	**1**	**-.003**	**-.151**	**-.101**
Cl^-	**.060**	**-.326 (**)**	**.120**	**.591 (**)**	**.593 (**)**	**.428 (**)**	**.081**	**-.135**	**-.026**	**.367 (**)**	**.327 (**)**	**.076**	**-.133**	**-.003**	**1**	**.039**	**-.313 (**)**
BOD	**-.027**	**-.097**	**-.438 (**)**	**.111**	**.116**	**.127**	**.058**	**-.058**	**.223 (*)**	**.075**	**.387 (**)**	**-.034**	**-.199 (*)**	**-.151**	**.039**	**1**	**.343 (**)**
COD	**.336 (**)**	**-.043**	**-.666 (**)**	**-.263 (**)**	**-.264 (**)**	**-.203 (*)**	**.203 (*)**	**.325 (**)**	**.417 (**)**	**-.133**	**.012**	**.222 (*)**	**-.042**	**-.101**	**-.313 (**)**	**.343 (**)**	**1**

****Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).**

Discussion

Temperature

Temperature is an important water quality parameter affecting ions and phase equilibria and influencing the rates of biochemical processes, which accompany changes of concentration and of the content of organic and mineral substances. Percent saturation of water containing a given amount of gas varies with the absolute temperature and with the pressure. Solubility of gases and amount of dissolved oxygen decreases with rising temperature while the rate of biochemical activity often double for every 10^0C increases in temperature. Decrease of dissolved oxygen is one of the causes of death of aquatic life. Ambient temperature (AT) of the Karnafuli River water (**Table 1.1-Table 1.10**) shows that at most sampling time ambient temperature was found between (25.0–29.0) ^{0}C. Highest temperature 30.1^{0}C was found in Majhirghat point.

pH

The descriptive statistics of the Karnafuli River pH value (**Table 1.1-Table 1.10**) shows that most of the samples were found in the alkaline pH range i.e. within the CCC limit. Histogram of sample pH of the Karnafuli River water shows that most of the samples have pH between 7.10-7.80. Highest value (8.20) was found in Sikol Baha Canal point. pH was found positively correlated with PO_4^{3-}, NO_3^-, Alkalinity, Acidity, CO_2. Higher values of almost all the points is higher than the value reported for Bareilly by Gangwara *et al*. where mean pH varied from 8.1 to 8.8 **[7].** The chemistry of marine waters differs from that of fresh water because of the large concentration of salts present. In addition to alkalinity based on the carbonate system, there is also alkalinity from other weak acid salts such as borate. Because of the buffering system present in seawater, the naturally occurring variability of pH is less than in fresh water.

Dissolved Oxygen (DO)

The optimal DO concentration for fish health is 5.00-mgL^{-1} and most species become distressed when levels drop to 4.00-mgL^{-1} to 2.00-mgL^{-1}. DO is also important for the microbial breakdown of waste in the water and for chemical reactions. GoB (1997) suggested DO level of (4-6)-mgL^{-1} for water used in irrigation, recreation and fisheries purposes. Surface water DO at different sampling locations of the Karnafuli River was measured. The values shown in **Table 1.1** that most of the samples have DO value between (0.90-1.80)-mgL^{-1}. A few samples also have greater than 7.00-mg L^{-1} (**Table 1.6**). Lowest value of DO 0.90-mg L^{-1} was found in Jalilgang canal point. DO was found positively correlated with EC, TDS, Salinity, SO_4^2, Acidity, CO_2 and Cl^-. According to Mishra *et al.* DO present in drinking water adds taste and it is highly fluctuating factor in water **[12].** DO value of the Karnafuli River varied with tide, season and location.

Electrical conductivity

The EC of irrigation water is important because it is a measure of the salinity of the water. EC test does not identify the dissolved salts or the effects they may have on crop or soil, but it does indicate whether a salinity problem is likely to occur. Figure of EC of the Karnafuli River water shows (**Table 1.2, 1.3, 1.4 1.7** and **1.8**) that almost all the samples have EC values within (100.00 to 400.00)-µscm^{-1}, the FAO guidelines for irrigation water is 700.00-µscm^{-1}. Highest value (1950.00-µscm^{-1}) was found in J. D. No.9 point. Lowest value (96.00-µscm^{-1}) was found in

Fakira khali (Southpara). EC was found positively correlated with pH, DO, EC, TDS, Salinity, Turbidity, NO_3^-, SO_4^{2-}, Cl^-, BOD and Hardness.

Total dissolved solids (TDS)

Dissolved solids are the portion of solids that passes through a filter of 2.00-µm (or smaller) pore size under specified conditions. The presence of dissolved solids in water may affect its taste. Waters with high dissolved solids generally are of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer. For this reason, a limit of 500-mgL^{-1} is desirable for drinking waters. Figure of Total dissolved solids (TDS) of the Karnafuli River water shows **(Table 1.2, 1.3, 1.4, 1.7** and **1.8)** a similar trend as that of EC. Highest value (975.00-mg L^{-1}) was found in J. D. No.9 point and lowest value (48.00-mg L^{-1}) was found in Fakira khali (southpara) point. TDS was found positively correlated with pH, DO, EC, TDS, Salinity, Turbidity, NO_3^-, SO_4^{2-}, Cl^-, BOD and Hardness. Elevated amount of TDS found at the estuary of the Karnafuli River is mainly due to the effect of sea water.

Phosphate

Phosphate of the Karnafuli River water samples revealed that most of the samples have o-phosphate-P value below 5.00-mgL^{-1}.High value of phosphate was observed in Chittagong (Barotakia, Mirsharai 9.3- mgL^{-1}) district shown in **(Table 3)** are beyond the Bangladesh Standard Testing Institute (BSTI) limit for drinking water. Phosphate was found positively correlated with chloride. Phosphate was found positively correlated with EC, TDS, salinity, total alkalinity and negatively correlated with pH.

Nitrate

In quantities normally found in food or feed, nitrates become toxic only under conditions in which they are, or may be, reduced to nitrites. Otherwise, at reasonable concentration nitrates are rapidly excreted in the urine. Nitrate of the Karnafuli River water shows (**Table 1.1-Table 1.10**) that most of the samples have nitrate value below 2.00-mgL^{-1}. Highest value (6.6-mgL^{-1}) was found at high and low tides in winter at Fisharighat canal point and lowest value (0.2-mgL^{-1}) was found at Ajgajja para point. Nitrate was found positively correlated with Temperature, pH, EC, TDS, Salinity, NO_3^-, SO_4^{2-}, Hardness, Alkalinity, Acidity, CO_2, BOD and COD.

Sulfate

Sulfate of the Karnafuli River water shows **(Table 1.1-Table 1.10**) that all the samples have sulfate value around 80.00-mgL^{-1}. Highest value (75.00-mgL^{-1}) was found at Super petrochemical and lowest value (2.9-mgL^{-1}) was found at Karnafulighat point. Sulfate was found positively correlated with Temperature, Turbidity, Salinity, TDS, EC, NO_3^-, SO_4^{2-} and Hardness.

Total hardness

Hardness is measured by soap requirements for adequate lather formation and as an indicator of the rate of scale formation in hot water heaters and low pressure boilers. Dissolved polyvalent metallic ions from sedimentary rocks, seepage and run-off from soils are the principal natural sources of hardness in water. With the predominance of calcium and magnesium ions, other ions e.g. iron, strontium, barium, zinc and manganese also contribute to the surface water hardness in

extent that appreciable concentrations are present. The hardness of the Karnafuli River water shows (**Table 1.1-Table 1.10)** that most of the samples have total hardness below 80.00-mgL^{-1}. Highest value (240.00-mgL^{-1}) was found at Kumirar Chor point and lowest value (20.00-mgL^{-1}) was found at Boalkhali (Sourth) point. Total hardness varied with tide, season and location and has similar trend as EC and TDS. Total hardness was found positively correlated with COD, BOD, Cl^-, EC, TDS, Salinity, NO_3^-, SO_4^{2-}, Hardness and Alkalinity. According to **Aris et al**. dissolution of carbonate minerals characterized by high loadings of Ca, Zn and Mg, dominated by the significant role of anthropogenic impact from the over abstraction of fresh water from the aquifer **[14].** But this study reveals that total hardness of the Karnafuli River is mainly for sea water of the Bay of Bengal.

Alkalinity

The alkalinity is equal to the stoichiometric sum of the bases in solution. In the natural environment carbonate alkalinity tends to make up most of the total alkalinity due to the common occurrence and dissolution of carbonate rocks and presence of carbon dioxide in the atmosphere. Histogram of total alkalinity of the Karnafuli River water shows (**Table 1.1-Table 1.10)** that most of the samples have alkalinity around 50-mgL^{-1}-120.00-mgL^{-1}. Highest value (130.57-mgL^{-1}) was found at Super petrochemical point and lowest value (18.18-mgL^{-1}) was found at Kumirar chor (north) point. Total alkalinity was found positively correlated with pH, TS and BOD. As phenolphthalein alkalinity was not found for any of the samples analyzed, total alkalinity is mainly due to carbonates and bicarbonates. According to Kar et al. river water of the Ganga exhibited a slightly alkaline pH and the conductivity apparently increased along the downstream due to the tidal effect of Bay of Bengal **[13].** Similar trend was also observed for this river also.

Acidity

Acidity is not a specific pollutant and it is a measure of the effects of combination of substances and conditions in water. The acidity of the Karnafuli River water shows (**Table 1.1-Table 1.10)** that most of the samples were found in the acidity range (4.00-20)-mgL^{-1}. Highest value 40.00-mgL^{-1} was found at Boalkhali Teksho canal point. Acidity was found positively correlated with pH, DO, NO_3^-, Alkalinity, Acidity and CO_2. The pH most of the samples was found more than 6, consequently CO_2 acidity is the only acidity present. Samples contaminated with acidic waste will have a pH below 4.5 and contain both mineral and CO_2 acidity.

Carbon dioxide

Carbon dioxide of the Karnafuli River water shows **(Table 1.1-Table 1.10**) that most of the samples were found between 7.00-mgL^{-1}- 21.00-mgL^{-1}. Highest value (55.00-mgL^{-1}) was found at Water supplier point. Dissolved CO_2 usually is the major acidic component of unpolluted surface waters. *Researchers found that the CO_2 plays a crucial role in climate change, so that the rising sea level could gravely affect our future. The ocean is a sink for carbon dioxide*.

Chloride

Chloride is one of the major inorganic anions in water and wastewater. The salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water. Some waters containing 250.00-mgL^{-1} chloride ion (Cl^-) may have a detectable salty taste if the

cation is sodium. On the other hand, the typical salty taste may be absent in waters containing as much as 1000.00-mgL^{-1} when the predominant cations are calcium and magnesium. Along the sea coast, chloride may be present in high concentrations because of leakage of salt water into the natural water distribution system. Industrial processes also may increase it. High chloride content may harm metallic pipes and structures as well as growing plants. Chloride of the Karnafuli River water shows **(Table 1.1-Table 1.10)** that most of the samples have chloride around 50.00-mgL^{-1}. Highest value (52.74-mgL^{-1}) was found at 9 No. JD point and lowest value (0.24-mgL-1) was found at Ramurhat (middle para) point. Chloride was found positively correlated with Cl^-, BOD, pH, DO, Acidity, Alkalinity, NO_3^- and PO_4^{3-}. Chloride content of the Karnafuli River is mainly for sea water of the Bay of Bengal.

Biochemical oxygen demand (BOD)

This is a water quality parameter for organic mater in water, which is empirical in nature. The BOD of the Karnafuli River water shows **(Table 1.1-Table 1.10)** that most of the samples have BOD value below 5.00-mgL^{-1}. Highest value (4.1.00-mgL^{-1}) was found at Chaktaikhal point and lowest value (1.3.00-mgL^{-1}) was found at Sikolbaha canal point. BOD was found positively correlated with total EC, TDS, Salinity, Turbidity, SO_4^{2-}, Hardness, Cl^-, BOD and COD. Higher values are found for most of the points except River mouth and Kaptai. The reason for lower value of BOD at river mouth and Kaptai is that polluted river water cannot reach to Kaptai due to flow of eater from Kaptai Dam and at the River mouth point polluted water gets diluted by the sea water from the Bay.

Chemical oxygen demand (COD)

COD of the Karnafuli River water shows **(Table 1.1-Table 1.10)** that most of the samples have COD value below 300.00-mgL^{-1}. Highest value (358.40-mgL^{-1}) was found at Jalilgang canal point and lowest value (34.00-mgL^{-1}) was found Ramurhat (middle para) point. COD values are generally higher than the BOD values because certain organic substances which are difficult to get oxidized by common microbial oxidants easily undergo chemical oxidation with strong oxidizing agents. COD was found positively correlated COD, BOD, Temperature, Turbidity, PO_4^{3-}, NO_3^-, SO_4^{2-}, Hardness and Alkalinity.

Conclusions and Recommendations

The main source of pollutants is generating both from inorganic and organic wastes were found to originate from industrial and agricultural activities, unsustainable development and household activities of local people. These waste materials were ultimately contaminating the Karnafuli River water. Due to this spawning of carps are decreasing gradually and lesser quantities of fish eggs are being harvested nowadays. Peoples are suffering from different types of water born diseases of these areas. Peoples of the holly regions are using acidic water continuous consumption may cause gastric and ulcer to them. The summary of the Karnafuli River water quality is presented in **Table 1.1-1.10.** It clearly indicates that this river water is not suitable for domestic purpose use. Values found for the key water quality parameters e.g.BOD (max. 4.1-mgL^{-1}), COD (max. 358.4-mgL^{-1}), TDS (975-mgL^{-1}) were several times higher and DO 0.9-mgL^{-1} was lower than the prescribed standard for freshwater bodies. From the present

physicochemical study of the Karnafuli River of greater Chittagong district, it can be concluded that the studied physicochemical parameters such as TDS,EC,COD,BOD most of sport of Karnafuli River were found to be quite higher than the recommendation values set by the Department of Environment (DoE), BSTI, WHO and the Dissolve Oxygen (DO) values of first 10 sports were found much lower 0.9-1.8-mgL^{-1} (Raja Khali Canal, Chaktai Canal, Fisharighat canal, Jalilgang canal, Bangobari Canal, Firingibazar Canal, Karnafulighat, Majhirghat and Anumajhirghat) that of the DO limit recommended by BSTI and WHO. Again pH values of the Karnafuli River most of the sports were recorded higher than the 7. This higher pH values indicate that the Karnafuli River water partially alkaline. Again most of anions e.g. Cl^-, NO_3^-, PO_4^{3-}, SO_4^{2-}were founded to be permissible limit. Besides, these alkalinity, hardness and turbidity etc. were not good conditions. Comparison of water quality of the Halda, Karnafuli and Sangu **Table 4.1-.4.5** shows that Karnafuli is most polluted among the rivers of this region. The urban runoff and industrial waste water discharged in the Karnafuli were the major threat of the river water quality at Chittagong. Like other city belt rivers the Karnafuli is loosing its water quality day by day. From our chemical analyses we saw that some of the water quality parameters have existed within the tolerance limits. Still it is the prime to control the pollution of Karnafuli River before it had been turned into a dead river. So it is very much necessary for more research on this river and increase people awareness about the effect and remedies of pollution. Result from this study show that Karnafuli River of greater Chittagong district is toxic in nature. This affects not only the aquatic environmental and human beings of the surroundings but also poses a serious threat to Karnafuli River water resources of the adjoining areas. For this reason from the agriculture fields, irrigated by these polluted rivers' water of Chittagong region. It is possible that wastewater may have entered in food chain.

- This study has direct impact on economy of our country, human health and standards for our drinking water, agricultural, industrial and livestock requirements.
- In order to create public awareness about the freshwater pollution due to the discharge of untreated industrial wastewater, this article will be published in national magazines, newspapers and international journal.

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Conflicts of Interest

There are no conflicts to declare.