

A STUDY ON WATER QUALITY OF *HAIL HAOR* ECOSYSTEM OF BANGLADESH

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During the last few decades, agricultural activities have been expanded in the wetland areas of *Hail haor*, which affected the wetland ecosystem adversely. There are some common natures of pollutions with domestic sewage, pesticides, insecticides, fertilizers, and industrial pollutants discharged from the upper catchment tea gardens and forest sites. The other threats are flood control dams, conversion of wetlands for agriculture or brickfields, human settlements, deforestation, extraction of sands or peats, algal blooms, etc. Therefore, water quality control is a top-priority agenda in many parts of the world (WHO 2011) and of course in Bangladesh. It becomes very important to assess the water quality of the *haor* basin ecosystem. For this reason, a study was conducted to analyze some important physicochemical parameters of water resources of the *Hail haor* ecosystem. Water samples were collected in four seasons viz monsoon (June-August), summer (September-November), winter (December-February) and post winter (March-May) from some selected spots. The bottles used for sampling were rinsed with deionized water and dried. At each sampling station, the sampling bottles were rinsed at least three times before samples were collected by immersing about 10 cm below the surface water. Water samples were collected in clean and opaque screw capped plastic bottles, wrapped up with aluminum foil, preserved in the refrigerator. The samples were filtered through 0.45 µm micro-pore Whitman filter paper and were kept at freeze to avoid further contamination. The parameters pH, EC (Electrical Conductivity), TDS (Total Dissolved Solids) and DO (Dissolved Oxygen) were measured by digital pH, EC, TDS, and DO meters, respectively. A digital thermometer determined the temperature of the water. The BOD₅ was determined by measuring initial DO₁ and DO₅ after 5 days incubation in the dark condition at 20°C (Klein and Gibbs 1979). Alkalinity was measured as CaCO₃ by

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titration of the water samples to an endpoint pH of 4.5 corresponding to the endpoint of the bromocresol green-methyl red indicator (APHA 2012). Ammonia-N contents of water were analyzed by micro Kjeldahl's distillation method (Jackson 1967). Nitrate-N contents were determined by the colorimetric method using a fixed absorbance in a UV-VIS spectrophotometer (Armstrong 1963). COD, chloride, and sulfate were determined by the USEPA Reactor Micro-digestion method, Titrimetrically, and Turbidimetrically, respectively (Jirka and Carter 1975, APHA 2012). The results of all the water quality parameters for *Hail haor* is presented in Table 1.

The highest temperature of *Hail haor* water was 29.78°C in June, and the lowest was 22.45°C in February, whereas the mean temperature was 25.90°C. In the winter season, the water temperature varies from 22.45 to 24.75°C and 26.20 to 27.0°C during the dry season, which was found within the standard limits (EQS 1997 and DoE 2017). In River water temperature, the DoE standard for sustaining aquatic life is 20 to 30°C both in dry and wet seasons. The highest pH of *Hail haor* water was recorded at 7.67 in February, and the lowest was 6.88 in June, with the mean pH value of 7.12. The standard limits of pH range were 6.5 to 8.5 (ADB 1994, EQS 1997, De 2005, WHO 2011 and DoE 2017), and the study showed that all of the values were within the standard limits. The pH in both wet and dry seasons was favorable for fisheries and other aquatic organisms. The highest EC of the water was found 186.75 ds/m in February and the lowest was 53.81 in June, and the mean EC was 115.63 ds/m and the standard limit of EC in water is 700 ds/m (EQS 1997, DoE 2017) and the study showed that all the observed EC were within the standard limits. The acceptable range of EC for irrigation water is 750 ds/m and aquaculture water are 800 to 1000 ds/m (ADB 1994). The measured EC of all samples was lower than acceptable limits. In the monsoon season, the flow of the water increases, which may cause the dilution of the salinity of the water, while in the dry season, the flow of the surface water decreases which increases EC. In the winter season, the EC ranged from 93.43 to 186.75 ds/m and in the dry season, the EC varies from 53.81 to 128.53 ds/m, which might be due to the seasonal variations. The highest DO of water was found 6.01 mg/l in June, and the lowest was 2.06 mg/l in April. The mean DO content was 4.40 mg/l. The standard limit of DO is 5.0 mg/l (EQS 1997, WHO 2011, De 2005, DoE 2017), and the study showed that DO contents were satisfactory level and suitable for fisheries and aquatic resources except in the summer. DO contents varied from 5.01 to 6.25 mg/l during the monsoon and winter season and 1.79 to 5.08 mg/l during the dry and late winter season. According to environmental quality standards (EQS), the following requirements for DO are prescribed: 6.0 mg/l for drinking water, 4.0 to 6.0 mg/l for fish and livestock, and 5.0 mg/l for industrial application. In summer, DO contents were much

lower than the desired limits, indicating that water quality is not satisfactory for aquatic organisms, which might be due to the presence of a higher level of organic waste pollutants. The highest TDS of the *haor* water was 125.73 mg/l in February, and the lowest was 45.85 mg/l in November, and the mean TDS contents were 73.36 mg/l. Seasonal variation revealed that TDS ranged from 45.85 to 125.73 mg/l in the winter and 35.91 to 85.96 mg/l in the dry season. The USPH (United States Public Health) acceptable TDS is 500 mg/l (De 2005), 1000 mg/l, 1500 mg/l, and 2000 mg/l for domestic water, drinking water, industrial water and for irrigation, respectively (ADB 1994). According to another report and the standard limit of TDS in water is 600 mg/l (EQS 1997 and WHO 2011). The TDS values were found within the standard limits.

The highest BOD₅ content of the water samples was found at 2.19 mg/l in June, and the lowest was 1.02 mg/l in February, and the mean BOD₅ was 1.50 mg/l. The BOD₅ status didn't show any significant variation among four distinct seasons because *Hail haor* water might not be contaminated to a large extent. The standard limit of BOD₅ in water is 5 mg/l (DoE 2017). Generally, unpolluted waters typically have BOD₅ values of 2 mg/l or less (Agbaire and Oyibo 2009, Garg *et al.* 2010, Utang and Akpan 2012). The permissible limit for BOD for drinking water is 2 mg/l, fish culture is 6 mg/l, and irrigation purpose is 10 mg/l in Bangladesh standard (EQS 1997). BOD₅ contents ranged from 1.02 to 1.5 mg/l in the winter season and 1.3 to 2.19 mg/l in the dry season revealed that the BOD₅ concentrations are within the desirable limits for aquaculture. In the present study, COD ranged from 54.71 to 75.83 mg/l in the winter and 27.33 to 52.91 mg/l in the dry season, demonstrating the highest COD as 75.83 mg/l in February and the lowest as 27.33 mg/l in June, and the mean COD was 52.70 mg/l. COD in the unpolluted surface water is 20 mg/l or less (Agbaire and Oyibo 2009, Garg *et al.* 2010, Utang and Akpan 2012). A higher COD indicates a higher level of pollution (Varunprasath and Daniel 2010). It can be assumed that the study site receives a higher amount of non-biodegradable chemical substances from surrounding sources. As a result, the water quality is not suitable for fish and other aquatic resources. It is found that the calculated ratio of mean BOD and COD matches well with the findings of Lee and Nikraz (2014). In the winter season, the alkalinity ranged from 25.85 to 28.67 mg/l, and in the dry season, it varied from 24.83 to 31.67 mg/l due to the seasonal variations. The highest alkalinity was 31.67 mg/l in April, and the lowest was 24.83 in June, and the mean alkalinity was 27.75 mg/l. The standard limit of alkalinity in water is 150 mg/l (DoE 2017). The studies showed that all the observed alkalinities were within the normal limit, and favorable for aquatic habitats.

Table 1. Water quality parameters of *Hail haor* in different seasons.

Samples	pH	EC (ds/m)	TDS (mg/l)	DO (mg/l)	BOD ₅ (mg/l)	COD (mg/l)	Alkalinity (mg/l)	Nitrate (NO ₃ ⁻)	NH ₃ (mg/l)	Temperature (°C)	Sulfate (mg/l)	Chloride (mg/l)
Monsoon Season												
S1	7.2	56.5	32.6	5.56	2.71	29	24.6	6.62	0.72	30.3	24	25.1
S2	7.1	76.5	40.3	5.86	2.97	20	28.1	6.16	0.95	30.3	32	29.5
S3	6.86	46.1	22.1	6.25	2.06	19	21.2	6.82	0.79	29.9	28	14.3
S4	6.82	53.1	41.3	6.1	2.27	26	23.1	6.98	0.47	29.6	22	21.6
S5	7.15	44.6	30.2	6.17	2.34	11	21.5	7.19	1.12	29.3	31	14.7
S6	6.58	46.7	38.4	6	2.58	30	28.1	8.70	1.32	30.2	28	19.6
S7	7.02	61.2	47.4	6.04	1.87	37	27.2	5.78	0.71	29.6	21	31.4
S8	6.74	32.8	16.7	6.02	1.81	29	25.4	4.62	0.31	30.5	31	13.5
S9	6.91	51.5	35.6	6.1	1.87	41	21.3	7.81	0.82	29.7	30	30.9
S10	6.81	57.5	46.3	6.03	1.95	27	24.8	5.95	0.58	29.5	20	26.8
S11	6.89	61.6	51	5.89	1.96	33	26.3	6.59	0.88	29.1	26	32.5
S12	6.56	57.7	29	6.12	1.98	26	26.6	7.1	0.93	29.4	19	35.7
Winter Season												
S1	6.98	85.9	42.2	5.23	1.22	76	28.1	4.31	0.61	24.8	31	34.2
S2	7.04	88.2	44.3	5.21	1.25	57	32.3	3.95	0.65	24.7	35	41.5
S3	7.08	101.2	46.7	5.01	1.51	53	28.4	4.13	0.79	24.9	22	23.9
S4	6.91	85.3	36.1	5.65	1.53	44	27.6	3.70	0.77	24.8	26	32.4
S5	7.12	74.5	40.7	5.28	1.58	36	33.1	3.21	0.82	24.7	36	19
S6	7.15	178.6	106.3	5.65	1.62	42	30.4	4.06	0.78	25.1	37	20.6
S7	7.01	93.1	36.7	5.45	1.68	48	32.5	3.02	0.41	25	25	25.8
S8	7.1	103.7	53.8	5.25	1.64	47	24.2	3.08	0.52	24.6	19	42.1
S9	7.3	79.3	40.44	5.62	1.53	58	25.8	4.27	0.42	24.2	28	37.3
S10	7.35	87.8	36.9	5.06	1.58	69	31.4	2.23	0.63	24.7	28	31.5
S11	7.46	59.6	29.4	5.32	1.69	75	20.5	3.50	0.41	24.8	23	39.7
S12	7.25	75.4	30.01	5.03	1.72	42	29.4	1.36	0.86	25	32	24.3
S13	7.2	91.4	55.5	5.22	1.65	38	28.6	2.02	0.79	24.9	21	39.1
S14	7.1	104.8	42.9	5.8	0.91	81	29.1	1.12	0.32	24.3	18	9.2

EC = Electrical Conductivity, TDS = Total Dissolved Solids, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand.
(Contd.)

Table 1 contd.

Samples	pH	EC (ds/m)	TDS (mg/l)	DO (mg/l)	BOD ₅ (mg/l)	COD (mg/l)	Alkalinity (mg/l)	Nitrate (NO ₃ ⁻) (mg/l)	NH ₃ (mg/l)	Temperature (°C)	Sulfate (mg/l)	Chloride (mg/l)
S1	8.11	194	119.8	2.87	0.98	106	25.4	3.05	0.7	22.8	53	55.1
S2	8.76	204.5	118.6	3.39	0.96	82	28.3	3.02	0.82	22.7	48	59.5
S3	7.74	169.5	97	2.4	1.12	61	31.2	2.98	0.5	22.5	51	41.3
S4	7.56	203.4	156.8	3.85	1.09	66	28.9	1.84	0.92	22.4	41	78.9
S5	7.33	181.5	98.7	4.43	1.13	51	29.4	2.45	1.02	22.6	59	24.7
S6	7.44	238.5	188.4	5.02	1.2	69	23.4	2.76	1	22.1	51	59.6
S7	7.26	139.2	99.5	4.56	0.92	83	26.8	1.78	0.63	22	32	29.6
S8	7.55	169.5	116.2	4.86	0.86	48	19.3	2.31	0.88	21.9	39	32.7
S9	7.31	164.5	102.3	4.34	1.02	91	22.8	2.15	0.93	22.5	38	47.9
S10	7.65	182.2	109.6	5.02	0.92	54	25.4	1.05	1.05	22.8	35	46.8
S11	7.53	193.6	142.3	5.08	0.81	101	21.8	0.98	0.52	22.2	48	63.5
S12	7.81	200.8	159.6	4.28	1.04	98	27.5	0.95	1.1	23	42	61.4
Summer Season												
S1	7.18	113.5	93.7	2.87	1.57	53	27.6	8.94	0.92	26.8	41	52.9
S2	6.96	130.2	72.6	2.92	1.49	62	28.1	9.15	1.21	26.5	56	48.6
S3	6.72	127.4	87.3	1.91	1.46	71	33.3	8.58	0.89	26.4	35	32.3
S4	7.02	127.8	86.2	1.94	1.5	41	31.4	8.57	1.69	26.6	37	40.5
S5	7.21	105.3	82.4	1.95	1.31	40	29.6	7.73	1.52	26.5	40	44.5
S6	6.79	185.5	113.5	1.9	1.13	58	31.4	5.56	1.02	27	36	72.1
S7	6.65	108.6	102.4	1.91	1.18	42	32.5	6.62	1.32	26.5	29	38.6
S8	6.63	129.9	64.1	1.87	1.27	35	34.9	9.25	1.92	26.9	33	36.5
S9	6.68	119.8	68.6	1.79	1.22	41	34.2	7.8	1.54	27	31	68.4
S10	6.84	142.6	78.8	1.92	1.19	56	34.1	8.98	1.85	26.8	37	50.6
S11	6.68	130.4	83.6	1.95	1.14	67	31.5	5.8	0.92	26.2	35	62.4
S12	6.21	121.3	98.4	1.83	1.18	69	31.6	7.33	1.36	26.4	30	77.9

EC = Electrical Conductivity, TDS = Total Dissolved Solids, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand.

Nitrate contents were 2.21 to 3.14 mg/l during the winter and 6.69 to 7.86 mg/l during the dry season. The highest nitrate content was 7.86 mg/l in April, and the lowest was 2.21 mg/l in February, and the mean nitrate content was 5.03 mg/l. The standard limit of nitrate is 10 mg/l (WHO 2011) and according to the surface water regulation of EU 1989 (EPA 2001) the recommended limit values of nitrate were 50 mg/l. The study showed that nitrate contents were at a satisfactory level for fisheries and other aquatic organisms. Ammonia content ranged from 0.63 to 0.84 mg/l in the winter season and 0.81 to 1.35 mg/l in the dry season, reaching the highest level at 1.35 mg/l in April and the lowest at 0.63 mg/l in November, and the mean ammonia content was 0.89 mg/l. According to the surface water regulation of EU 1989 report (EPA 2001), the recommended limit of ammonia ranged from 0.2 to 4.0 mg/l, where, in another report suggested the limit of ammonia in water as 1.2 mg/l (ADB 1994). The study revealed that ammonia concentration in *haor* water was much lower compared to the recommended limits; similar observation was reported for ammonia contents for *Tanguar haor* water (Islam 2011). Sulfate contents were 27.21 to 44.75 mg/l during the winter season and 26 to 36.67 mg/l during the dry season, touching the highest value of 44.75 mg/l in February, the minimum value of 26 mg/l in June, and the mean sulfate content was 33.65 mg/l. The standard limit of sulfate is 250 mg/l (WHO 2011), and the regulation of EU 1989 (EPA 2001) recommended the limit as 200 mg/l. The study revealed that the sulfate contents were at a satisfactory level. Chloride contents were 30.04 to 50.07 mg/l during the winter and 24.26 to 52.1 mg/l during the dry season. The highest chloride content was 52.1 mg/l in April and the lowest was 24.26 mg/l in June and the mean chloride content was 39.11 mg/l. The standard limit of chloride is 250 mg/l (EQS 1997, EPA 2001), and the study showed that chloride contents were satisfactory and suitable for aquaculture and other aquatic resources.

Concerning all measured parameters, it could be settled that the only COD level was much higher than the standard level in the study site. The reason behind this is that along its course *Mono* River receives many types of point, and non-point sources of pollutants from industries, agricultural fertilizer residues, and municipal wastes, rural market discharges, agrochemicals, and pesticides used in upstream tea gardens. So, it is suggested to control point and non-point sources of pollutants immediately to restore the water quality of the *Hail haor* ecosystem.

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(Revised copy received on 19.01.2021)