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Water quality and comparative pollution assessment of twelve major rivers in Bangladesh

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Abstract

This research provided a comprehensive picture of all Bangladeshi rivers by examining the essential water quality characteristics of twelve major rivers dispersed around the nation. The country's twelve districts were selected where the main courses of each river were sampled for their water quality. These districts include Rajshahi (Padma), Comilla (Meghna), Sirajganj (Jamuna), Sylhet (Surma), Mymensingh (Brahmaputra), Khulna (Rupsa), Dhaka (Buriganga), Chattogram (Karnaphuli), Kurigram (Teesta), Chandpur (Dakatia), Khagrachari (Halda) and Madaripur (Arial Khan). During 2022–2023, the water samples were collected in plastic bottles from various geographic areas along the rivers. In a laboratory-based investigation, several physicochemical water quality indicators were examined, including pH, electrical conductivity (EC), total dissolved solids (TDS), suspended solids (SS), DO, BOD, and COD. The maximum and minimum values of such respective parameters were compared with the water quality standards as set by the EQS 1997 guideline, ADB 1994 guideline, Irrigation standard (Ayers and Westcot 1976), and the guideline of the Department of Environment (DoE) in Bangladesh. These study findings can serve as the basis for further investigation into river water treatment and water quality monitoring.

Keywords: *Water quality; Physicochemical; Pollution; Rivers; Bangladesh.*

1 Introduction

Water has become an essential commodity for the development of industrials and agriculture (Kudesia, 1990). Water is extremely necessary for all living things, including humans, animals, plants, and other organisms. The quantity and quality of water sustain ecological equilibrium, which has an impact on human lifestyle. On the other hand, contaminated water is the main cause of disease and makes the ground unfit for sustaining life. Due to the abundance of good-quality water supplies and their accessibility, water quality concerns have frequently been disregarded. Many aspects of this issue are currently evolving. Intensive use of nearly all good quality supplies means that new irrigation projects, and old projects seeking new or supplemental supplies, must rely on lower quality and less desirable sources (Cuena, 1989). The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients (Ayers and Westcot, 1985; Rowe *et al.*, 1995). The physiochemical properties that are significant for each field and their acceptable concentration levels must be identified in order to assess the quality of river water for irrigation, domestic use, and aquaculture.

2 Materials and Methods

2.1 Study Region

Bangladesh is well known for its stunning geomorphic characteristics, which include the enormous rivers that run across it. In this study, twelve major rivers of Bangladesh were selected for investigation. The name of the rivers is as follows: Padma, Meghna, Jamuna, Surma, Brahmaputra, Rupsa, Buriganga, Karnaphuli, Teesta, Dakatia, Halda, and Arial Khan. Reasons behind selecting these rivers:

(i) Covering the almost whole country and geological river types; especially the northern and southern part rivers conditions of Bangladesh.

(ii) To show water conditions of particular regions.

(iii) Different ecological aspects.

Three points of each river were selected in this investigation. The districts of sample collecting points of these twelve rivers are shown in Figure 1.

Figure 1. Sampling points with river courses

River Name	District name	Sampling Upazila
Padma	Rajshahi	Motihar
Meghna	Comilla	Homna
Jamuna	Sirajganj	Sirajganj Sadar
Surma	Sylhet	Sylhet Sadar
Brahmaputra	Mymensingh	Mymensingh Sadar
Rupsa	Khulna	Daulatpur
Buriganga	Dhaka	Savar
Karnaphuli	Chattogram	Kaptai
Teesta	Kurigram	Kurigram Sadar
Dakatia	Chandpur	Chadpur Sadar
Halda	Khagrachari	Khagrachari Sadar
Arial Khan	Madaripur	Madaripur Sadar

Table 1. Location of sampling points with river courses

2.2 Sample Collection and Data Record

Sampling and testing were done in various periods from March 2022 to April 2023. River water samples were collected in dried plastic bottles. The 250 ml plastic bottles were washed well and rinsed with 2% Hydrochloric acid. Water samples were collected securely, sealed, and labeled after the bottles had been rinsed one more time with sampling water. As far as feasible, aeration was prevented during sampling. The water samples were sent to the lab with care, where they are being stored for physical and chemical studies. Samples were collected from the river at a distance of about 100 meters from one sample to another. Three samples of each river were taken. After taking samples from every sampling point, pH, electrical conductivity (EC), total dissolved solids (TDS), suspended solids (SS), DO, BOD, and COD were measured. The minimum and maximum values of these parameters from these three samples are selected for Table 1.

2.3 Experimental Method

pH

Initially, buffer solution and distilled water were used to normalize the pH meter. After waiting for at least five minutes, 50 ml of the sample was poured into a clean 100 ml plastic beaker and placed inside the pH meter. The pH reading was then recorded in the notebook after being taken from the pH meter. The pH of all other samples was tested in the same manner, but before each measurement, the pH meter was submerged in either distilled water or a buffer solution.

EC, TDS, SS

The electrical conductivity (EC), total dissolved solids (TDS), and suspended solids (SS) of the river water samples were analyzed by specific digital meters.

DO (Dissolved Oxygen)

Initially, distilled water and a buffer solution were used to standardize the DO meter. The DO meter was then submerged with 50 ml of the sample in a clean 100 ml plastic beaker, and at least five minutes were required to pass.

After that, the DO reading was obtained from the DO meter and recorded in the notebook. In a similar manner, DO was measured for all subsequent samples, but before each measurement, the DO meter was submerged in distilled water or a buffer solution.

BOD (Biological Oxygen Demand)

The Biochemical Oxygen Demand (BOD) of polluted water is the amount of oxygen required for the biological decomposition of dissolved organic matter (Uddin et al., 2014). The test involves taking the provided sample and diluting it with water to the appropriate quantities in BOD bottles. Three concentrations are used for each sample, and two bottles are taken for each concentration. The initial dissolved oxygen content (D1) in the other set of bottles will be determined immediately while the first set of bottles is incubated in a BOD incubator for five days at 20°C. The dissolved oxygen content (D2) of the incubated set of bottles is measured after 5 days.

COD (Chemical Oxygen Demand)

The COD findings are shown as mg of oxygen. The oxidizing agent solution N/8 or 0.125 N is used in the calculation. 2 mg of oxygen is contained in each ml of 0.25 N dichromate solution. A surplus of an oxidizing agent is introduced, and the surplus is measured by a different reducing agent, such as ferrous ammonium sulfate. The excess dichromate is titrated against ferrous ammonium sulfate.

SL	River Name	pH		Electrical Conductivity (μmhos/cm)		SS (mg/l)		TDS (mg/l)		DO (mg/l)		BOD (mg/l)		COD (mg/l)	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1	Buriganga	6.76	7.90	105.50	1176	6	83	53.5	579	0	7.8	3.37	56.3	13	215.66
2	Meghna	6.10	7.05	59.2	460	12	64	27.9	235	0.9	8.6	0.8	9.8	3.2	6.3
3	Arial Khan	6.62	7.95	117.3	6138	90	150	105.34	503	2	15	1.2	45	14	99
4	Dakatia	7.25	7.68	163	177	21	28	567	1667	3.6	5.9	0.9	1.3	28	112
5	Jamuna	6.74	8.20	122.4	265	17	115	68.8	127.79	6.5	8.7	1.5	4.8	9.5	109.5
6	Teesta	7.03	7.47	83	147.68	48	96	69	301	4.50	6.89	2.01	7.89	172.6	1544.7
7	Rupsha	7.68	7.93	270	12560	45	96	613	952	4.53	6.43	0.9	1.4	587.6	1968.8
8	Karnaphuli	6.50	8.70	2249	40608	75	315	1190	20280	4.8	6.4	7.20	65.4	114	512
9	Surma	6.71	7.43	86	422	11.5	51	47	213	4.76	6.9	27	53.8	65	112
10	Padma	7.05	8.34	73	484	6	76	54	258	3.06	7.47	3	33	18	167
11	Halda	6.72	7.93	125	403	24	229	75	246	4.22	7.59	0.6	3.4	11	122
12	Brahmaputra	7.22	7.80	108	324	15	56	56	167.8	5.34	7.32	1	2.7	47	213

3 Results and Discussion

Maximum and minimum values (among collected samples) of physical and chemical parameters from laboratory tests are shown in Table 2 as standard values of EQS 1997, ADB 1994, Irrigation standard (Ayers and Westcot 1976), and the guideline of the Department of Environment (DoE) in Bangladesh are mentioned in Table 3.

Table 2. Physical and chemical parameters of selected rivers

Table 3. Standards

Parameters	Department of Environment Standards (DoE, 2001)	Bangladesh Standard for Fisheries (EOS.1997)	Domestic Standards (De, 2005)	Drinking Standards (ADB,1994)	Irrigation standard (Ayers and Westcot, 1976)
pH	7.25	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
EC (μS/cm)	300	800-1000 (μS/cm)	-	-	750
TDS (mg/l)	165	500	500	1000	<450
DO (mg/l)	6.5	4-6 (mg/I)	4-6	-	-
BOD (mg/l)	5.0	(-) or below 2 (mg/I)	-	-	-
COD (mg/l)	4.0	-	-	-	-
SS (mg/l)	-	150 (mg/l)	-	-	-

3.1 pH

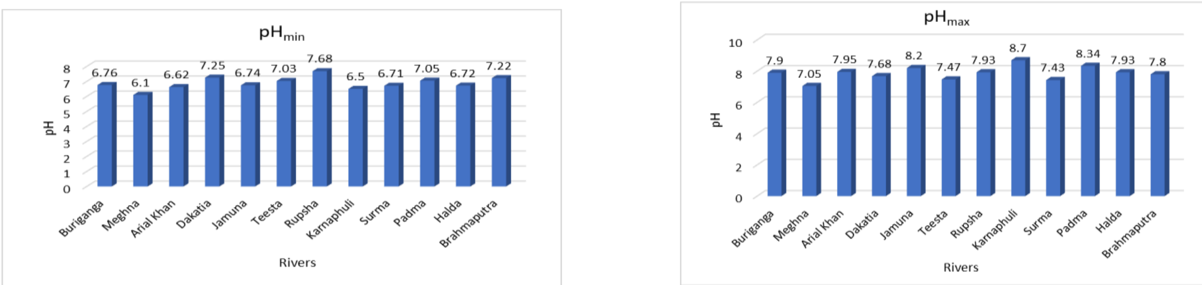

Figure 2. The pH values of the major 12 river waters of Bangladesh

From laboratory analysis, Karnaphuli has the greatest pH value of 8.7 and Meghna has the lowest pH value of 6.1 among all the samples.

3.2 EC

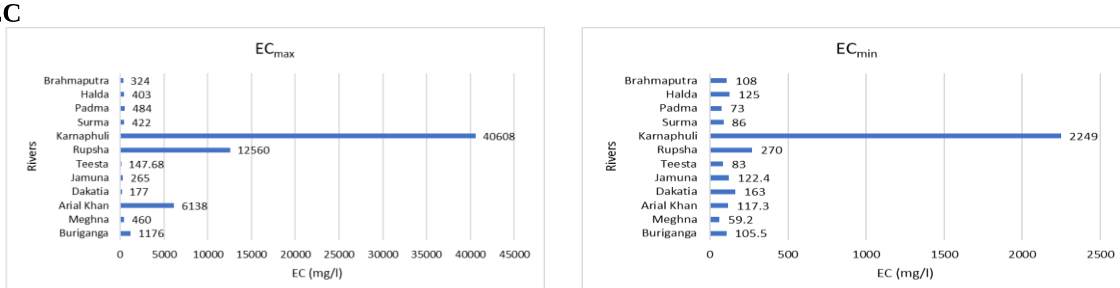

Figure 3. The EC values of the major 12 river waters of Bangladesh

From laboratory analysis, Karnaphuli has the greatest electric conductivity of 40608 µS/cm and Meghna has the lowest electric conductivity of 59.2 µS/cm among all the samples.

3.3 SS

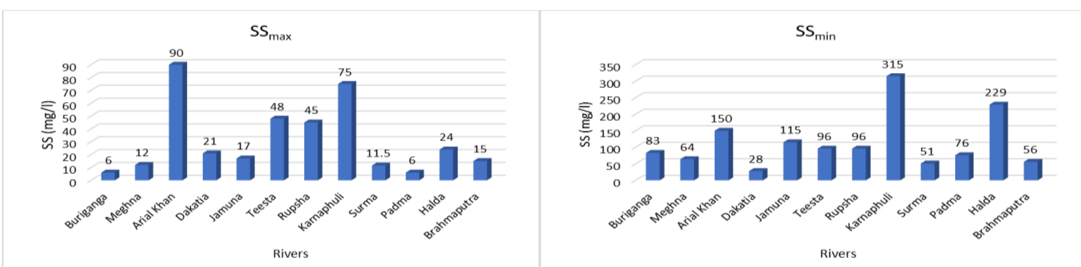

Figure 4. The SS values of the major 12 river waters of Bangladesh

From laboratory analysis, Arial Khan has the greatest electric conductivity is 90 mg/l and Dakatia has the lowest electric conductivity is 28 mg/l among all the samples.

3.4 TDS

From laboratory analysis, Karnaphuli has the greatest TDS, it is 20280 mg/l and Meghna has the lowest TDS, it is 27.9 mg/l among all the samples.

3.5 DO

From laboratory analysis, Arial Khan has the greatest DO, it is 15 mg/l and Buriganga has the lowest DO, it is 0 mg/l among all the samples.

From laboratory analysis, Karnaphuli has the greatest BOD value of 65.4 mg/l and Halda has the lowest BOD value of 0.6 mg/l among all the samples.

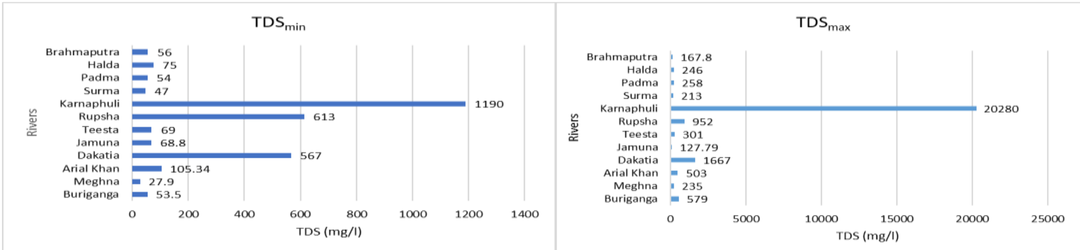

Figure 5. The TDS values of the major 12 river waters of Bangladesh

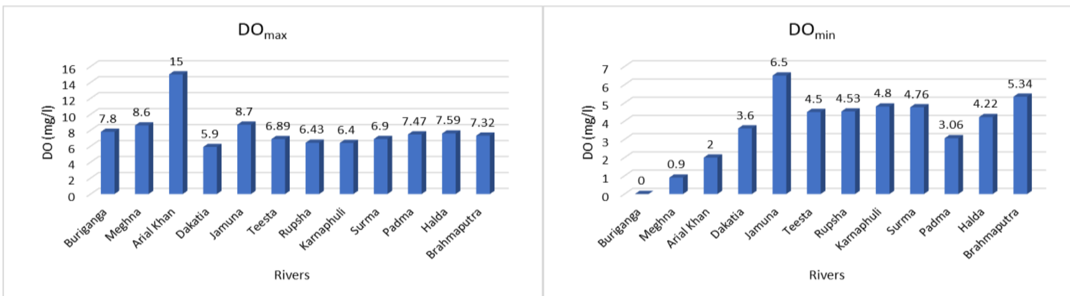

Figure 6. The DO values of the major 12 river waters of Bangladesh

3.6 BOD

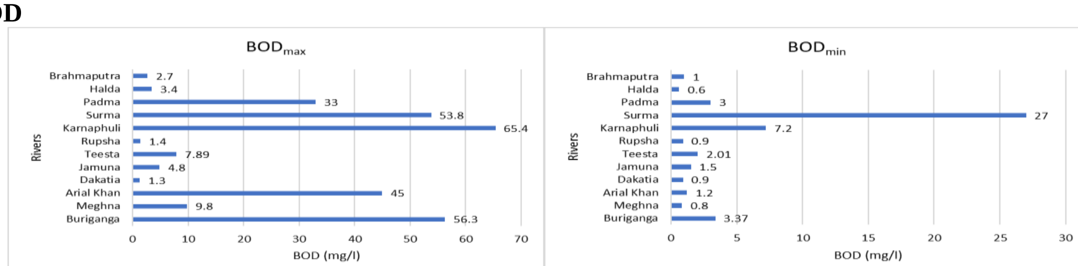

Figure 7. The BOD values of the major 12 river waters of Bangladesh

3.7 COD

Figure 8. The COD values of the major 12 river waters of Bangladesh

From laboratory analysis, Karnaphuli has the greatest COD value of 1968.8 mg/l and Meghna has the lowest COD value of 3.2 mg/l among all the samples.

4 Pollution Assessment and Effects

Water contamination is caused by the improper collection and treatment of sewage. Due to the use of chemicals like fertilizers, pesticides, fungicides, herbicides, and insecticides that run off into the water, agriculture has an impact on water pollution. Industries generate a large amount of garbage that contains hazardous chemicals and pollutants. Huge amounts of industrial waste

are discharged into freshwater.Sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are the primary pollutants that cause acid deposition (also known as acid rain). The pH of freshwater is mostly impacted by acid deposition. Both natural and human-made sources emit nitrogen and sulfur. A low BOD is an indicator of good-quality water, while a high BOD indicates polluted water. Higher COD values indicate that there is more oxidizable organic material present in the sample, which lowers the concentration of dissolved oxygen (DO). Anaerobic conditions, which are harmful to higher aquatic life forms, can result from a decrease in DO.
Some effects according to human health and the environment:

(i) Short-term effects can include gastrointestinal issues, while long-term exposure might lead to chronic health problems like cancer, neurological disorders, and developmental issues.
(ii) The introduction of pollutants like chemicals, toxins, and excess nutrients can disrupt the balance of aquatic environments, leading to oxygen depletion, algal blooms, and fish kills.
(iii) Contaminated water can lead to healthcare costs, loss of productivity, lower property values, reduced agricultural yields, increased water treatment costs, loss of biodiversity, etc.

5 Limitations and Challenges

(i) Sample Preservation: Proper preservation of water samples before analysis is crucial to avoid potential changes in water quality during transportation and storage.
(ii) Data Integration: Integrating data from various sources and time points can be challenging, particularly when dealing with long-term trends and complex datasets. Certain pollutants may be overlooked if the chosen testing methods are not sensitive enough to detect them.
(iii) Limited Parameters: Surface water tests typically focus on a limited set of parameters due to constraints in equipment, time, and cost. This might miss some pollutants or changes in water quality.

6 Conclusion

According to all tested parameters, Karnaphuli is the worst river among these twelve rivers. Karnaphuli, Rupsa, Arial Khan, and Buriganga exceeded all the mentioned standards according to EC. In the case of TDS, Karnaphuli and Dakatia exceeded all the standards. According to COD, all the rivers are not in good shape. But experimental results of BOD show that Jamuna, Dakatia, Rupsa, Brahmaputra, and Halda are quite okay. As per pollution assessment, the low level of dissolved oxygen in water is a sign of pollution. Karnaphuli, Dakatia, and Rupsa have lower values of DO than all the mentioned standards.

The study advises taking the following actions to maintain the river's suitable aquatic environment:

(i) River water quality parameters are routinely monitored for seasonal fluctuations.
(ii) Sand extraction and illegal dredging must be stopped.
(iii) To make sure that pesticides and fertilizers are used responsibly.
(iv) Habitat restoration for fisheries and keeping track of fish species and their conditions.

Treatment: River water treatment using alum is significantly less expensive, has been around for a while, and works well for uses other than drinking. Further purification of the water is required in order to make it suitable for drinking. These lab experiments' results are encouraging and serve as a prescription for alum coagulation treatment of river water. This study is able to provide a hint to get the right amount of alum dosage for large-scale usage.

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