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REVIEW ARTICLE

CrossMark

A review of the water quality indices of riverine ecosystem, Bangladesh

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ABSTRACT

Rivers have been the most important freshwater resource, and our ancient civilizations have flourished along the banks of rivers. River water finds multiple uses like agriculture, industry, transportation, aquaculture, and public water supply. Natural waters are being contaminated as the quality of water is being affected by anthropogenic activities, in developing countries like Bangladesh. From the point of view, the physicochemical parameters (water temperature, pH, electrical conductivity, total dissolved solids, DO, BOD, alkalinity, total hardness, nitrate) of seventeen rivers in Bangladesh were reviewed from January 2021 to June 2021. The water quality parameters of some rivers were found to be far above the suitable limits, which is dangerous for human health, agriculture, and fisheries. It is therefore necessary to check the water quality at regular interval of time to conserve the natural ecosystem of the rivers of Bangladesh. Furthermore, this study would help to create and develop awareness among the people to help maintain the quality of the river waters.

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INTRODUCTION

Water is the most vital element in shaping the land and regulating the climate. It is one of the most necessary compounds that profoundly has an impact on life (Gorde *et al*., 2013). Water is a main natural aid for people for different purposes, such as drinking, irrigation, hydro-electricity, fish fostering, and recreation. Therefore, it requires at least a suitable degree of water quality (Emamgholizadeh *et al*., 2014). The need to learn about water quality is one of the fundamental issues today due to the growing load of pollution from industrial, commercial, and residential sources, with its results on human fitness and aquatic ecosystems (Rankovic *et al*., 2010). Human activities that include urbanization, agricultural development, overuse of fertilizers, inadequate administration of land use and sewage disposal have without delay or in a roundabout way affected the quality of water, making it unfit for extraordinary purposes (Kumar *et al*., 2018). Therefore, now a day's fresh water has turned out to be a scare commodity due to over exploitation and pollution. Most of the rivers in urban areas of developing nations are the ends of effluents discharged from the industries. Asian nations are experiencing rapid industrial growth, and this is making environmental conservation a challenging venture (Agarwal *et al*., 2011). Water exceptionality is generally determined by both herbal methods along with the lithology of the basin, atmospheric inputs and climatic conditions, and anthropogenic inputs (Najah *et al*., 2013).

Bangladesh is an agro-based riverine country with a large delta of water assets and one of the world's richest and most numerous inland aquatic environments, which influences various ichthyofauna (Sultana *et al*., 2016; Islam and Sultana., 2016). These rivers offer vast scope and potential for fish production and economic safety of the fishing communities that live around these water bodies (Shumi *et al*., 2019). River water is used by innumerable rural and urban communities and livestock, fish culture, recharge of ground water, managing of floods etc. (Agarwal *et al*., 2011). But the quality of the water is being degraded unceasingly due to haphazard industrialization

(Manjare *et al*., 2010). Most industries discharge their insufficiently handled waste into the rivers or streams, which causes serious trouble for aquatic plants and fauna (Kesalkar *et al*., 2012). The darkish color of the waste water reveals the poisonous effects on the biota and inhibits the photosynthetic activities by means of reducing the sunlight (Swamy *et al*., 2011). River pollution is now counted as a difficulty all over the world (Noori *et al*., 2010). Bangladesh is going through serious problems with water contaminations from distinctive industries, home wastes and agrochemicals (Islam *et al*., 2015a; Islam *et al*., 2015b; Venugopal *et al*., 2009). Due to lack of waste management and sanitation facilities, raw and partially decomposed industrial and urban wastes and a range of hazardous chemicals materials discover their way to the river. Consequently, water quality deterioration takes place which step by step decreasing fish and other species availability and variety (Akter *et al*., 2020). Biodiversity loss especially loss of species variety is a principal risk and abundance of indigenous fish species are decreasing each year in special inland water bodies (Sultana *et al*., 2019). To evaluate the quality of river water for the purpose of irrigation, health, domestic and fisheries, we want to identify the physio-chemical characteristics that are necessary for respective field, and their perfect levels of concentrations.

Therefore, the present finding was aimed at checking the water quality of different rivers in Bangladesh. Referred to quite a number of technical lookup papers on the evaluation of water quality parameters of exclusive rivers are summarized here. Water quality parameters of the Padma, Meghna, Jamuna, Brahmaputra, Ganges, Balu, Dakatia, Halda, Khiru, Rupsha, Shilmari, Shitalakkhya, Surma, Titas, Turag, Karnafuli, and Buriganga rivers were studied to gain a better understanding of Bangladesh's water quality parameters.

LITERATURE SURVEY METHODS

The research was based on material obtained from an examination of relevant theses, journals, publications, and books. Working in an aquatic environment, attending several seminars on water quality management, and watching research presentations connected to rivers provided some practical expertise. The necessary information was gathered from the internet, Bangladesh's annual statistical yearbooks, national fish week compendiums, newspapers, river visits with various ongoing research, and consultations with associated consultants and researchers.

STATUS OF DIFFERENT WATER QUALITY PARAMETERS

At the research level, a number of technical papers on the assessment of water quality parameters in river environments were presented, from which a number of articles were referred for further investigation. The objective of the current research was to evaluate the water quality parameters of numerous rivers in Bangladesh.

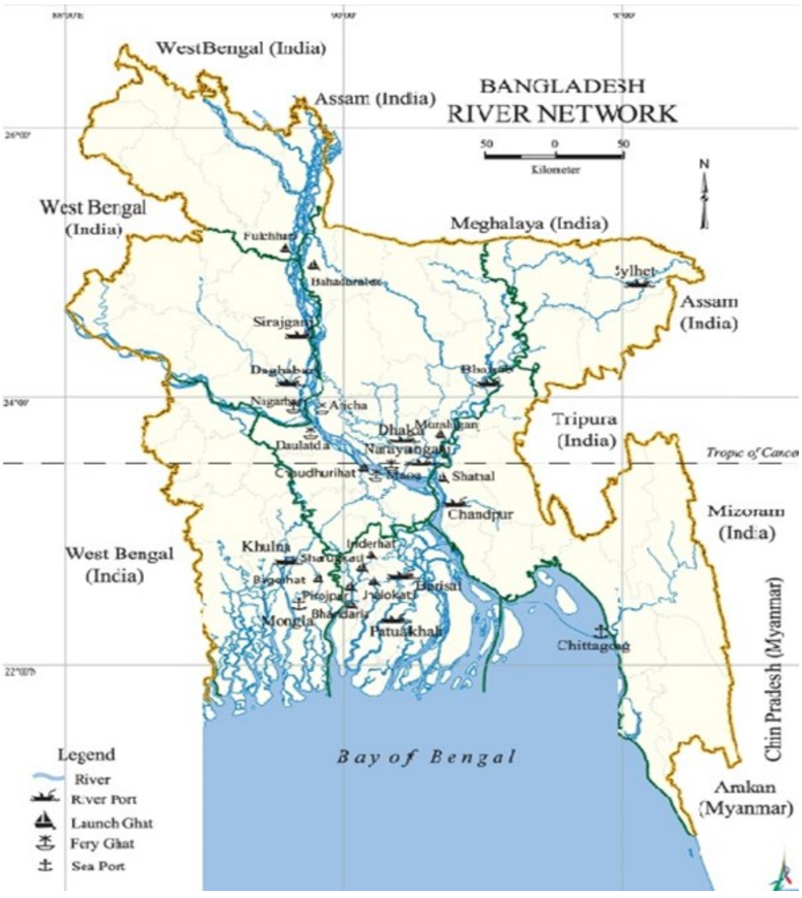

Figure 1. *Map depicting major river systems of Bangladesh (Source: Islam et al., 2015a)*

Physico-chemical parameters

It is very fundamental and essential to check the water before it is used for drinking, domestic, agricultural, or fishing purposes. Water needs to be examined with exceptional physico-chemical parameters. The parameters used for water testing are entirely dependent on the purpose for which we intend to use the water and the degree to which we desire its quality and purity. Water does contain special kinds of floating, dissolved, suspended, and microbiological impurities as well as bacteriological impurities. Temperature, color, odor, pH, turbidity, TDS, and other physical checks should be performed, while chemical assessments should be performed for BOD, COD, dissolved oxygen, alkalinity, hardness, and other characteristics (Patil *et al.*, 2012). The following one-of-a-kind physico-chemical parameters are observed from quite a number of technical lookup papers of exclusive rivers in Bangladesh for monitoring the first-rate of water.

Temperature

It is the temperature that holds a key role in learning about water quality as it has a direct impact on pH and dissolved oxygen (DO) and regulates the self-purification capability of the river. The temperature of water can affect the metabolic and biological activities of organisms, and at higher temperatures, the metabolic things activities of organisms increase, requiring more oxygen for breathing (Halim *et al.*, 2018). Temperature changes will have an immediate impact on all aspects of fish metabolism. The metabolic fee of aquatic organisms is closely associated with the water temperature. The greater the water temperature, the higher the metabolic rate. Generally, the metabolic demand for oxygen in aquatic animals' doubles or triples with each 10°C increase in temperature range that the animal can tolerate (Halim *et al.*, 2018). Further, if the temperature is above 35°C, then denaturation of positive enzymes takes place, which can limit the metabolic characteristics of enzymes (Panda *et al.*, 2018). Besides, the temperature can have an effect on the respiratory and photosynthesis processes. At higher temperatures, photosynthesis of algae increases, though distinctive species require a specific temperature for most desirable photosynthesis (Halim *et al.*, 2018). Photosynthesis will draw more attention to dissolved oxygen while drawing less attention to dissolved CO_2. According to the Bangladesh Standard for Fisheries 25°C is the standard temperature for fish culture (Environmental Quality Standard for Bangladesh, Department of Environment, Government of the People's Republic of Bangladesh, 1997).

Bhuyan *et al.*, 2017 discovered that the Meghna river has a very low temperature (11°C) in the post-monsoon (October-January). Haque *et al.*, 2020, recognized the Ganges River has a 22.37°C temperature in post-monsoon. Islam *et al.*, 2014, referred to the Padma River having a 20.3°C post-monsoon and a temperature of above 25 in the pre-monsoon (February-May) and in the monsoon (June-September) season, the temperature was between 27.8 and 31. 9°C. Tahmina *et al.* (2018) measured 24.38°C in the Turag River during the pre-monsoon season. Sarwar *et al.*, 2010, showed a 22.75°C temperature in winter weather on the Karnafuli river. In the Buriganga river, (Rahman *et al.*, 2010) determined 20.86°C in the pre-monsoon (December-March) (Table 1), which was under the well-known temperature. According to Haque *et al.*, 2020, the Meghna river has a temperature of 28°C during the pre-monsoon season (February-May), while Panda *et al.*, 2018, found the Jamuna river to have a temperature range of 32.59-35.93°C throughout the season. Haque *et al.*, 2020, located on the Ganges river, had a 29.54°C monsoon. The Buriganga river has a temperature range of 31-33.5°C (Ahammed *et al.*, 2016), the Dakatia river has a temperature range of 26.73°C (Hasan *et al.*, 2015), the Rupsha River has a temperature range of 29.7°C (Islam *et al.*, 2018), the Shitalakkhya river has a temperature range of 27.06° (Islam *et al.*, 2015c), the Karnafuli river has a temperature range of 28.09°C (Hossen *et al.*, 2019) (Table 1). Water temperatures ranging from 15 to 35°C are considered suitable for fish lifestyle (Table 2). So, besides the Meghna river in the post-monsoon and the Jamuna river in the monsoon, it was suitable for fish culture.

pH

pH is the measure of the acidity of a solution of water. The pH scale usually ranges from zero to fourteen. The scale is now not linear but, as an alternative, logarithmic (Gorde *et al.*, 2013). From 7 to 14, the pH value ranges from 7 to 14 is alkaline, from zero to 7 is acidic, and 7 is neutral. pH is an essential parameter required for the promotion, protection, and management of each abiotic and biotic ecological system. The corrosive nature of water is measured via pH, and it is inversely proportional to pH. The pH of any water body is no longer constant throughout the year; rather, it is modified due to a number of elements that alter the pH value both directly and indirectly with the change of season (Panda *et al.*, 2018). According to Bangladesh Standards for Fisheries (EQS, 1997; Bureau of Indian Standards, 2009), the ideal limit range for pH is 6.5-8.5 (Table 2). All these values of all these rivers are within the permissible limit of WHO and FAO set for drinking, fish production, and irrigation purposes without the Jamuna river (Uddin *et al.*, 2014) (Table 1 and 2). Its degrees are 8.6-8.9, which is greater or much less alkaline and therefore not appropriate for fish culture.

Electrical conductivity

Conductivity is a numerical expression of an aqueous solution's capability to raise an electric power current. This potential relies upon the presence of ions, their complete concentration, mobility, valence, and relative concentrations, and the temperature of the liquid (Gorde *et al.*, 2013). Each anion and cation are represented by an ion. Hence, TDS and EC are complementary to each other and have a correlation between the two parameters (Panda *et al.*, 2018). Bangladesh Standard for Fisheries (EQS, 1997) recommended an EC range of 800 to 1,000 S cm^{-1}, whereas WHO, 2011, recommended only 300 S cm^{-1}(Table 2). Stone and Thom Forde, 2004, endorsed that the applicable range of EC is a hundred to 2,000 µS $cm^{-1}$and the desirable range is 30-5,000 µS cm^{-1} for fish culture. The range of EC

Table 1. **Physico-chemical parameters of different rivers.**

Name of the River	Season/ Month	Water Temp. (°C)	pH	EC (µS/cm)	TDS (mg/l)	Alkalinity (mg/l)	Total Hardness (mg/l)	DO (mg/l)	BOD (mg/l)	Nitrate (mg/l)	References
Padma	Pre-monsoon (Feb-May)	27.8-29.1	7.0-7.6	200-260	129-166	192-222	76.8-113.0	6.9-7.8	1.5-2.2	-	Islam *et al.* 2014
	Monsoon (Jun-Sep)	31.1-31.9	7.6-8.2	180-220	118-140	112-146	36-92	6.9-7.9	2.1-2.7	-	
	Post-monsoon (Oct-Jan)	20.3-28.6	7.5-7.8	240-285	147-178	146-188	56-80	6.4-7.2	2.6-3.8	-	
Meghna	Pre-monsoon (Feb-May)	28	7.3	220	122	-	-	4.3	3.71	.124	Bhuyan *et al.* 2017
	Monsoon (Jun-Sep)	25	7.5	210	130	-	-	4.7	3.23	.135	
	Post-monsoon (Oct-Jan)	11	7.2	189.7	120	-	-	4.2	3.67	.125	
Jamuna	Pre-monsoon (Feb-May)	32.59	8.6	137.83	130.04	-	-	1.01	34.26	88.04	Uddin *et al.* 2014
	Monsoon (Jun-Sep)	35.93	8.9	107.70	109.48	-	-	0.45	59.04	84.83	
Brahmapu-tra	Average of pre, post and mon-soon		7.66	168	155	-	-	7.52	2.63	-	Tareq *et al.* 2013
Ganges	Pre-monsoon (Feb-May)	25.94	8.35	350.58	227.87	317.75	66	9.12	-	-	Haque *et al.* 2020
	Monsoon (Jun-Sep)	29.54	7.91	200.40	130.26	220.5	30.25	6.88	-	-	
	Post-monsoon (Oct-Jan)	22.37	8.31	315.94	205.37	258.3	48.8	9.43	-	-	

Table 1. *Contd…..*

Balu	Mar	-	7.76	996	-	-	-	-	-		Sultana *et al.* 2019
Dakatia	Jun-Jul	26.73	-	-	138-372.3	-	-	5.52-5.72	-	-	Hasan *et al.*, 2015
Halda	Pre-monsoon (Feb-May)	-	7.1	-	-	77	-	4.7	4.3	0.15	Islam *et al.*, 2017
	Monsoon (June-Sep)	-	7.3	-	-	73	-	3.9	0.28	0.18	
	Post-monsoon (Oct-Jan)	-	7.2	-	-	81	-	4.2	4.1	0.12	
Khiru	Dec-May	-	8.41	-	-	269.58	-	1.7	-	34.59	Rashid *et al.*, 2012
Rupsha	-	29.7	8.5	16705	8638	90.45	2063	-	-	-	Islam *et al.*, 2018
Shilmari	Pre-monsoon (Feb-May)	-	7.61	34295.46	17236.37	-	-	4.85	-	7.20	Islam *et al.*, 2016
	Monsoon (June-Sep)	-	7.87	600.59	300.89	-	-	5.7	-	5.97	
	Post-monsoon (Oct-Jan)	-	7.67	442.59	221.56	-	-	3.21	-	2.50	
Shitalakkhya	Oct-Aug	27.06	7.48	644	417	-	-	2.10	-	0.27	Islam *et al.*, 2015
Surma	-	-	7.33	153Tita	86.46	37.19	68.64	8.05	0.8	-	Howladar *et al.*, 2021
Titas	Pre-monsoon (Feb-June)	-	7.09	-	157.4		-	6.01	1.06	1.01	Islam *et al.*, 2011
	Post mon-soon (Oct-Jan)	-	6.95	-	146.3	-	-	5.61	0.90	1.16	
Turag	Post-monsoon (Nov-Feb)	24.38	7.52	1568.75	1454.5	760.03	776.51	1.88	-	15.21	Tahmina *et al.*, 2018

Table 1. ***Contd.....***

	Monsoon (June-Sep)	25.7	7.74	1376.25	1233.75	608.01	692.37	3.23		11.80	
Turag	Pre-monsoon (Feb-May)	-	7.5	997	-	562.5	191	0.15	167	-	Rahman *et al.*, 2012
	Monsoon (June-Sep)	-	7.2	455	-	305	62	4.8	76.5	-	
	Post-monsoon (Oct -Jan)	-	7.2	690	-	432.5	123.5	3.1	128	-	
Karnafuli	Jan-Aug	22.75	6.6	15946	9411	-	-	1.55	223.5	-	Sarwar *et al.*, 2010
Karnafuli		28.09	6.81	4676.5	3217.8	50.4	262.45	3.47	7.65	1.33	Hossen *et al.*, 2019
Buriganga	Pre-monsoon (Dec-Mar)	20.86	7.41	660.56	-	-	-	0.85	34.5	-	Rahman *et al.*, 2010
	Monsoon (Aug-Oct)	29.82	7.42	82.6	-	-	-	2.8	2.5	-	-
Buriganga	-	-	-	-	-	-	-	8.65	216.25	4.45	Kamal *et al.*, 1999
Buriganga	-	27.08	8.48	354.71	-	-	-	0.89		-	Fatema *et al.*, 2018
Buriganga	Spring (Jan)	31	6.86	728.48	260	-	-	1.25	93.90	8.7	Ahammed *et al.*, 2016
	Summer (May)	33	7.28	704	980.5	-	-	1.84	114.45	7.1	-
	Autumn (Sep)	33.5	7.25	760	1060.5	-	-	1.14	148.18	7.80	-

EC (Electrical conductivity); TDS (Total Dissolved Solids); DO (Dissolved oxygen); BOD (Biological oxygen Demand) used to be 100-350 S cm^{-1} in the Padma, Meghna, Jamuna, Brahmaputra Ganges, Surma, and Titas rivers (Islam *et al*., 2014, Bhuyan *et al*., 2017, Uddin *et al*., 2014, Tareq *et al*., 2013, Haque *et al*., 2020, Howladar *et al*., 2021, Islam *et al*., 2011) (Table 2). In Balu, Shilmari, Shitalakkhya, Turag, and Buriganga, the range of EC was 400 –1000 µS cm^{-1} (Sultana *et al*., 2019, Islam *et al*., 2016; Sarkar *et al*., 2015; Rahman *et al*., 2012; Rahman and Bakri, 2010; Ahammed *et al*., 2016). Karnafuli confirmed excessive degree of EC of 4676.5 µS cm^{-1} which was nevertheless within the suitable range of 18. Only the Rupsha (16705 S cm-1) and Turag (1376.25–1568.75 S cm^{-1}) rivers were able to circumvent the restriction (Islam *et al*., 2018, Tahmina *et al*., 2018) (Table 1).

TDS

TDS is a measure of total solids in a body of water that includes inorganic salt, natural materials, and other soluble materials (Weber-Scannell and Duffy, 2017; Banam *et al*., 2011). The foremost components of TDS are usually Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-}, SO_4^{2-} and NO_3^{-}. The permissible range is 500mg/L (Indian Standard for Drinking Water, Bureau of Indian Standards (IS-10500), New Delhi, 2012). According to WHO suggestions (WHO / SDE / WSH /, 03.04.16, Geneva 2003a) the stratification is-

i) Excellent (<300mg/L)
ii) Good (300-600 mg/L)
iii) Fair (600-900 mg/L)
iv) Poor (900 – 1200 mg/L)
v) Unacceptable (>1200 mg/L)

In general, TDS is higher in the rainy and post-rainy seasons than in the summer and winter seasons.

Padma, Meghna, Jamuna, Brahmaputra Ganges, Surma, Shilmari (except pre-monsoon), Buriganga (winter) and Titas river showed first-rate range (<300mg/L) (Islam *et al*., 2014; Bhuyan *et al*., 2017; Uddin *et al*., 2014; Tareq *et al*., 2013; Haque *et al*., 2020; Azad *et al*., 2016; Howladar *et al*., 2021; Ahammed *et al*., 2016). Dakatia river showed something between excellent and good ranging 138-372.3 mg/L (Hasan *et al*., 2015). Buriganga river confirmed fair (600-900 mg/L) range in summer time (704 mg/L) and autumn (760 mg/L) (Ahammed *et al*., 2016) and Shitalakkhya confirmed correct range of 417 mg/L (Islam *et al*., 2015d). Rupsha, Shilmari (pre-monsoon) and Karnafuli river showed the unacceptable (>1200 mg/L) range (Islam *et al*., 2018; Azad *et al*., 2016; Sarwar *et al*., 2010; Hossen *et al*., 2019).

Alkalinity

Alkalinity is the sum total of components in the water that have a tendency to increase the pH to the alkaline aspect of neutrality. It is determined by titration with standardized acid to a pH of 4.5 and is commonly expressed in milligrams per liter as calcium carbonate (mg/l as $CaCO_3$). Commonly occurring substances in water that increase alkalinity are carbonate, phosphates, and hydroxides. Muthukumaravel *et al.* (2010) suggested that thick deposits of glacial till are the best sources of carbonate buffering. According to BIS (Bureau of Indian Standards, 2009), the desired value of alkalinity is 200 mg/l. However, it is permissible up to 600 mg/l and WHO (2011) encouraged 300 mg/l (Table 2). Padma,Ganges, Halda, Khiru, Rupsha, Surma, Turag and Karnafuli river confirmed alkalinity between suitable to permissible range (Islam *et al*., 2014; Haque *et al*., 2020; Islam *et al*., 2017; Rashid *et al*., 2012; Islam *et al*., 2018; Howladar *et al*., 2021; Rahman *et al*., 2012; Hossen *et al*., 2019) but crossed the restriction in Turag river in each the seasons ranging from 608.10-760.03 mg/l which showed unsuitable situation for fish culture (Tahmina *et al*., 2018) (Table 1).

Hardness

Numerous inorganic (mineral) resources are dissolved in water. Among these, the metals calcium and magnesium, along with their counter ion carbonate, contain the foundation for the measurement of hardness. Hard waters have the capability of buffering the consequences of heavy metals such as copper or zinc, which are frequently toxic to fish. Hardness is a necessary aspect in keeping accurate pond equilibrium. Water containing more than 300 mg/L of complete hardness is no longer viewed as suitable for drinking purposes. Optimum hardness for aquaculture is in the range of forty to four hundred ppm of hardness. Water is classified into three categories based on hardness: soft water (0 to 75 mg/L), moderately hard water (76 to 150 mg/L), and hard water (151 to 300 mg/L) (Soni *et al*., 2013). According to Islam *et al*., 2014; Haque *et al*., 2020; Howladar *et al*., 2021; Rahman *et al*., 2012; Hossen *et al*., 2019), Padma (except pre-monsoon), Ganges, and Surma have soft water, Turag (monsoon), and Karnafuli have moderately hard water, and Turag (except monsoon) and Karnafuli have hard water. But Rupsha surpassed the permissible range of hardness (Islam *et al*., 2018).

Dissolved oxygen

DO is one of the most necessary parameters. Its correlation with water physique offers direct and indirect facts, e.g., bacterial activity, photosynthesis, availability of nutrients, stratification, etc. (Premlata, 2009). DO is the dissolved gaseous form of oxygen. It is critical for the respiration of fish and different aquatic organisms. D.O. enters water by way of diffusion from the surroundings and as a by- product of photosynthesis via algae and vegetation (Gorde *et al*., 2013). Mustapha said that a dissolved oxygen concentration of 3 mg/l to 12 mg/l will promote the growth and survival of fish in a reservoir (Mustapha, 2008). The range of dissolved oxygen recorded at 4.8 mg/l to 8.2 mg/l suggests the water is properly satisfactory and will aid fish production (Alam *et al*., 2007). Temperature directly affects the amount of oxygen in water. The less warm the water, the more oxygen it can preserve (Verma and Singh., 2013). None of the rivers exceeded the suitable range of DO. The range of dissolved oxygen was recorded between 4.8 mg/l and 8.2 mg/l in the Padma, Brahmaputra, Ganges (monsoon), Dakatia, Shilmari, Surma, Titas, Turag (monsoon), and Buriganga rivers, indicating that the water is suitable for fish production (Islam *et al*., 2014; Tareq *et al*., 2013; Haque *et al*., 2020; Hasan

Table 2. Different physico-chemical parameters with their acceptable limits.

S.N.	Parameters	EQS (1997)	DoE (2016)	WHO (2011)	BIS (2012)
1	TDS (mg/l)	500	500-1000	600	500
2	DO (mg/l)	4-6	5-6	5	5
3	BOD (mg/l)	<2	5-10	5	-
4	COD (mg/l)	-	4	-	-
5	Alkalinity	-	-	300	200
6	pH (mg/l)	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
7	Total Hardness (mg/l)	-	>100	300	-
8	EC (µS/cm)	800-1000	0.7-1	300	750
9	Temperature (^{0}c)	25	20-34	25	-
10	Turbidity (NTU)	-	10	1	1
11	Nitrate (mg/l)	-	10	-	-

EQS (Environmental Quality Standard); DoE (Department of Environment); WHO (World Health Organization); BIS (Bureau of Indian Standards)

et al., 2015a; Islam *et al.*, 2016; Howladar *et al.*, 2021; Islam *et al.*, 2011; Rahman *et al.*, 2012). Meghna, Jamuna, Halda, Khiru, Shilmari (post-monsoon), Shitalakkhya, Turag, Karnafuli, Buriganga river also showed suited range but under 4.8 mg/l-8.2 mg/l (Bhuyan *et al.*, 2017; Uddin *et al.*, 2014; Islam *et al.*, 2017; Rashid *et al.*, 2012; Azad *et al.*, 2016; Sarkar *et al.*, 2015; Tahmina *et al.*, 2018; Sarwar *et al.*, 2010; Hossen *et al.*, 2019; Rahman *et al.*, 2010; Fatema *et al.*, 2018; Ahammed *et al.*, 2016). Ganges (except monsoon) and Buriganga river confirmed acceptable range but above 4.8 mg/l-8.2 mg/l (Haque *et al.*, 2020; Kamal *et al.*, 1999).

Biochemical oxygen demand (BOD)

BOD is a measure of organic material contamination in water, expressed in mg/L. BOD is the quantity of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic substances (e.g., iron, sulfites) (Patil *et al.*, 2012). Typically, the test for BOD is carried out over a five-day period (Milacron Marketing Co, Technical Report No. J/N 96/47). Like DO, BOD is a vital parameter required to study water pollution. The higher the BOD value of any body of water, more polluted the water will be by organic pollutants. On the basis of five days of BOD tests, the quality of water has been labeled as following (Radojeviae and Bashkin., 2006).

1. Very clean, if BOD Level is < 1mg / L
2. Clean if BOD Level is 1.1 – 1.9 mg/L
3. Moderately polluted if BOD Level is 2-2.9 mg/L
4 Polluted if BOD is 3-3.9 mg/L
5. Very polluted if BOD Level is 4-10 mg/L
6. Extremely polluted if BOD Level is > 10mg/L

In Halda (monsoon), Surma, Titas, and the river, BOD was < 1mg /L with very smooth water (Islam *et al.*, 2017; Howladar *et al.*, 2021; Islam *et al.*, 2011). The Padma River was once smooth and now polluted after exceptional seasons ranging from 1.1-3.9 mg /L (Islam *et al.*, 2014). Rahman *et al.* (2010) discovered that the Buriganga river experienced moderate air pollution only during the monsoon season (Rahman *et al.*, 2010). The Meghna, Halda (except during the monsoon season), Brahmaputra, Ganges, and Karnafuli rivers were once heavily polluted, with BOD levels ranging from 4 to 10 mg/L (Bhuyan *et al.*, 2017; Tareq *et al.*, 2013; Haque *et al.*, 2020; Islam *et al.*, 2017; Hossen *et al.*, 2019). The Jamuna, Turag, and Brahmaputra rivers, for example, were severely polluted for fish culture (Uddin *et al.*, 2014; Rahman *et al.*, 2012; Ahammed *et al.*, 2016).

Nitrate is found in raw water and has the general structure of an N2 compound (in its oxidizing state). Nitrate is produced by chemical and fertilizer plants, animal waste, deteriorating vegetables, and domestic and industrial discharges (Dohare *et al.*, 2014). It is a critical nutrient for many photosynthetic autotrophs and is typically found in trace amounts in surface water, according to Sarda and Sadgir (2015). When nitrate concentrations emerge as immoderate and different vital nutrient factors are present, eutrophication and associated algal blooms can turn out to be a problem (Sarda and Sadgir, 2015). The approach to measuring the quantity of nitrate is through a UV Spectrophotometer. As per IS: 10500-2012, the desirable limit for nitrate is a maximum of 45 and there is no relaxation in the permissible limit (Dohare *et al.*, 2014). Except for the Khiru river (34.59 mg/l), the Meghna, Ganges, Khiru, Titas, Turag, Karnafuli, and Buriganga rivers did not exceed the maximum limit and nitrate quantity was low (Bhuyan *et al.*, 2017; Haque *et al.*, 2020; Islam *et al.*, 2017; Rashid *et al.*, 2012; Islam *et al.*, 2016; Sarkar *et al.*, 2015; Alam *et al.*, 2011; Tahmina *et al.*, 2018; Hossen *et al.*, 2019; Kamal *et al.*, 1999; Ahammed *et al.*, 2016). But the Jamuna river crossed the maximum limit, ranging from 84.83-88.04 mg/l in distinct seasons (Uddin *et al.*, 2014).

Conclusion

This review is the first to provide a summary of the current condition of the water quality parameters of major rivers in Bangladesh. The ranges of several water quality parameters were found to be far above the acceptable limits in some rivers. The study noted that rivers are frequently contaminated, posing a significant threat to aquatic life, rivers, and the people who use them for domestic purposes and other activities. It is indeed suspected that this is due to improper disposal of sewage, surface and agricultural runoff, and wastewater disposal from home activities. It is essential to take actions to reduce the man-made and natural factors that affect water quality. This review recommended that the water quality parameters should be closely monitored, and industrial effluent and household sewage discharge should be minimized. There is also an urgent need for public awareness and to comply with legal and regulatory laws for the proper treatment of industrial and household discharges before they enter the river flow. In Bangladesh, the authorities responsible for water pollution control require a sufficient and comprehensive control mechanism as well as a database on the sources, quantities, and types of pollutants released into water bodies. Better sustainable management is also needed to improve the quality of river water. Furthermore, the findings of this study can be used as a baseline for future researchers, protecting the river from further degradation and allowing its biodiversity to also be conserved.

Conflict of interest

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

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