

1 **Evaluation of the Surface Water Quality in Bangladesh with an Introduction of Water**
2 **Quality Index (WQI) and its Prediction from Limited Parameters**

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9

10 **Abstract**

11 Healthy aquatic environment is crucial for preserving aquatic lives in surface waters. Increasing
12 industrial or agricultural discharge or run-off can pollute water leading to unhealthy aquatic
13 environment causing distress in fishes and other aquatic lives. In places with lack of
14 infrastructure and regulatory enforcement, pollution can be particularly challenging to handle.
15 Assignment of an indexing system can be helpful for analyzing pollution pattern in the polluted
16 rivers which can be helpful for remediation purposes and prevention of future pollution.
17 Bangladesh currently does not have any indexing system in place. Assignment of indices in the
18 rivers of Bangladesh can be helpful for remediation of the rivers on a preferential basis as
19 remediation of all the rivers at once will pose challenges with funding and infrastructural
20 allocation. Parameters monitored in the water monitoring stations of ten rivers were extracted
21 from the reports published by the Department of Environment (DOE) of Bangladesh. A water
22 quality index (WQI) was assigned on the rivers across seven years of time period to identify the
23 most polluted rivers. The degree of pollution in the river was in the order of Mayuri > Buriganga
24 > Korotoa > Turag > Shitalakhya > Surma > Halda > Dhaleshwari > Mathavanga > Brahmaputra
25 based on the WQI analysis. Among the ten rivers, only Mathavanga and Brahmaputra were in
26 good condition. The most polluted rivers were located in areas with manufacturing, textile etc.
27 industries. Hence, monitoring of industrial discharge into the rivers and regulatory enforcement
28 is crucial for the prevention of pollution in rivers. In addition to regulatory enforcement,
29 adoption of remediation plans and implementation of them is also essential for remediation of the
30 polluted rivers.

31 **Keywords:** Water quality index; Dissolved oxygen (DO); Biochemical oxygen demand (BOD);
32 Industrial discharge; Pollution; Developing countries

33 **Highlights**

- 34 • Rivers located in industrialized areas were highly polluted
- 35 • The fiver most polluted rivers were Mayuri, Buriganga, Korotoa, Turag, and Shitalakhya
- 36 • Brahmaputra and Mathavanga were in good condition
- 37 • Water quality index (WQI) can be predicted with dissolved oxygen (DO) or biochemical
- 38 oxygen demand (BOD)

39

40 **1. Introduction**

41 All living being need water for sustaining life. Quality of life is directly correlated to
42 accessibility of clean water (Oni & Fasakin, 2016). However, to meet the increasing demand for
43 food and various products, demand for agricultural and industrial production is increasing with
44 time which consequently causes water pollution with high strength agricultural run-off and
45 industrial discharge into receiving water bodies (UN-water, 2018). With a lack of well-developed
46 infrastructure and regulatory enforcement, water pollution is particularly more prevalent in the
47 developing countries (da Silveira Barcellos et al., 2021). Moreover, remediation of polluted
48 waterbodies also poses challenge for implementation due to lack of financial resources (Joseph et
49 al., 2019). However, use of polluted water for everyday needs including for drinking, cooking,
50 bathing, and irrigation is a common trend in the developing countries (Ahmed & Alam, 2019).
51 This poses a public health risk along with a high risk associated with sustaining healthy aquatic
52 lives in the waterbodies. Hence, remediation of polluted waterbodies is crucial for sustainable
53 water resources management.

54 Bangladesh is relatively small country consisting of about 700 rivers, including tributaries
55 flowing through it that are a key source of domestic, industrial, and agricultural water use
56 (Bhuyan et al., 2018). These rivers are major role players in the advancement of economic
57 growth of Bangladesh as they provide multiple uses including transportation of goods and
58 production materials (Tajmunnaher & Chowdhury, 2017). However, rapid and unplanned
59 urbanization and industrialization to meet the demand exerted by an overly populous country
60 resulted in an overabundant and unchecked pollution of the river waters in Bangladesh with
61 untreated discharge or run-off of chemical, industrial and agricultural wastes, micro-organisms,
62 or fecal matters (Islam, et al., 2016; Puri et al., 2011). In addition to the anthropogenic activities,

63 river water is also polluted for a combination of other factors such as geochemical factors,
64 chemical composition, and lithogenic structure (Shil, et al., 2019; Tajmunnaher & Chowdhury,
65 2017). About 80% of diseases in the world are caused due to poor hygiene and contaminated
66 water (Bhuyan et al., 2018). Water pollution negatively affects the quality of life for both
67 terrestrial and aquatic beings, directly or indirectly. Therefore, water quality needs to be closely
68 monitored and maintained for achieving sustainable economic and social development, and
69 preservation of terrestrial and aquatic beings.

70 Generally, river water quality can be evaluated based on several physical, biological, and
71 chemical parameters (Tajmunnaher & Chowdhury, 2017). For instance, the National Science
72 Foundation (NSF) recommends evaluation of water quality by monitoring dissolved oxygen
73 (DO), biochemical oxygen demand (BOD), fecal coliform, pH, temperature, total phosphate,
74 nitrate, turbidity, total solids etc. and assigns weights to each parameters to determine the overall
75 quality of a water body (Kumar & Dua, 2009). The combination of the monitored parameters in
76 different intensities helps define the status of pollution and determine the degree of it for a
77 certain surface water body (Kotoky & Sarma, 2017). Hence, an index considering the monitored
78 parameters and associated values can help quantify the degree of pollution and water quality of a
79 water body. Generally, the cumulative assessment of the monitored parameters is quantified as
80 an index termed as water quality index (WQI) which is a useful tool for overall water quality
81 evaluation (Kotoky & Sarma, 2017). The assignment of weights on different parameters and
82 which parameters are considered for WQI calculation can vary across different kind of water
83 quality monitoring agencies. WQI has been used as a strong tool for water quality assessment in
84 different countries for the purposes of aquatic ecosystems preservation and monitoring of water
85 usage for different purposes (Wu et al., 2020; Oni & Fasakin, 2016). As discussed above,

86 assessment of water quality is often poorly structured in the developing countries. Consequently,
87 a universal WQI assignment and evaluation is seldom prevalent among the developing countries.
88 Similarly, Bangladesh currently monitors a few parameters only and there has been no attempt at
89 employment of WQI to assess water quality quantitatively and qualitatively in the country. A
90 WQI particularly adopted for the monitored parameters in Bangladesh will be useful for
91 determining water quality and the degree of pollution in the rivers of Bangladesh. Evaluation of
92 the pollution level in different waterbodies will be helpful in remediation planning and
93 management by focusing on the most polluted waterbodies on priority basis.

94 The Department of Education (DOE) monitors some parameters at different monitoring stations,
95 but DOE does not assign WQI to the different waterbodies. There are several published works
96 on assigning WQI to different water sources in Bangladesh. Two of the identified studies were
97 focused on WQI for surface water while two other studies focused on WQI for groundwater.
98 Iqbal et al. (2020) studied and assigned WQI for groundwater quality evaluation in Bangladesh.
99 Assignment of WQI to evaluate groundwater quality in Tala Upazila in the Sathkhira district
100 covering a smaller geographical area has also been reported (Saha et al. 2018). However, surface
101 water is the main resource for water usage in different sectors and it is directly correlated to a
102 well-preserved aquatic ecosystem. Hence, WQI assignment to surface water bodies will be
103 helpful for preservation of aquatic systems and remediation of the polluted waterbodies to
104 achieve sustainable water resources management (Shil, et al., 2019). Currently, there are limited
105 studies investigating different surface water quality parameters to employ WQI to surface
106 waterbodies in Bangladesh. Hossain et al. (2019) studied water quality of the Karnaphuli river by
107 assigning WQI at five different sampling locations of the river. Similar studies were published
108 on WQI assignment based on selected parameters at different sampling locations of Buriganga,

109 Turag and Dhaleshwari rivers (Hasan et al, 2020; Khan et al., 2020; Fatema et al., 2013;
110 Pramanik & Sarker, 2013). However, a more holistic approach for WQI assignment on the main
111 rivers and more widespread area of Bangladesh is yet to be employed. Assignment of WQI to
112 several big rivers will be helpful for identifying the rivers requiring the most focus for
113 remediation. Moreover, trend analysis of water quality by studying WQI of a number of rivers
114 across a several years of time period will help understand the overall timeline, degree of
115 improvement or deterioration in the rivers. Therefore, the objective of this study is to (i) analyze
116 DO and BOD trend and (ii) assign and analyze WQI trend in ten selected rivers in Bangladesh
117 across a seven years of time period.

118 **2. Methods**

119 Trend analysis of two water quality parameters were conducted for ten selected rivers across a
120 time period of seven years starting from 2010 till 2016. The two selected parameters were DO
121 and BOD. Then WQI was calculated using a weighted average of four parameters, i.e. DO,
122 BOD, suspended solids (SS), and pH. Data for the trend analysis and WQI assignment was
123 extracted from water quality reports published by DOE (DOE, 2016; DOE, 2015; DOE, 2014;
124 DOE 2013; DOE, 2010). Ten rivers were selected based on the availability of most data points
125 both in terms of number of parameters and timeline of data collection. Moreover, the selected ten
126 rivers were located in industrialized urban or rural agricultural areas. The ten selected rivers were
127 Buriganga, Shitalakhya, Turag, Dhaleshwari, Brahmaputra, Halda, Moyuri, Surma, Korotoa,
128 Mathavanga. Among these rivers, Buriganga, Shitalakhya, Turag, Dhaleshwari, Moyuri, Surma,
129 Korotoa rivers have different types of industries located on their banks or in surrounding areas.
130 Halda flows though areas where tea gardening is prevalent while Mathavanga flows through

131 Chuadanga district that is mostly agricultural economy dependent. Brahmaputra flows through
132 an urban unindustrialized area, Mymensingh district.

133 Water quality reports published by the DOE from 2010 till 2016 (the latest published report)
134 were extracted. The annual average DO and BOD was calculated for all ten rivers for the time
135 period of seven years. The amount of oxygen available in water for aquatic uptake is DO and if it
136 drops between 2 – 4 mg/L, fishes get distressed in a hypoxic condition (Francis-Floyd, 2011).
137 BOD is an indirect measurement of the organic matters present in water which is quantified by
138 tracking DO depletion needed for degradation of the organic matters (Lee & Nikraz, 2015).
139 Therefore, there is a DO depletion in a water sample with high BOD concentration; typically,
140 BOD greater than 15 mg/L indicates a very polluted water unsustainable for healthy aquatic
141 environment. In a limited data acquisition situation, DO and BOD can be very helpful for
142 determining water quality of a waterbody.

143 In addition to DO and BOD, two other parameters, i.e. pH and SS were considered for WQI
144 calculation. For aquatic sustainability, pH ranging from 6 – 9 is sufficient and a sudden change in
145 pH of a water indicates introduction of foreign matters into the waterbody (Liou et al., 2004).
146 The amount of insoluble matters is quantified as SS which might be an indicator of a number of
147 aquatic events, i.e. runoff of particulate organics, algal bloom etc. Weights were employed on
148 DO, BOD, SS, and pH according to their values and a weighted average of the values were
149 calculated for quantifying the water quality of the rivers as WQI [Equation 1].

$$150 \quad WQI = \frac{1}{n} \sum_{i=1}^n I_i \quad \text{[Equation 1]}$$

151 where, n = the number of parameters monitored, and I is the weight normalized value assigned to
152 the monitored parameters.

153 The weights assigned to the parameters for WQI calculation was conducted following weight
 154 assignment proposed by Liou et al. (2004). Table 1 lists the weight assignment to the parameters
 155 use in this study for WQI calculation.

156 **Table 1:** Weight assignment on the parameters (pH, dissolved oxygen, biochemical oxygen
 157 demand, suspended solids) used for water quality index (WQI) calculation

Parameter weight		Parameters for WQI calculation			
Qualitative interpretation	Quantitative weight	pH	DO (mg/L)	BOD (mg/L)	SS (mg/L)
Good	1	6.5 – 8.5	> 6.5	< 3	< 20
Slightly polluted	3	4.6 – 6.4, 8.6 – 10.4	4.6 – 6.4	3 – 4.9	20 – 49
Moderately polluted	6	2 – 4.5, 10.5 – 12	2 – 4.5	5 – 15	50 – 100
Very polluted	10	< 2, > 12	< 2	> 15	> 100

158

159 A qualitative interpretation of the WQI was made according to Table 2.

160 **Table 2:** Qualitative interpretation of water quality index (WQI) assigned to the rivers

Water quality index (WQI)	Quantitative interpretation
< 2	Good
2 – 2.9	Slightly polluted
3 – 4.9	Moderately polluted
≥ 5	Very polluted

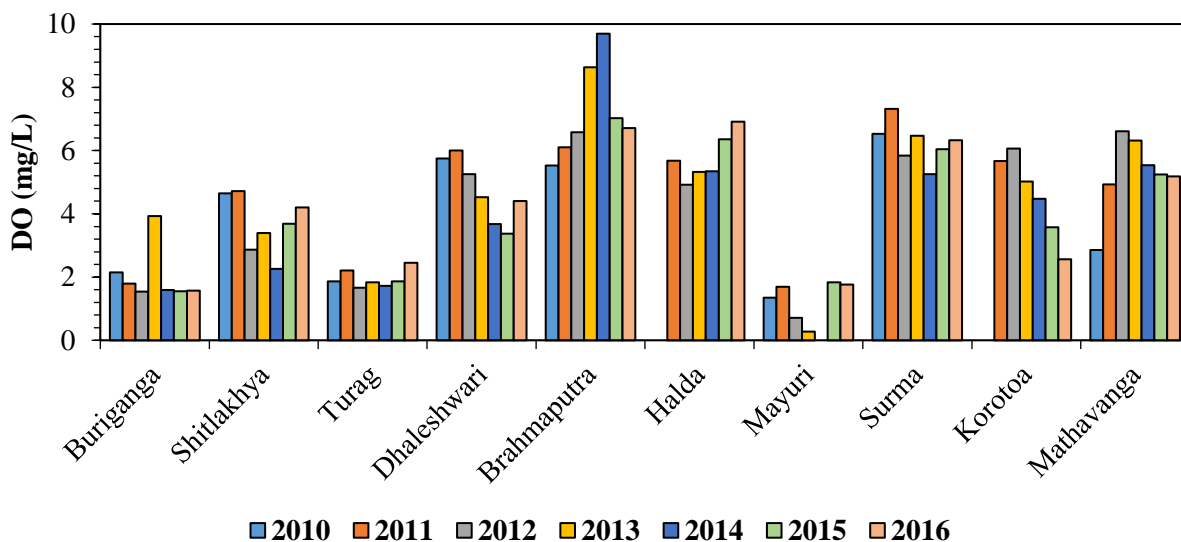
161

162 In addition to the assigned weights and WQI calculation, regression analysis of the data points
 163 across seven years were performed to analyze correlation of WQI with DO or BOD or both.

164 3. Results & Discussion

165 3.1. Dissolved oxygen (DO) level in ten selected rivers

166 The amount of gaseous form of oxygen (O₂) dissolved in the water is measured as DO which
 167 indicates the availability of oxygen for aquatic uptake. DO is therefore crucial for all forms of
 168 aquatic lives (Ewaid & Abed, 2017). By the direct absorption of O₂ from the atmosphere, rapid
 169 movement of water and byproduct of photosynthetic activities atmospheric oxygen enters water.
 170 A number of factors including temperature, salinity, presence of organic matter can affect DO
 171 level in water. The level of DO from 2010-2016 for all ten rivers were analyzed as an annual
 172 average as presented in Figure 1.



173
 174 **Figure 1:** Level of dissolved oxygen (DO) in ten rivers of Bangladesh across a time period of
 175 seven years starting from 2010 till 2016.

176 Three rivers, Buriganga, Turag and Mayuri had overall the lowest DO for the seven years of
 177 period. Except for 2013, DO level was near or below 2 mg/L (1.575 – 2.150 mg/L) in Buriganga
 178 in all other years. Similarly, DO of Turag was in the range of 1.66 – 2.455 mg/L all through the
 179 seven years. The extremely hypoxic conditions in Buriganga and Turag might have been caused
 180 industrial pollution as both these rivers are located in the heavily industrialized areas of
 181 Bangladesh. The surrounding areas of Buriganga is a hotspot for the tannery industry while

182 many textile industries are located on or near the banks of Turag. Mayuri had 0.280 – 1.675
183 mg/L DO in all through the seven years. Apart from industrial pollution, another reason for low
184 level of DO in Mayuri can be relatively higher salinity in Mayuri as the river is very closely
185 located near the Bay of Bengal.

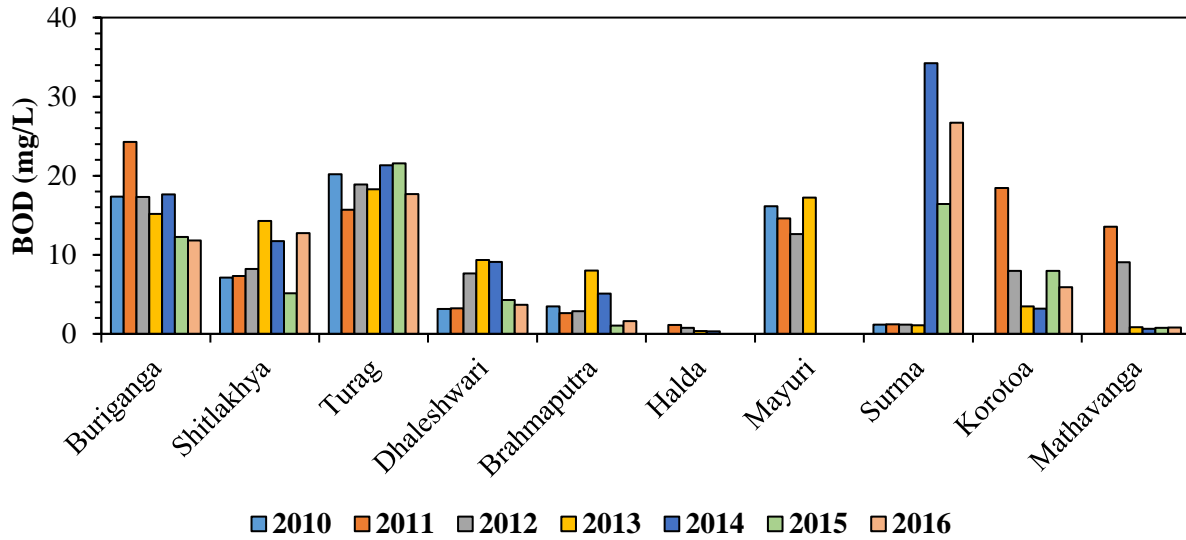
186 Shitalakhya, Dhaleshwari, and Korotoa had DO level near 4 mg/L in the recent reported years,
187 showing an overall downward trend. Shitalakhya river water sampling locations were near two of
188 biggest factories in the country, Advanced Chemical Industries (ACI) Factory and Ghorashal
189 Fertilizer Factory. Dhaleshwari river water sampling stations were in Munshiganj and
190 Hemayetpur surrounded by manufacturing and textile industries. Korotoa river sampling
191 locations were in Bogura district where economy is heavily agriculture dependent with some
192 minor industries in the area. While DO level of Shitalakhya and Dhaleshwari rivers were above 4
193 mg/L in 2016, it showed an ever-decreasing trend for Korotoa river reaching 2.565 mg/L in
194 2016.

195 Brahmaputra, Halda, and Surma had near 6.5 mg/L DO in recent reported years while
196 Mathavanga shows a downward trend for DO starting from 2012, the only year it had DO greater
197 than 6.5 mg/L. Mathavanga river sampling locations were in Chuadanga, an agriculture
198 dependent district. Brahmaputra and Halda sampling locations were in unindustrialized areas
199 where sampling locations of Surma were near a few manufacturing industries including Chhatak
200 Cement Factory. Level of DO in Brahmaputra was above 6.5 mg/L in 2012, 2013 and then
201 decreased in the next few years. Surma's DO level stayed at the same level ranging from 6.04 –
202 7.315 mg/L across the seven reported years while Halda's DO level showed an upward trend,
203 reaching 6.915 mg/L in 2016. Overall, location and surrounding industrialization level might be

204 an important factor leading to low DO in industrialized and high DO in relatively less
205 industrialized areas.

206 **3.2. Biochemical oxygen demand (BOD) in ten selected rivers**

207 Biochemical oxygen demand generally an indicator of presence of organic matter. With a high
208 level of organic matter present in water, consumption of DO for breaking down organic matter
209 causes DO depletion in water. Consequently, aquatic systems with high level of BOD generally
210 has low level of DO in the system. Accordingly, it was observed that BOD was generally high in
211 the rivers with low level of DO. For instance, DO was very low in Buriganga, Turag Maoyuri
212 and these three rivers had BOD always in the toxic regime across the observed time period
213 [Figure 2]. Buriganga river's BOD level dropped from 17.6 mg/L in 2014 to 11.8 mg/L in 2016,
214 but it was still toxic for aquatic healthy environment. Similarly, Turag and Mayuri rivers' BOD
215 level was in the range of 18.9 – 21.6 mg/L and 12.6 – 17.3 mg/L, respectively. Notably, the BOD
216 level in Mayuri river was not available from 2014 through 2016. However, low level of DO in
217 Mayuri's water in 2015 (1.830 mg/L) and 2016 (1.765 mg/L) is likely an indicator of a toxic
218 level of BOD in the river in 2015 and 2016.



219

220 **Figure 2:** Level of biochemical oxygen demand (BOD) in ten rivers of Bangladesh across a time
 221 period of seven years starting from 2010 till 2016.

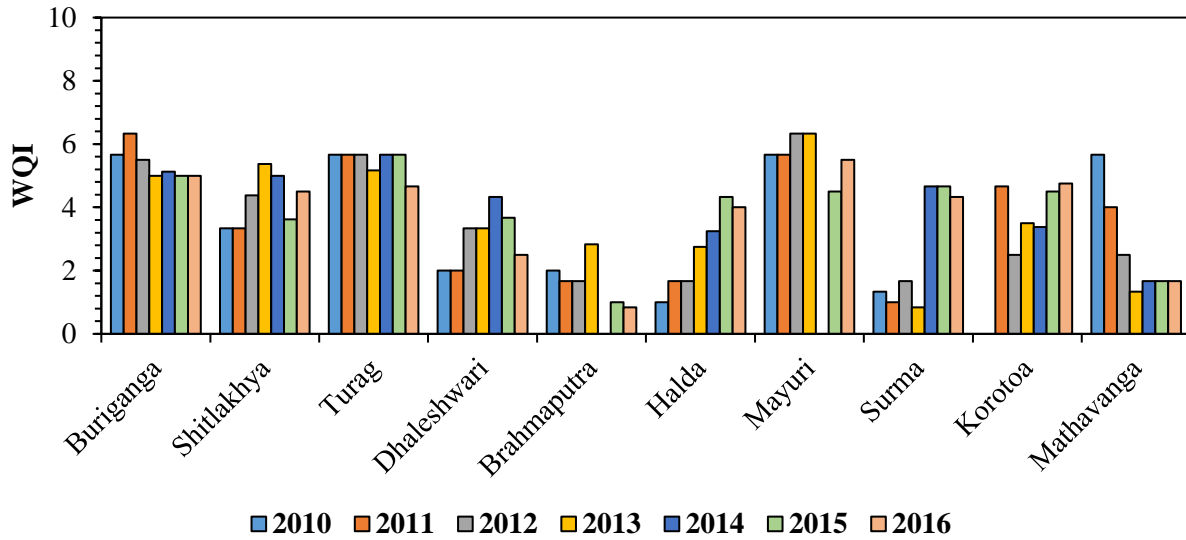
222 Brahmaputra, Halda, Mathavanga rivers showed a downward trend for BOD likely because of
 223 the less of an industrialization in the locations the rivers are located, especially, Mathavanga
 224 rivers' BOD level were in the healthy range of BOD (< 3 mg/L) in recent years. Notably,
 225 Halda's BOD levels in the most recent years were not available, but referring to the relatively
 226 high level of DO in Halda and the overall trend of DO And BOD in the river, it can be presumed
 227 that Halda's BOD was till in healthy range in 2014, 2015, and 2016. Korotoa's BOD indicates
 228 moderate pollution but its BOD level stayed almost at the same level after 2010 indicating the
 229 pollution level in the river likely did not deteriorate further till 2016.

230 Dhaleshwari, Shitalakhya, and Surma rivers' BOD level was above the range for healthy level (>
 231 3 mg/L). The level of BOD in Surma was in the range of 16.4 – 34.2 mg/L in recent years while
 232 Dhaleshwari's BOD was below 8 mg/L indicating a moderate pollution level in Dhaleshwari
 233 based on the recent BOD level in the river. The BOD level was above the healthy range in recent

234 years in Shitalakhya with the exception in 2015 when it was 5.1 which is below 8 mg/L beyond
235 which aquatic lives are severely threatened.

236 **3.3. Water Quality index (WQI) in ten selected rivers**

237 Water quality index (WQI) can indicate the overall quality of water. In absence of a universal
238 indexing of water quality different water quality agencies adopt different methods for WQI
239 assignment. In this study, DO, BOD, pH, and SS- these four parameters were considered for
240 WQI calculation. However, SS data was not available for all rivers. But weights were assigned to
241 each parameter according to the associated intensity and then an average of the total weight was
242 used for WQI employment to minimize the effect of lack of one or two parameters (if any). The
243 level of DO and BOD in all ten rivers across a seven-year period was discussed in the previous
244 sections. A separate section on pH level in the rivers was not provided as pH was within the
245 range of 6.5 – 8.5 in all the rivers (Qiao et al., 2016). Moreover, no drastic fluctuation of pH was
246 observed in the rivers which indicates a sudden introduction of foreign materials into the water
247 body. Additionally, SS values were also considered for WQI calculation, when available. Figure
248 3 shows the calculated WQI for all ten rivers in a seven-year period (2010 – 2016).



249

250 **Figure 3:** Calculated water quality index (WQI) for ten rivers from 2010 till 2016.

251 Among the ten rivers, Brahmaputra had the lowest WQI in recent years with a downward trend
 252 over the years while Halda showed an upward trend in WQI. As discussed earlier, Brahmaputra
 253 flows through a residential urban area that is not industrialized. Halda flows through hilly areas
 254 with tea gardens. One possible reason for Halda’s increasing WQI over the years could be due to
 255 run-off from tea gardens that would carry sediments, nutrients with it. Buriganga, Turag, and
 256 Mayuri are the three most polluted rivers in terms of WQI across the observed time period,
 257 showing no major fluctuations over the years. Buriganga, Turag, and Moyuri are in the most
 258 industrialized areas of Bangladesh. Some of those industries include tanneries, textiles, and
 259 manufacturing industries. Lack of regulatory enforcement and infrastructure for industrial
 260 discharge control very likely contributed to the high level of WQI in those three rivers.
 261 Contribution of industrial discharge can be more clearly observed by comparing WQI of these
 262 three rivers to that of Brahmaputra and Mathavanga. Being in relatively under-industrialized
 263 areas, Brahmaputra and Mathavanga had lower WQI compared to Buriganga, Turag, and
 264 Moyuri.

265 Shitalakhya (4.5 – 5.0), Surma (4.3 – 4.7), and Korotoa (4.5 – 4.8) rivers had WQI almost at the
 266 same level in recent years (2014 – 2016) indicating moderate pollution in the rivers. Pollution in
 267 Shitalakhya and Surma rivers might be due to these rivers being adjacent to some of the largest
 268 factories in the country, i.e. ACI, Chhatak cement factory. Korotoa’s moderate pollution might
 269 have been caused by the small industries located in the adjacent area. Dhaleshwari river showed
 270 a downward trend of WQI from 4.3 in 2014 to 2.1 in 2016. However, Dhaleshwari river is
 271 located in an area with manufacturing and textile industries. There is no evidence or
 272 documentation of any drastic regulatory enforcement in the area for controlling industrial
 273 discharge. The downward trend of WQI in the river might be due to lack of sampling in the
 274 monitoring stations which is a very common phenomena in many of the monitoring stations
 275 across the country. Overall, Brahmaputra and Mathavanga were the only two rivers with a WQI
 276 for healthy aquatic environment identified in this study. All the other rivers either slightly or
 277 moderately polluted and not healthy for aquatic lives. The degree of pollution in the ten rivers in
 278 2016 based on WQI was in the order of Mayuri > Buriganga > Korotoa > Turag > Shitalakhya >
 279 Surma > Halda > Dhaleshwari > Mathavanga > Brahmaputra. A qualitative interpretation was
 280 made based on the WQI calculated in this study for a convenient identification of the polluted
 281 rivers [Table 3].

282 **Table 3:** Degree of pollution in the ten selected rivers presented with different color codes

Color code:

	Good
	Slightly polluted
	Moderately polluted
	Very polluted

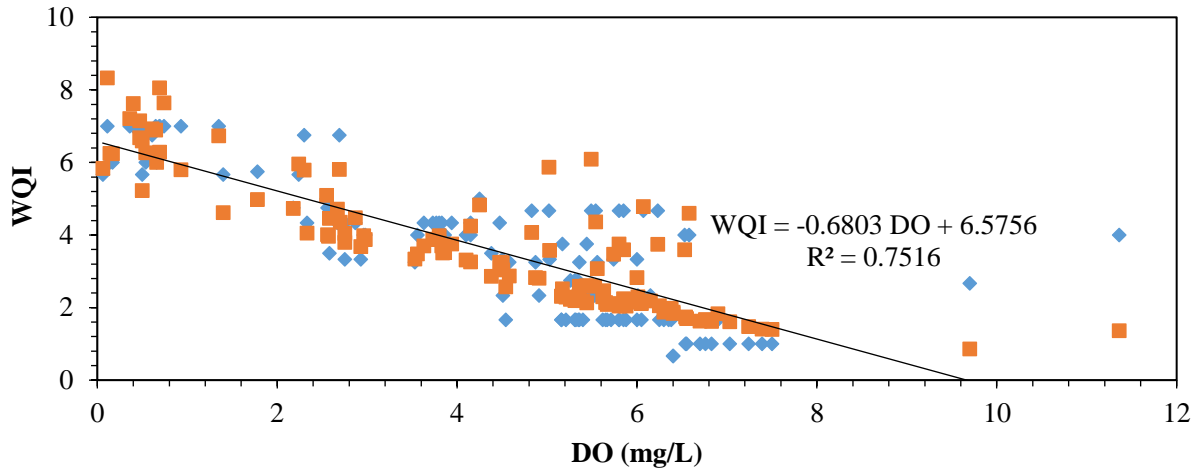
283

River	2010	2011	2012	2013	2014	2015	2016
Buriganga	Orange	Dark Orange	Orange	Orange	Orange	Orange	Orange
Shitalakhya	Orange	Orange	Orange	Orange	Orange	Orange	Orange
Turag	Orange	Orange	Orange	Orange	Orange	Orange	Orange
Dhaleshwari	Yellow	Yellow	Orange	Orange	Orange	Orange	Yellow
Brahmaputra	Yellow	Green	Green	Yellow	White	Green	Green
Halda	Green	Green	Green	Yellow	Orange	Orange	Orange
Mayuri	Orange	Orange	Dark Orange	Dark Orange	White	Orange	Orange
Surma	Green	Green	Green	Green	Orange	Orange	Orange
Korotoa	White	Orange	Yellow	Orange	Orange	Orange	Orange
Mathavanga	Orange	Orange	Yellow	Green	Green	Green	Green

284

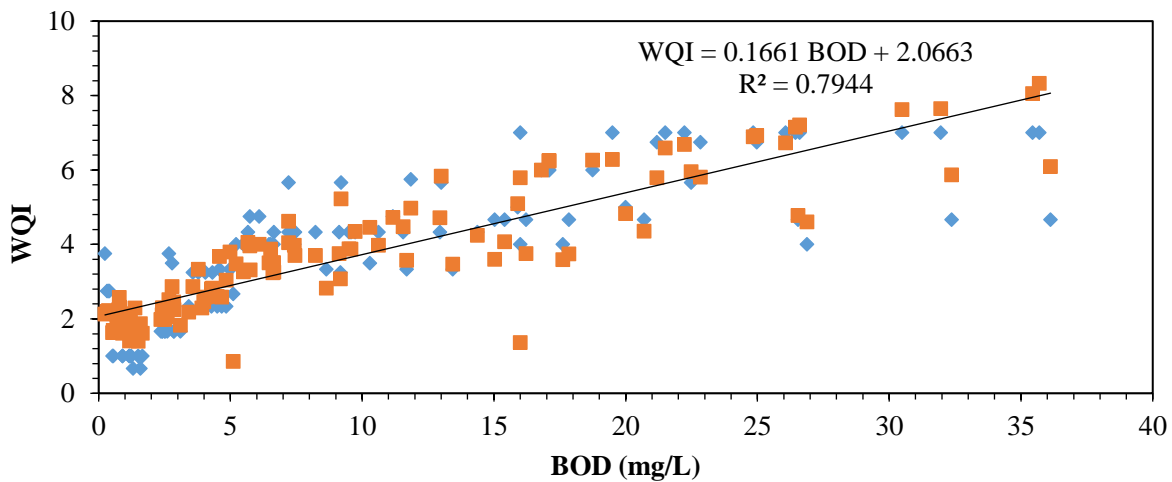
285 As presented in Table 3, Buriganga, Shitalakhya, Turag, Halda, Mayuri, Surma, Korotoa rivers
 286 were moderately polluted in 2016, and Dhaleshwari was slightly polluted while Brahmaputra and
 287 Mathavanga were in good conditions. This shows a trend of rivers being more polluted when
 288 there are industries in surrounding areas.

289 Monitoring of more parameters and incorporation of them into WQI will be helpful for
 290 calculation of more accurate WQI representative of the actual water quality. However,
 291 monitoring of more parameters might be challenging due to lack of resources and infrastructure
 292 in developing countries like Bangladesh. Therefore, WQI can be prediction with a few
 293 parameters will be helpful in resource limited situations. A correlation between DO, BOD and
 294 WQI was analyzed in this study [Figure 4].



(a) ◆ Actual WQI ■ Predicted WQI — Fitted Predicted WQI

295



(b) ◆ Actual WQI ■ Predicted WQI — Fitted Predicted WQI

296

297 **Figure 4:** Regression analysis of (a) dissolved oxygen (DO) and water quality index (WQI), and

298 (b) biochemical oxygen demand (BOD) and WQI to determine correlation between them.

299 Predicted WQI using DO and BOD as variable resulted in R^2 of 75.16% and 79.44%,

300 respectively.

301 With using DO and BOD both as variables, WQI can be predicted as follows ($R^2 = 86.68%$ and

302 standard error 0.68).

303 $WQI = 4.42 - 0.42 DO + 0.11 BOD$ [Equation 2]

304 In challenging situations with difficulty in monitoring multiples parameters, the correlation of
305 WQI with DO and BOD individually or both parameters can be helpful for prediction of water
306 quality.

307 **4. Conclusion**

308 Access to clean water is essential for all living beings. Similarly, clean and pollution free surface
309 water is crucial for a healthy aquatic environment where all aquatic beings can sustainably
310 thrive. However, with an increasing industrial and agricultural production to meet the demand of
311 the ever-increasing population, water pollution is becoming challenging for sustainable
312 development. This phenomenon is particularly more challenging in developing countries like
313 Bangladesh where lack of infrastructure and regulatory enforcement poses higher risk for water
314 pollution. Anthropogenic activities generated huge transformations in the river water quality and
315 ecosystem in the country. Because of economic benefit many industries are established near the
316 river side and the subsequent discharge of untreated and semi treated toxic waste into the river is
317 likely to negatively affect the water quality in the receiving waterbodies.

318 The water quality index can be helpful for reducing the bulk of the monitored parameters into a
319 single value to communicate in a rearranged and consistent manner. Hence, a well-adopted water
320 quality indexing system can be helpful for remediation planning and implementation purposes.
321 However, currently the country does not have a country wide indexing system in place. There are
322 a few published works on assignment of WQI on some selected waterbodies. But an overall
323 indexing to apply on a vast region of the country covering both industrialized and under-
324 industrialized areas is yet to be explored. This study proposed an indexing system considering

325 four parameters, generally monitored in the monitoring stations of DOE. An analysis of DO,
326 BOD, and WQI in the ten selected rivers showed that rivers located in the heavily industrialized
327 areas were highly polluted and the degree of pollution were generally lower in the areas with less
328 industries. Rivers in the industrialized areas showed a general trend of having low DO and high
329 BOD. The rivers can be in the order of Mayuri > Buriganga > Korotoa > Turag > Shitalakhya >
330 Surma > Halda > Dhaleshwari > Mathavanga > Brahmaputra in terms of the degree of pollution
331 based on the WQI assignment in this study. This order can be helpful for identifying which rivers
332 need remediation on a preferential basis.

333 Similarly, WQI can be calculated for other rivers in the country to gather a better understanding
334 of the degree of pollution in the rivers and make a holistic plan for remediation of the rivers.
335 However, setting up more monitoring stations in the rivers and frequent sampling is crucial for
336 assignment of WQI for development and implementation of remediation plans. In a resource
337 limited situation, the relationship derived in this study can be useful for prediction of WQI using
338 DO, BOD or both parameters. In addition to remediation, adoption of regulatory measures and
339 enforcement is also recommended for preventing pollution in future.

340 **Author Contributions**

341 **Mallick, Z.:** Conceptualization, Methodology, Investigation, Data Curation, Writing – Original
342 draft, Writing – Review & Editing. **Hossain, M.R.B.:** Investigation, Data Curation, Writing –
343 Original draft, Writing – Review & Editing. **Ayshi, F.T.:** Investigation, Data Curation, Writing –
344 Original draft, Writing – Review & Editing. **Mallick, S.P.:** Conceptualization, Methodology,
345 Validation, Formal Analysis, Investigation, Data Curation, Writing – Original draft, Writing –
346 Review & Editing, Supervision.

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349 **Conflicts of Interest**

350 The authors declare no conflict of interest.

351

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