Assessment of Water Quality Index (WQI) in Different Locations of Bangladesh using Groundwater Quality Parameters

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Abstract. In Bangladesh, groundwater is the main source of potable, industrial, and irrigational water supply. Due to its heavy dependence, an excessive groundwater table drawdown and deterioration in groundwater quality is noticeable. The groundwater from ten cities in Bangladesh (Gazipur, Kishoreganj, Rajshahi, Bhola, Khulna, Patuakhali, Lakshmipur, Bagerhat, Chattogram, and Mymensingh) was evaluated for this study. Six groundwater parameters (pH, Turbidity, Chloride, Hardness, Iron, and Arsenic) were assessed to determine the Water Quality Index (WQI) using the Weighted Arithmetic Method. Using this method, it is revealed that the following parameters differ as follows: pH ranges from 6.8 to 8, turbidity from 0.9 to 5.5 NTU, chloride from 59 to 244 mg/L, hardness from 20.3 to 116 mg/L, iron from 0.12 to 9 mg/L, and arsenic from 0.002 to 0.024 mg/L. According to the WQI value, the water quality at the hydro-stations in Bhola, Khulna, Patuakhali, and Mymensingh was rated as "Excellent," with WQI values of 11.79, 11.19, 8.14, and 15.95, respectively. On the other hand, the water quality of the hydro-stations in Gazipur, Rajshahi, Lakshmipur, Bagerhat, and Chattogram is rated as "Good," with WQI values of 45.83, 34.96, 38.35, 48.35, and 36.89, respectively. Kishoreganj is the only hydro-station to achieve "Very Poor" water quality, with a WQI of 80.24. The assessment of groundwater test findings will aid in identifying groundwater pollution, which is required to evaluate the risk to public health and provide strategies for protecting groundwater.

Keywords: weighted arithmetic method, water quality index (WQI), ECR 2023, Bangladesh, groundwater.

1 Introduction

The subsurface water found in saturated areas under the surface is known as groundwater (USGS, 2023). Though Bangladesh is a riverine country, groundwater is the critical source most people rely on for drinking. Currently, groundwater is the

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primary source of drinking water for around 80% of Bangladesh's rural population. Groundwater is also a significant source of water for urban areas. Over 95% of Dhaka City's supply is derived from groundwater, with treated surface water providing the remaining portion; additionally, groundwater plays a significant role in irrigation; in 1995, groundwater supplied 72% of the total coverage (Banglapedia, 2021). In Asia's expanding agricultural economy, groundwater is vital for billions of people's livelihoods and food security. Approximately 50% of the world's current supply of potable water, 40% of the water used for industry, and 20% for irrigation come from groundwater (Alam, 2017).

Water quality has changed as a result of numerous surface and groundwater sources being exhausted over time and having significant portions of them contaminated by various factors like urbanization, population increase, and industrial development (Imneisi & Aydin, 2016). Groundwater is most seriously threatened by arsenic, which is present nationwide. Before the finding of arsenic poisoning, 97% of rural residents relied on groundwater, which is now only 80% (Banglapedia, 2021). Apart from these parameters, groundwater is also affected by other parameters such as pH, turbidity, hardness, and iron. Consuming excessive iron may create fatigue, weight loss, and joint pain and eventually may affect the liver and heart and lead to pancreatic damage and diabetes (Dutta, 2019). Additionally, hard water causes an unpleasant taste and makes water unsuitable for household work.

The Water Quality Index (WQI) is an effective method of assessing water quality based on water's physical, chemical, and biological characteristics. Water resource authorities receive a broader range of knowledge, crucial information for identifying trends, and recommendations for future planning from examining these three categories based on parameters obtained from field monitoring of water sampling (Sutadian et al., 2016). An index's function is to convert complicated data on water quality into information that the general public can utilize and understand (Akkaraboyin & Raju, 2012). Many techniques were developed over time to assess the quality of water. For this study, the Weighted Arithmetic Method was used, which was developed by (Brown et al., 1972). It is one of the standard techniques for evaluating the water quality of various locations. The analysis's outcome was compared with Bangladesh's drinking water quality criteria in the Environment Conservation Rules (ECR, 2023). Ten groundwater samples from ten districts (Gazipur, Kishoreganj, Rajshahi, Bhola, Patuakhali, Khulna, Bagerhat, Lakhshmipur, Chattogram, and Mymensingh) throughout six divisions (Dhaka, Rajshahi, Barisal, Khulna, Chattogram and Mymensingh) of Bangladesh were collected for this purpose. Based on this index, the study looked at groundwater quality, ranging from excellent to unsuitable. Additionally, the Geographic Information System (GIS) was utilized in each area to display the variance of several water parameters. The Geographic Information System (GIS) technique combined with the IDW interpolation method has recently been used to regularly assess and monitor groundwater quality. GIS is an effective tool for analyzing and evaluating spatial information related to water resources (Panneerselvam et al., 2020).

The study's objectives are to assess the concentrations of pH, turbidity, chloride, hardness, iron, and arsenic in groundwater, assess the suitability of water for drinking purposes considering tested parameters, and compare various groundwater metrics in the research locations using ArcGIS.

2 Methodology

2.1 Study Area

Geographically, Bangladesh is located between latitude 20°34′N–26°38′N and longitude 88°01′E–92°41′E. Rainfall in Bangladesh varies from 1600 mm in the northwest to more than 4400 mm in the northeast. About 75% of rainfall occurs during monsoon (Salman et al., 2018). Groundwater is mainly recharged by rainwater during monsoon. Many factors, like geology, topographic relief, climate, and land use, affect the groundwater quality (Salman et al., 2018). Physical factors, including temperature, turbidity, color, taste, and odor, determine groundwater quality. Groundwater's chemical and biological properties are the primary cause of worry because it is often tasteless, odorless, and colorless.

2.2 Sample Collection

For this study, ten groundwater samples were collected and tested. These locations were Gazipur, Kishoreganj, Rajshahi, Bhola, Patuakhali, Khulna, Bagerhat, Lakhshmipur, Chattogram, and Mymensingh. Before collecting the groundwater, the bottles were cleaned using clean water, and then the bottles were filled with groundwater. Water samples were collected from 18th September 2022 to 12th April 2023 and sent for testing in the laboratory.

Table 1. Study area and their co-ordinates

Sample No	Location	Collection Date	Latitude	Longitude
L-1	Gazipur	13 Nov 2022	24°10'57.36"N	90°32'50.98"E
L-2	Kishoreganj	17 Nov 2022	24°26'16.18"N	90°46'54.43"E
L-3	Rajshahi	17 Nov 2022	24°22'33.56"N	88°35'57.84"E
L-4	Bhola	9 Apr 2023	22°11'58.33"N	90°43'33.46"E
L-5	Khulna	12 Apr 2023	22°20'41.67"N	89°17'31.17"E
L-6	Patuakhali	9 Apr 2023	21°53'22.57"N	90° 7'25.54"E
L-7	Lakshmipur	2 Apr 2023	22°39'23.83"N	90°54'40.20"E
L-8	Bagerhat	6 Apr 2023	22°22'53.23"N	89°50'44.95"E
L-9	Chattogram	2 Apr 2023	22°26'4.06"N	91°44'59.82"E
L-10	Mymensingh	18 Sept 2022	24°46'10.72"N	90°23'52.63"E

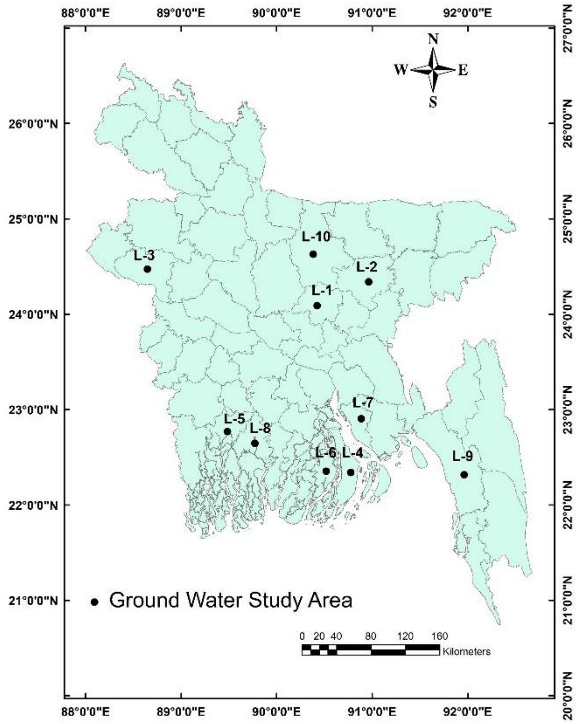

Fig. 1. Map of Bangladesh highlighting the designated study areas

2.3 Data Collection and Software

For this study, the groundwater samples were tested for pH, Turbidity, Chloride, Hardness, Iron, and Arsenic. pH was measured using a pH meter. Turbidity was measured using the nephelometric method. Chloride and Hardness were measured using the titrimetric method. Iron was measured using a spectrophotometer, and arsenic was measured using the Atomic Absorption Spectrophotometry (AAS) method. Also, Microsoft Excel and ArcGIS 10.5 is used for data analysis.

2.4 WQI Calculation

The WQI has been determined using the drinking water quality standard recommended by the ECR 2023. The Water Quality Index has been calculated using the weighted arithmetic method originally proposed by (Horton, 1965) and developed by (Brown et al., 1972). The weighted arithmetic Water Quality Index (WQI) is represented in the following way.

Calculation of Unit Weight. The various water quality parameters' unit weight (Wi) is inversely proportional to the recommended standards for the corresponding parameters.

$$W_i = k/S_n \tag{1}$$

Where W_i= unit weight for the i^{th} parameter, S_n= standard value for i^{th} parameters, k= proportional constant, the value of k has been considered 'i' here and is calculated using the mentioned equation below:

$$k = 1/\sum (1/S_n) \tag{2}$$

Calculation of Quality Rating. According to (Brown et al., 1972) the value of quality rating or sub-index (Q_i) is calculated using the equation as given below:

$$Q_i = 100[(V_o - V_i)/(S_n - V_i)] \tag{3}$$

Where V_o= observed value of i^{th} parameter at a given sampling site, V_i= ideal value of i^{th} parameter in pure water, S_n= standard permissible value of i^{th} parameter.

Calculation of WQI. The weighted arithmetic Water Quality Index (WQI) is represented by,

$$WQI = \sum_{i=0}^{n} W_i Q_i / \sum_{i=0}^{n} W_i \tag{4}$$

3 Result and Discussion

3.1 Ground Water Quality Parameters

For this study, a total of six groundwater parameters (pH, Turbidity, Chloride, Hardness, Iron, and Arsenic) were tested. The lower value of these parameters would decrease the WQI index value, and higher values would increase the WQI index value.

pH. The maximum permissible limit for pH in drinking water, as per (ECR, 2023), is 8.5. The value of pH in the groundwater data varied from the range of 6.8 to 8.0. The majority of the areas in the mining locations have a pH of 7.2, and all the districts' pH values are within the permissible limit. The graph in Fig. 2 shows that Mymensingh has the lowest pH value of 6.8, indicating that the groundwater in the area is almost neutral. On the other hand, Chattogram has the maximum value of 8, indicating that the ground water in the area is basic.

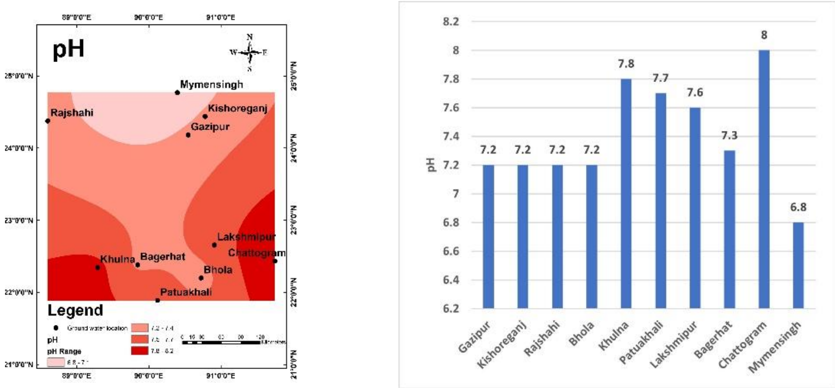

Fig. 2. pH value of groundwater at different locations in Bangladesh

Turbidity. The turbidity concentrations at all places are within the range of 5 NTU, except for Khulna, which has a value of 5.5 NTU (Fig. 3). During the rainy season, there is more turbidity because of surface runoff. In Khulna, particular care must be needed while cleaning water before it is distributed to the public.

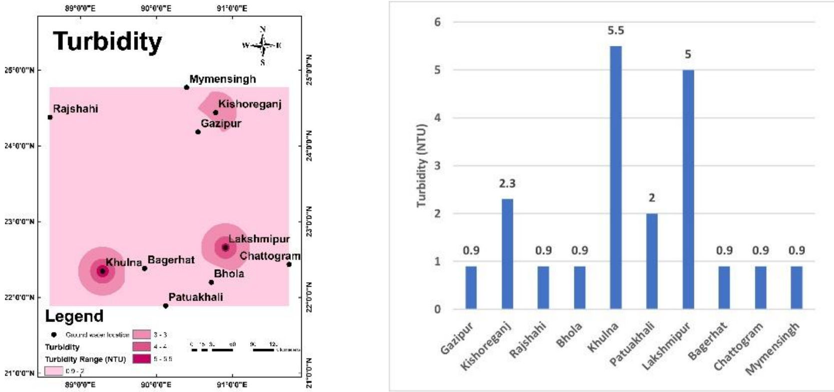

Fig. 3. Turbidity value of groundwater at different locations in Bangladesh

Chloride. The concentration of chloride in natural waterways varies depending on the geochemical conditions. Chloride concentrations can arise from industrial waste, sewage disposal, and soil leaching of salty residues. The presence of a high concentration of chloride produces a salty taste in drinking water. Chloride concentrations can be removed by electrolysis and reverse osmosis process. The test result indicates that chloride concentration ranges from 59 mg/l to 122 mg/l, which is within desirable limit. The distribution of Chloride is shown in (Fig. 4).

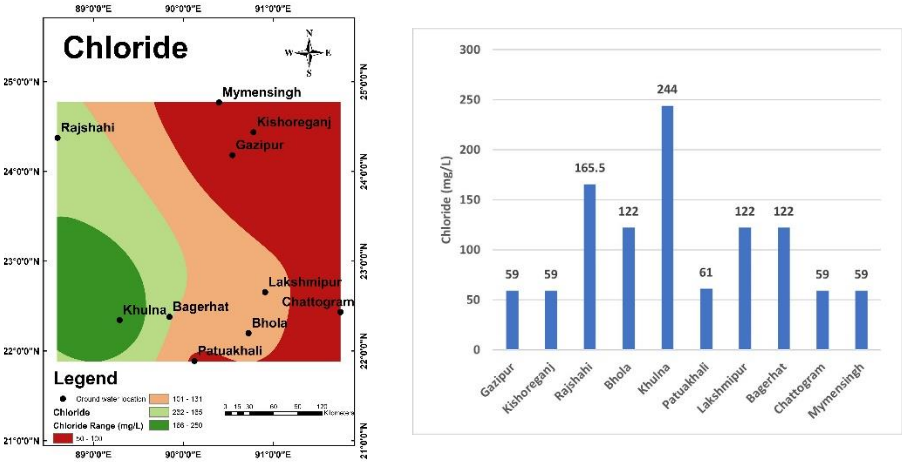

Fig. 4. Chloride value of groundwater at different locations in Bangladesh

Hardness. Hardness in water is caused due to the presence of carbonates and bicarbonates of calcium and magnesium, chlorides, nitrates, and sulphates of calcium and magnesium. A high concentration of total hardness is found in Khulna and Kishoreganj, with a value of 116 mg/l in both locations. However, all the hardness values of the districts are within the desirable limit. Softening of water may be required to impart palatability to water. Distribution of Total Hardness is shown in (Fig. 5).

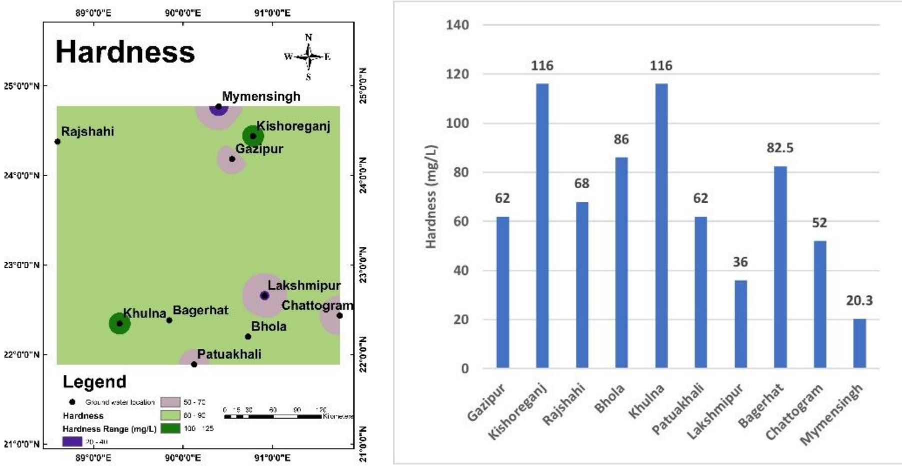

Fig. 5. Hardness value of groundwater at different locations in Bangladesh

Iron. Most of the districts are found to be above permissible limit i.e. >1.00 mg/l. But locations like Kishoreganj, Lakshmipur, Bagerhat and Chattogram high very iron content more than 1.5, values of 9 mg/l, 5.93 mg/l, 6.25 mg/l and 4.55 mg/l respectively.

Iron must be removed for avoiding rusting in distribution pipes. Distribution of Iron is shown in (Fig. 6).

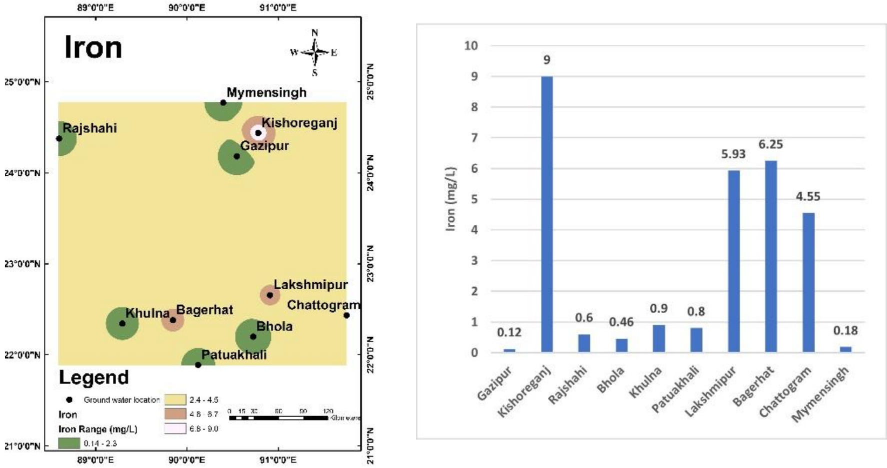

Fig. 6. Iron value of groundwater at different locations in Bangladesh

Arsenic. Groundwater in Bangladesh contains a higher concentration of arsenic than surface water sources. The groundwater contains both forms of inorganic arsenic (AsIII and AsV), and AsIII is the predominant species. In present study, arsenic value is within permissible limit (0.05mg/l) in all the districts. Distribution of Iron is shown in (Fig. 7).

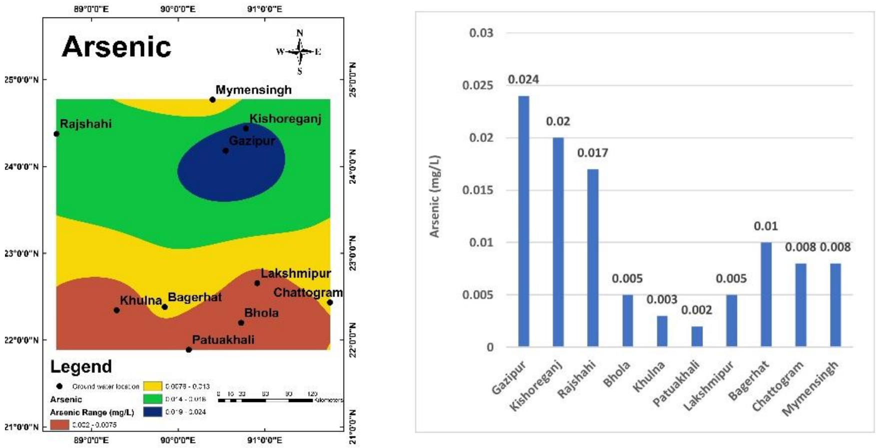

Fig. 7. Arsenic value of groundwater at different locations in Bangladesh

Water Quality Index. In the following Table 2, the value of the constant of proportionality (k), unit weight (Wn), quality rating (Qi), and water quality index (WQI) are calculated for all ten groundwater samples consisting six parameters each.

Table 2. WQI calculation table - 1

Sample No	Parameters	Units	Standard Values, S_n	$1/S_n$	Constant of Proportionality, $k = 1/\sum (1/S_n)$	Unit Weight, W_n
1	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E-05
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	**$\sum_{i=0}^{n} W_i$ =**	**1**
2	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E-05
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	**$\sum_{i=0}^{n} W_i$ =**	**1**
3	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E-05
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	**$\sum_{i=0}^{n} W_i$ =**	**1**
4	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E-05
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	**$\sum_{i=0}^{n} W_i$ =**	**1**
5	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E-05
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586

Sample No	Parameters	Units	Standard Values, S_n	$1/S_n$	Constant of Proportionality, $k = 1/\sum (1/S_n)$	Unit Weight,
			$\sum (1/S_n)$ =	**21.32364706**	$\sum_{i=0}^{n} W_i$ =	
6	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	$\sum_{i=0}^{n} W_i$ =	
7	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	$\sum_{i=0}^{n} W_i$ =	
8	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	$\sum_{i=0}^{n} W_i$ =	
9	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	$\sum_{i=0}^{n} W_i$ =	
10	**pH**	-	8.5	0.117647059	0.046896293	0.005517211
	Turbidity	NTU	5	0.2		0.009379259
	Chloride	mg/L	250	0.004		0.000187585
	Hardness	mg/L	500	0.002		9.37926E
	Iron	mg/L	1	1		0.046896293
	Arsenic	mg/L	0.05	20		0.93792586
			$\sum (1/S_n)$ =	**21.32364706**	$\sum_{i=0}^{n} W_i$ =	

Table 3. WQI calculation table - 2

Sample No	Parameters	Units	Observed Values, V_O	Standard Values, S_n	Unit Weight, W_n	Ideal Values, V_i	Quality Rating, Q_i=100 * [(V_o−V_i) / (S_n−V_i)]	W_iQ_i
1	**pH**	-	7.2	8.5	0.005517211	7	13.33333333	0.073562813
	Turbidity	NTU	0.9	5	0.009379259	0	18	0.168826655
	Chloride	mg/L	59	250	0.000187585	0	23.6	0.00442701
	Hardness	mg/L	62	500	9.37926E-05	0	12.4	0.001163028
	Iron	mg/L	0.12	1	0.046896293	0	12	0.562755516
	Arsenic	mg/L	0.024	0.05	0.93792586	0	48	45.02044127
							$\sum_{i=0}^{n} W_iQ_i$ =	**45.83117629**
2	**pH**	-	7.2	8.5	0.005517211	7	13.33333333	0.073562813
	Turbidity	NTU	2.3	5	0.009379259	0	46	0.431445895
	Chloride	mg/L	59	250	0.000187585	0	23.6	0.00442701
	Hardness	mg/L	116	500	9.37926E-05	0	23.2	0.002175988
	Iron	mg/L	9	1	0.046896293	0	900	42.20666369
	Arsenic	mg/L	0.02	0.05	0.93792586	0	40	37.51703439
							$\sum_{i=0}^{n} W_iQ_i$ =	**80.23530978**
3	**pH**	-	7.2	8.5	0.005517211	7	13.33333333	0.073562813
	Turbidity	NTU	0.9	5	0.009379259	0	18	0.168826655
	Chloride	mg/L	165.5	250	0.000187585	0	66.2	0.012418138
	Hardness	mg/L	68	500	9.37926E-05	0	13.6	0.001275579
	Iron	mg/L	0.6	1	0.046896293	0	60	2.813777579
	Arsenic	mg/L	0.017	0.05	0.93792586	0	34	31.88947923
				$\sum (1/S_n)$ =	**1**		$\sum_{i=0}^{n} W_iQ_i$ =	**34.95933999**
4	**pH**	-	7.2	8.5	0.005517211	7	13.33333333	0.073562813
	Turbidity	NTU	0.9	5	0.009379259	0	18	0.168826655
	Chloride	mg/L	122	250	0.000187585	0	48.8	0.009154156
	Hardness	mg/L	86	500	9.37926E-05	0	17.2	0.001613232
	Iron	mg/L	0.46	1	0.046896293	0	46	2.157229477
	Arsenic	mg/L	0.005	0.05	0.93792586	0	10	9.379258597
				$\sum (1/S_n)$ =	**1**		$\sum_{i=0}^{n} W_iQ_i$ =	**11.78964493**
5	**pH**	-	7.8	8.5	0.005517211	7	53.33333333	0.29425125
	Turbidity	NTU	5.5	5	0.009379259	0	110	1.031718446
	Chloride	mg/L	244	250	0.000187585	0	97.6	0.018308313
	Hardness	mg/L	116	500	9.37926E-05	0	23.2	0.002175988
	Iron	mg/L	0.9	1	0.046896293	0	90	4.220666369
	Arsenic	mg/L	0.003	0.05	0.93792586	0	6	5.627555158
				$\sum (1/S_n)$ =	**1**		$\sum_{i=0}^{n} W_iQ_i$ =	**11.19467552**
6	**pH**	-	7.7	8.5	0.005517211	7	46.66666667	0.257469844
	Turbidity	NTU	2	5	0.009379259	0	40	0.375170344
	Chloride	mg/L	61	250	0.000187585	0	24.4	0.004577078

Sample No	Parameters	Units	Observed Values, V_O	Standard Values, S_n	Unit Weight, W_n	Ideal Values, V_i	Quality Rating, Q_i=100 * [(V_o−V_i) / (S_n−V_i)]	W_iQ_i
	Hardness	mg/L	62	500	9.37926E-05	0	12.4	0.001163028
	Iron	mg/L	0.8	1	0.046896293	0	80	3.751703439
	Arsenic	mg/L	0.002	0.05	0.93792586	0	4	3.751703439
				$\sum (1/S_n)$ =	**1**		**$\sum_{i=0}^{n} W_iQ_i$ =**	**8.141787172**
7	**pH**	-	7.6	8.5	0.005517211	7	40	0.220688438
	Turbidity	NTU	5	5	0.009379259	0	100	0.93792586
	Chloride	mg/L	122	250	0.000187585	0	48.8	0.009154156
	Hardness	mg/L	36	500	9.37926E-05	0	7.2	0.000675307
	Iron	mg/L	5.93	1	0.046896293	0	593	27.80950174
	Arsenic	mg/L	0.005	0.05	0.93792586	0	10	9.379258597
				$\sum (1/S_n)$ =	**1**		**$\sum_{i=0}^{n} W_iQ_i$ =**	**38.3572041**
8	**pH**	-	7.3	8.5	0.005517211	7	20	0.110344219
	Turbidity	NTU	0.9	5	0.009379259	0	18	0.168826655
	Chloride	mg/L	122	250	0.000187585	0	48.8	0.009154156
	Hardness	mg/L	82.5	500	9.37926E-05	0	16.5	0.001547578
	Iron	mg/L	6.25	1	0.046896293	0	625	29.31018312
	Arsenic	mg/L	0.01	0.05	0.93792586	0	20	18.75851719
				$\sum (1/S_n)$ =	**1**		**$\sum_{i=0}^{n} W_iQ_i$ =**	**48.35857292**
9	**pH**	-	8	8.5	0.005517211	7	66.66666667	0.367814063
	Turbidity	NTU	0.9	5	0.009379259	0	18	0.168826655
	Chloride	mg/L	59	250	0.000187585	0	23.6	0.00442701
	Hardness	mg/L	52	500	9.37926E-05	0	10.4	0.000975443
	Iron	mg/L	4.55	1	0.046896293	0	455	21.33781331
	Arsenic	mg/L	0.008	0.05	0.93792586	0	16	15.00681376
				$\sum (1/S_n)$ =	**1**		**$\sum_{i=0}^{n} W_iQ_i$ =**	**36.88667023**
10	**pH**	-	6.8	8.5	0.005517211	7	-13.33333333	-0.073562813
	Turbidity	NTU	0.9	5	0.009379259	0	18	0.168826655
	Chloride	mg/L	59	250	0.000187585	0	23.6	0.00442701
	Hardness	mg/L	20.3	500	9.37926E-05	0	4.06	0.000380798
	Iron	mg/L	0.18	1	0.046896293	0	18	0.844133274
	Arsenic	mg/L	0.008	0.05	0.93792586	0	16	15.00681376
				$\sum (1/S_n)$ =	**1**		**$\sum_{i=0}^{n} W_iQ_i$ =**	**15.95101868**

Table 4. Classification of water quality and status based on weighted arithmetic WQI Method (Brown et al., 1972; Horton, 1965)

WQI	Rating Class
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
>100	Unsuitable

Table 5. Water quality index summary

Sample No	Hydro-Station	WQI Value	Class
L-1	Gazipur	45.83	Good
L-2	Kishoreganj	80.24	Very Poor
L-3	Rajshahi	34.96	Good
L-4	Bhola	11.79	Excellent
L-5	Khulna	11.19	Excellent
L-6	Patuakhali	8.14	Excellent
L-7	Lakshmipur	38.35	Good
L-8	Bagerhat	48.35	Good
L-9	Chattogram	36.89	Good
L-10	Mymensingh	15.95	Excellent

From the study it can be seen that the WQI of Bhola, Khulna, Patuakhali, Mymensingh are excellent. On the other hand, the WQI of Kishoreganj is very poor. And the rest have good water quality.

4 Conclusions

The current study aims to assess and map groundwater quality in 10 districts. The estimated WQI provides an easy way of understanding the overall water quality. The integration of various thematic layers with the help of ArcGIS 10.5 is of immense help in determining the suitability of groundwater quality for drinking purposes. According to the study, pH, chloride, hardness and arsenic values of all the locations are within permissible limits. With the exception of the Khulna district, turbidity is likewise within permissible bounds. Here, turbidity is slightly higher (5.5 NTU) than the allowable limit (5 NTU). Notably, it also revealed that Kishoreganj, Lakshmipur, Bagerhat, and Chattogram district consists of high iron of more than 1.5, with values of 9 mg/l, 5.93 mg/l, 6.25 mg/l and 4.55 mg/l respectively. It is a matter of concern for the user of groundwater in that location because there is a high possibility of rusting in distribution lines. Overall, the Kishorganj district's groundwater is a matter of concern since it is classified as Very Poor water quality. On the basis of WQI, it is concluded that with the exception of this place, the groundwater in the research region is safe and drinkable.

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