USING WATER QUALITY INDEX TO ASSESS GROUNDWATER SUITABILITY AT GAZIPUR DISTRICT, BANGLADESH

Geological Society of America : Poster Booth No.61 : Session No.26:Sunday, 22 September 2019 : T193. Importance of Involving Undergraduate and High School Students in Geoscience- and Environmental Science–Based Research (Posters)

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THE GEOLOGICAL SOCIETY OF AMERICA

GSA 2019
22-25 September
Phoenix, Arizona, USA

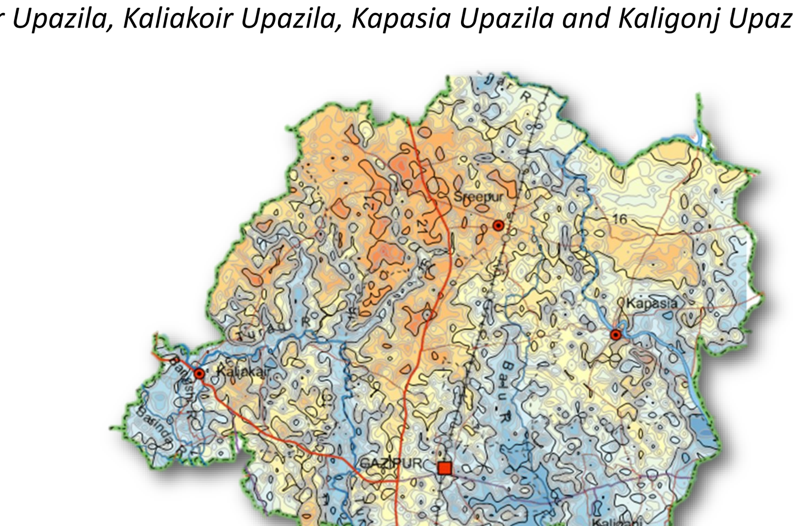
Abstract

This study targeted to estimate the suitability of groundwater for drinking in a district undergoing rapid urbanization and increasing industrialization. Gazipur District has an area of 1741.53 km², located in between 23°53' and 24°21' north latitudes and in between 90°09' and 92°39' east longitudes. From six Upazilas in Gazipur District around 130 samples were collected, which are, Gazipur Sadar Upazila, Sreepur Upazila, Kaliakoir Upazila, Kapasia Upazila and Kaligonj Upazila.

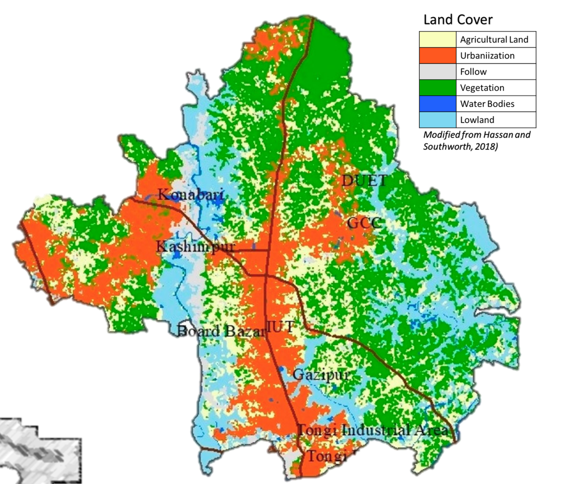
A recent review of industrial sludge found that heavy metal concentration was above the acceptable limit for an agricultural soil. Gazipur being adjacent to Dhaka and has a similar complex situation with regard to contamination and abstraction. In recent years, the District has seen rapid growth in industrial development and increased urbanization.

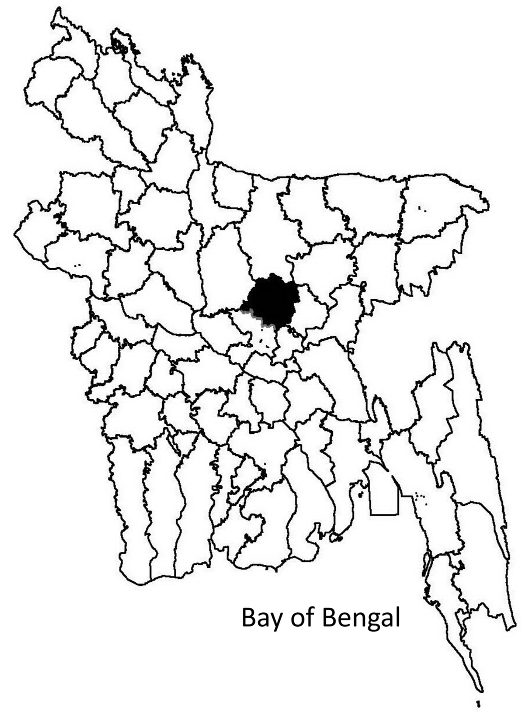
Water Quality Index (WQI) has been used to assess groundwater condition and its vulnerability to contamination, based on hydrochemical data.

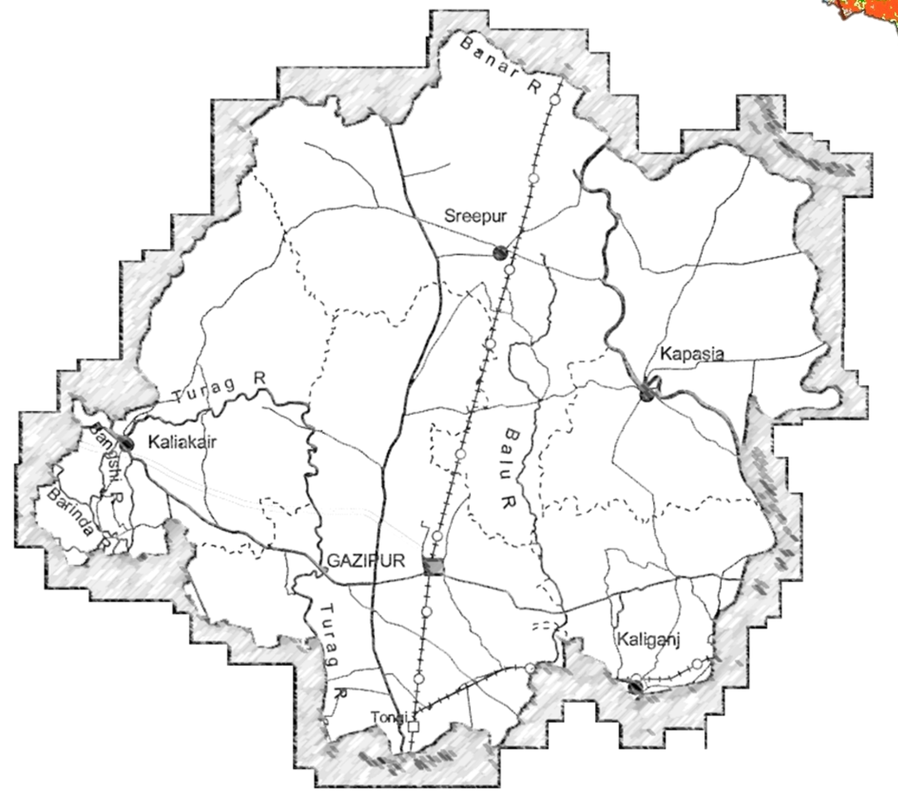
WQI calculated to determine drinking water standards as per Horton's method. Thirteen parameters were taken into account to calculate WQI, namely, pH, TDS, sodium, potassium, calcium, magnesium, iron, manganese, bicarbonate, chloride, sulphate, nitrate, and fluoride. The computed WQI shows that 48% of water sample falls in excellent categories and 48% falls in the good water category.



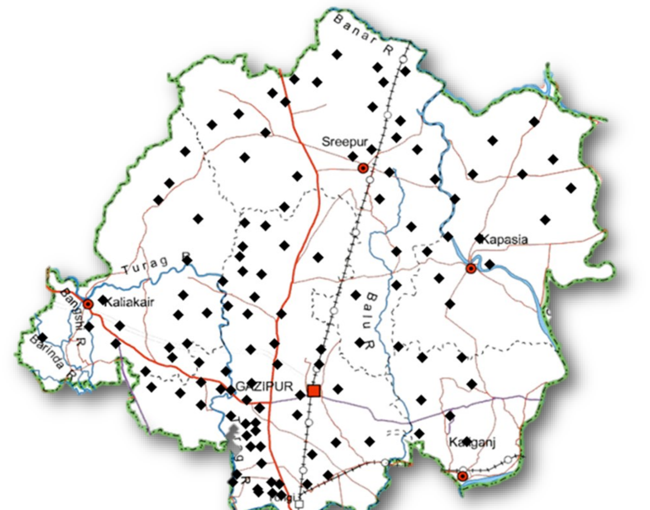
Elevation variation



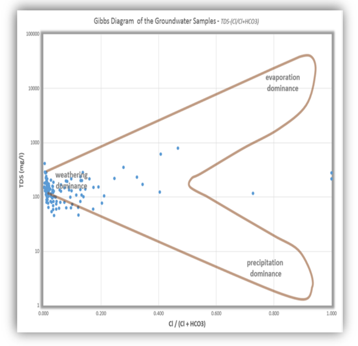


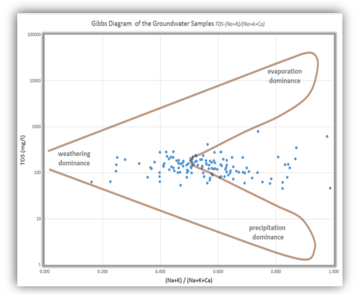


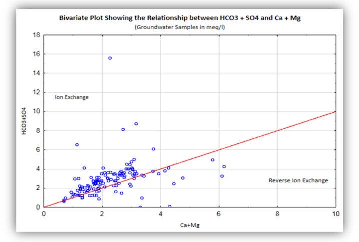
LOCATION

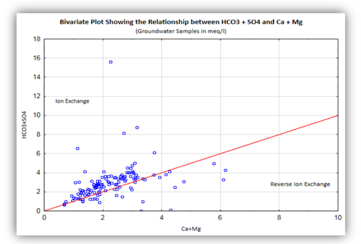


Geochemical Sampling Points

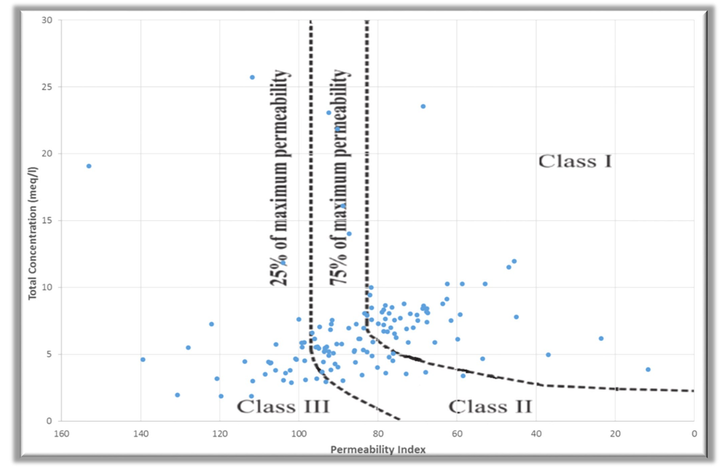




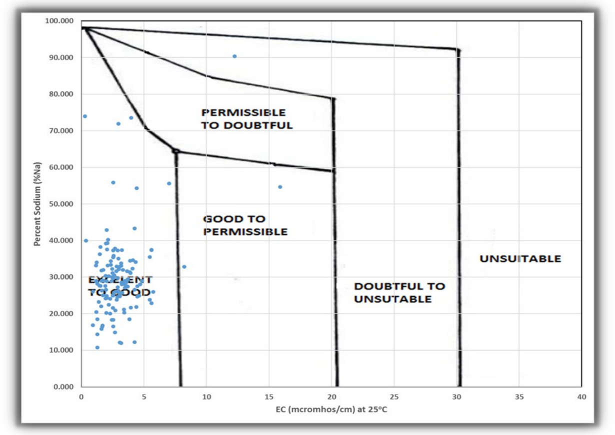




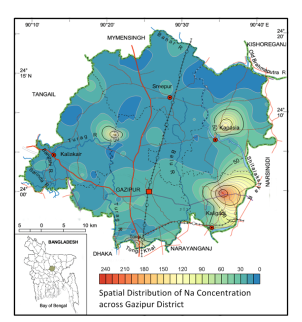
Correlations are significant at p < .05000 N=129	pH	EC	TDS	Na	K	Ca	Mg	Fe	Mn	HCO3	Cl	SO4
pH												
EC	0.157871											
TDS	0.177741	0.977302										
Na	0.149525	0.566840	0.638646									
K	-0.051212	0.263906	0.329247	0.637589								
Ca	0.222903	0.345168	0.363204	0.271486	0.252289							
Mg	0.222763	0.539612	0.537865	0.281092	0.241588	0.699838						
Fe	-0.076900	0.012782	-0.003433	-0.024480	0.030839	-0.087994	-0.041347					
Mn	-0.005607	0.193994	0.201274	0.136378	0.334030	0.148989	0.276505	0.050442				
HCO3	0.282927	0.371589	0.405187	0.338590	0.109512	0.297472	0.402530	0.063029	0.078227			
Cl	-0.061516	0.613089	0.636346	0.665637	0.338796	0.080510	0.169711	0.011874	0.145114	0.097537		
SO4	0.023559	0.160584	0.278363	0.598377	0.639417	0.212251	0.126891	-0.015111	0.081146	0.128868	0.403249	



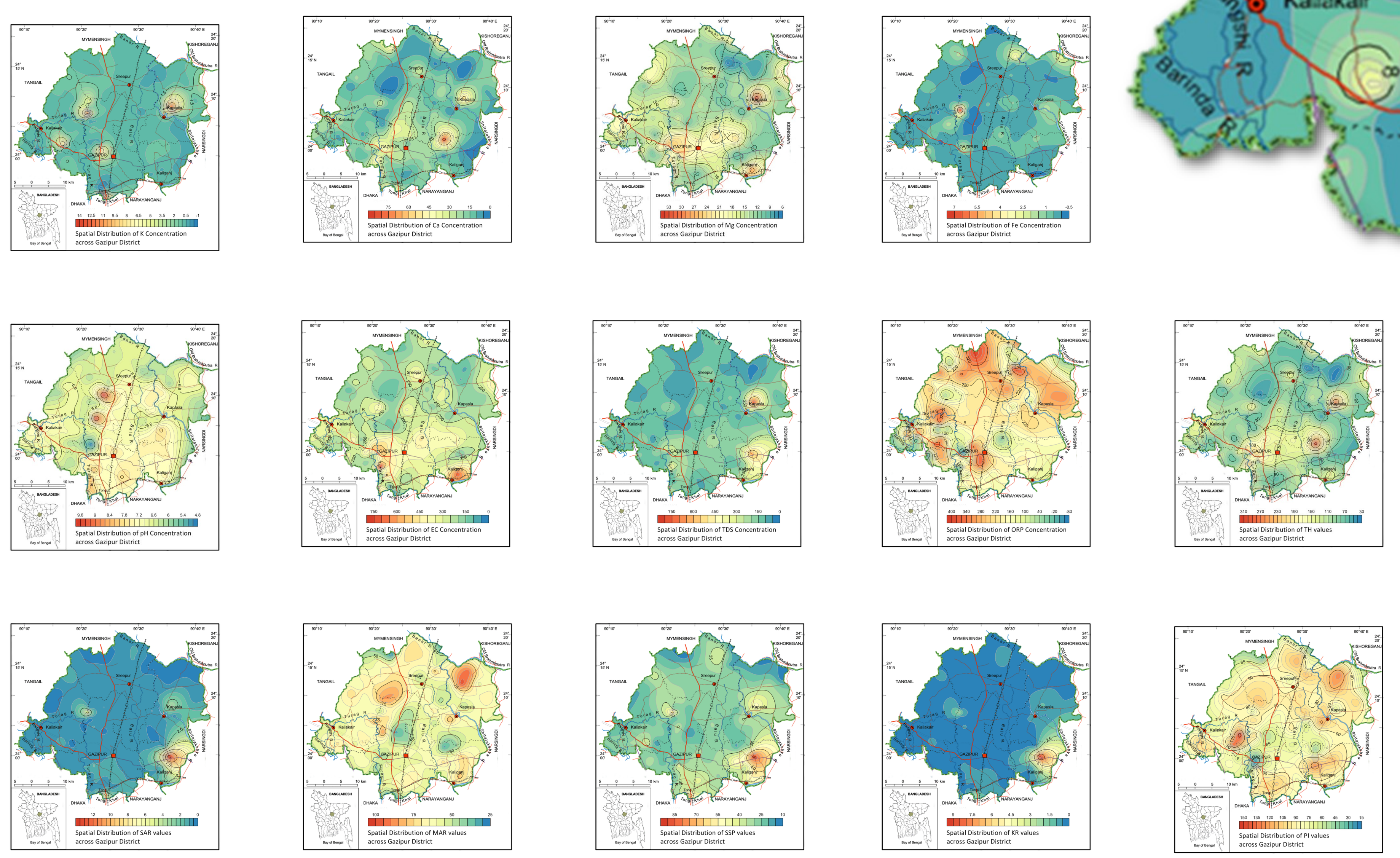
Doneen diagram showing Permeability Index Classification.



Wilcox's diagram for irrigation water classification, showing EC and SSP relationship for rating irrigation water.



Spatial Variation of of different hydrochemical parameters



Water Quality Index (WQI)

Calculation of WQI for the study area is based on hydrochemical data as per Horton's method, as follows;

$$WQI = \frac{\sum(q_n * + W_n)}{\sum W_n}$$

where, n is water quality parameters and quality rating or sub index (qn) corresponding to nth parameter (i.e a number reflecting the relative value of this parameter with respect to its standard, (maximum permissible value), qn is quality rating for the nth water quality parameter, and Wn= Unit weight of nth water quality parameter.

Calculation of the Water Quality Index (WQI) of the study area is based on hydrochemical data as per Horton's method, as follows;

Quality Rating

$$qn = \left[\frac{V_n - V_{io}}{S_n - V_n}\right] \times 100$$

Vn is estimated value of the nth parameter at a given sampling point, Sn is standard permissible value of the nth parameter, and Vio is ideal value of nth parameter in pure water (i.e. 0 for all other parameters except pH and Dissolved Oxygen (7.0 and 14.6 mg/l respectively).

Water Quality (Wn)

$$W_n = \frac{k}{S_n}$$

where, Sn = Standard permissible value of n th water quality parameter, and k = Constant of proportionality. The Unit weight (Wn) is calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter

$$k = \left[\frac{1}{\left(\sum \frac{1}{S_n}\right)}\right]$$

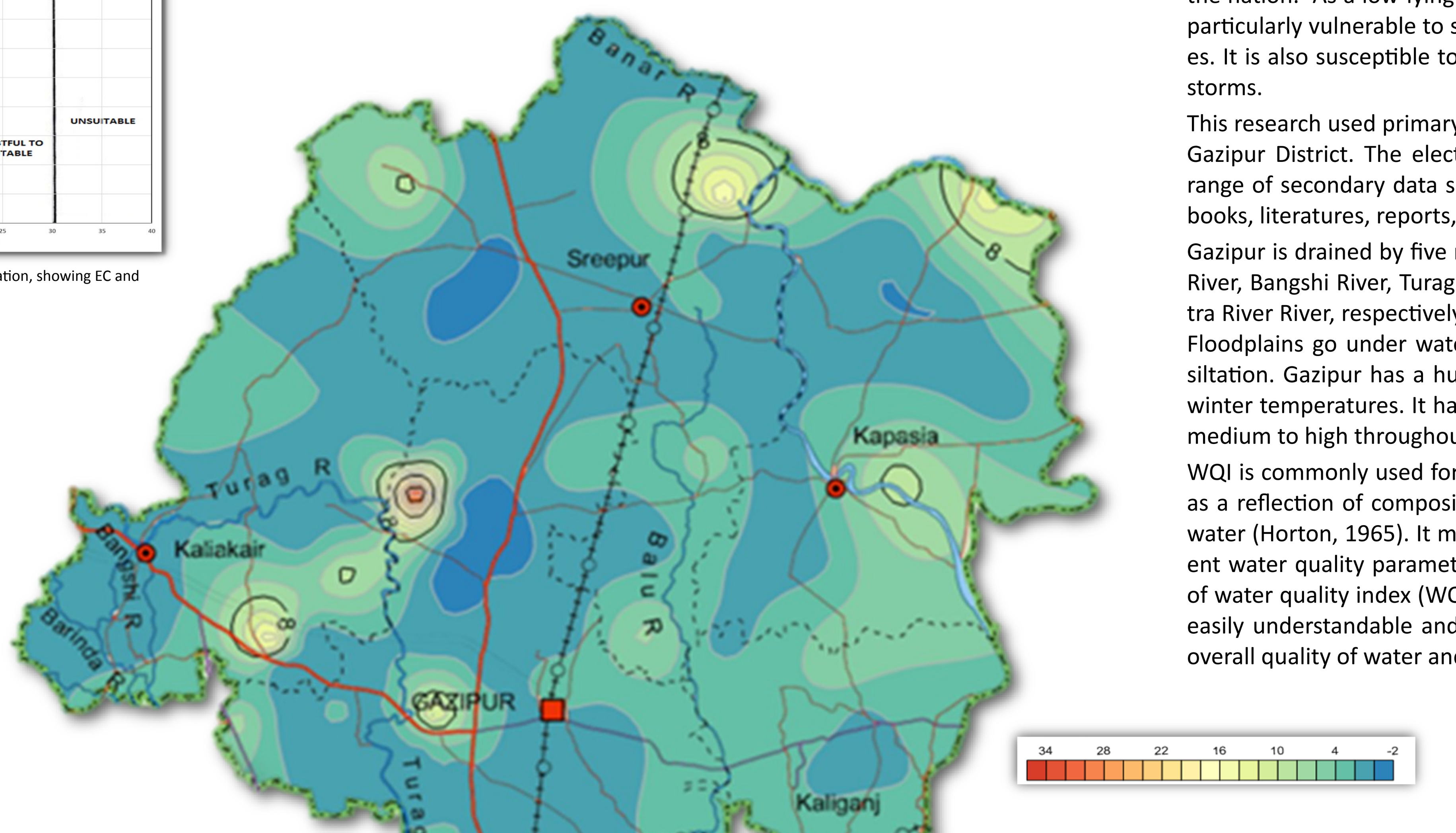
Calculation of Water Quality Index (WQI).

Parameter		Observed Values	Standard Values	Unit Weights	Quality Rating	$w_i q_i$
		v_i	s_i	w_i	q_i	
pH		7.54	8.5	0.00578	0.36000	0.00208
EC	uS/cm	990	500	0.00010	1.98000	0.00019
TDS	mg/l	520	1000	0.00005	0.52000	0.00003
Na	mg/l	159.503	200	0.00025	0.79752	0.00020
K	mg/l	16.395	12	0.00409	1.36625	0.00559
Ca	mg/l	38.29	75	0.00065	0.51053	0.00033
Mg	mg/l	15.42	35	0.00140	0.44057	0.00062
Fe	mg/l	0.029	0.10	0.49124	0.29000	0.14246
Mn	mg/l	0.024	0.10	0.49124	0.24000	0.11790
HCO3	mg/l	251.625	600	0.00008	0.41938	0.00003
Cl	mg/l	87.861	600	0.00008	0.14644	0.00001
SO4	mg/l	157.804	400	0.00012	0.39451	0.00005
NO3	mg/l	19.229	10	0.00491	1.92291	0.00945
F	mg/l	0.231	1.000	0.049	0.23110	0.01135

Classification of water quality based on weighted arithmetic WQI method.

WQI	STATUS	POSSIBLE USAGES
0 - 25	Excellent	Drinking, Irrigation and Industrial
26 - 50	Good	Domestic, Irrigation and Industrial
51 - 75	Fair	Irrigation and Industrial
76 - 100	Poor	Irrigation
101 - 150	Very Poor	Restricted use for Irrigation
150	Unsuitable for drinking	Proper treatment required before use.

(Modified from: Brown et.al., 1972; Chatterji and Raziuddin, 2002)



Spatial Variation of Water Quality Index (WQI) of measured samples across Gazipur District

Conclusion

In Bangladesh more than 40 million reside in urban centers. By 2060, when the total population of the country is expected to stabilize at 230 million, more than 70 percent of the population will be urban-based.

Currently, it is estimated that 43% of urban dwellers are poor and 23% extremely poor. Bangladesh is vulnerable to both natural and manmade hazards. Water pollution is one of the significant dangers to the wellbeing of people. Drinking water quality is inadequately overseen. Both surface and groundwater are debased with coliforms, harmful metals and pesticides all through the nation. As a low-lying country with multiple large river tributaries and a large coastline it is particularly vulnerable to slow onset hazards including sea level rise and global temperature rises. It is also susceptible to rapid onset events, including flooding, heat waves and large coastal storms.

This research used primary data. Water samples were collected from almost 140 points to cover Gazipur District. The electronic and web based information were used for data collection. A range of secondary data sources were also reviewed, collected from different offices, journals, books, literatures, reports, thesis papers and websites.

Gazipur is drained by five major rivers flowing in North-South direction mainly, namely, Barinda River, Bangshi River, Turag River, Balu River, Banar River, Shitalakshya River, and Old Brahmaputra River River, respectively from East to West. Only Balu River originates within Gazipur District. Floodplains go under water during monsoon season, eventualy renewing the fertility through siltation. Gazipur has a humid sub-tropical climate with large variations between summer and winter temperatures. It has a tropical monsoon climate. Rainfall frequency of Gazipur District is medium to high throughout the wet season.

WQI is commonly used for the detection and evaluation of water pollution and may be defined as a reflection of composite influence of different quality parameters on the overall quality of water (Horton, 1965). It may be defined as a rating, reflecting the composite influence of different water quality parameters on the overall quality of water. The main objective of computing of water quality index (WQI) is to turn the complex water quality data into information which is easily understandable and usable. A parameter has to be selected based on its impact in the overall quality of water and health effects.

Ground water is being used for drinking and domestic purposes. Industries are using deep tube wells within their premises to meet requirement. Iron and arsenic are the major water quality concern for drinking purposes in Gazipur District. The strongest Correlation relation was observed between EC and TDS (r=0.977). TDS in water supplies originate from natural sources, sewage, urban and agricultural run-off, and industrial wastewater. This work shows that weathering is a dominant factor, which is influenced by surface contamination sources from an excessive use of fertilizers, irrigation return flow, industrial outflows and domestic discharges.

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Acknowledgement

- Department of Geology, Faculty of Earth and Environmental Sciences, University of Dhaka.
- # 39.00.0000.09.06.79.2017/78ES Ministry of Science and Technology, Government of the People's Republic of Bangladesh, Bangladesh Secretariat