

SPATIAL & TEMPORAL ASSESSMENT OF GROUNDWATER QUALITY OF CENTRAL DHAKA FOR DRINKING PURPOSE

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ABSTRACT

Dhaka, the capital of Bangladesh is the most densely populated city of the country. Major part of its supply water is abstracted from groundwater. Due to heavy extraction of groundwater, dispose of industrial waste, municipal waste, infiltration of polluted surface water in shallow aquifer, groundwater quality is changing and degrading day by day. So groundwater quality assessment is essential. Physio-chemical analysis reveals whether the water is suitable for drinking purposes. In specifying the quality characteristics of groundwater, chemical, physical & biological analysis is required. Properties of groundwater evaluated in the Physical analysis include temperature, color, turbidity, taste. Important Chemical constituent present in groundwater are Na, Ca, Mg, K, Cl, Nitrate, Sulfate, Carbon Di-Oxide, As, Fe etc. Biological analysis includes test to detect the presence of coliform bacteria. For classifying the water quality parameters Piper diagram were used & USSI classification were used. Spatial Analysis using data from lab tests shows that most of the physical & chemical parameters are within the acceptable limit to WHO standard & Bangladesh Standard except Iron, Silica m Manganese were observed quiet equal & in some cases exceeding the limiting value. Again the samples were less susceptible to bacteria. So the water is quiet suitable for drinking purpose. The groundwater of Dhaka city falls into C2-S1 category in USSI classification & into Calcium & Bi-carbonate dominant type in Piper diagram. Temporal analysis shows that values of pH, Temperature, TDS, Calcium, Carbon Dioxide, Bi-carbonate has been increasing while value of Sodium, Magnesium, Chlorine, Iron, Nitrate has been falling in last 20-25yrs. DRI analysis states that groundwater of Dhaka city contributes very little to amount of intake recommended for an individual per day. From the analyses, it is hoped that this study will be of immense help for the groundwater quality development and would serve as a guide for taking necessary measures for improving the water quality and availability to people. Furthermore this study will help us to predict the groundwater quality based on these correlation equations which can be used for any other location.

Keywords: *Groundwater, Parameters, Laboratory tests, ArcGIS, Dhaka.*

1. INTRODUCTION

Dhaka city mainly depends on the groundwater for its supply. More than 400 pumping stations are set to abstract the groundwater by Dhaka WASA. Due to heavy abstraction of groundwater the water table is declining alarmingly every year. Groundwater quality issue gets more importance due to rapid increase of population, rapid industrialization, and flow of pollution from surface water through infiltration and much use of fertilizer and pesticides in agriculture. So investigation of groundwater quality for drinking uses is a compulsory task. Groundwater generally contains Fe, Ca, Mg, Silica, arsenic, phosphate, sulphate, chloride, Mn, Na, K, Mg in dissolve state the presence of which above certain limits also affect the body system.

In Bangladesh, water extracted from shallow aquifer is the primary source of drinking and cooking for most of its population of over 150 million. Not only the rural supply but also the urban water supply heavily depends on groundwater. About 70% of irrigation water and around 83% of supply water are supplied by groundwater. Shahidullah et al. (2000) attempted to assess the groundwater quality in a selected area of Bangladesh. Their results suggested that there was neither salinity nor toxicity problem of irrigation water, so that groundwater can safely be used for long-term irrigation. All the research so far completed on groundwater quality of different areas of Bangladesh is based on physicochemical analyses. A few numbers of studies are available regarding the analysis of groundwater quality data using regression techniques for prediction purposes. Joarder et al. (2008) studied groundwater quality of Sunamganj district, Bangladesh using regression techniques. No attempt has yet been made to predict groundwater quality of Dhaka district using this regression technique. In the present study an attempt has been made to study groundwater quality of Dhaka district and to find correlation among different quality parameters. Zahid & Bodruddoha (2018) presented the current situation of groundwater quality in Hazaribag tannery area in Dhaka & observed trace elements being present in groundwater. Bodruddoha (2019) investigated the existence & amount of trace elements in Dhaka found little trace elements in majority of locations. Zahid & Khan (2016) assessed the impact of mega city pumping on groundwater quality, how this overexploiting groundwater pumping is affecting the quality of groundwater beneath soil.

2. OBJECTIVE

The main aim of this work is to analyze the groundwater quality parameter of Dhaka city using both primary & secondary data for drinking purpose.

For evaluating the groundwater quality parameters, water samples were collected from different zones of the study area & then tested on laboratory to find out the current status of groundwater quality. It was then represented with the help of ArcGIS. And to assess the changing pattern of various groundwater quality parameters, groundwater quality data of previous 35 years were collected to check the changing pattern of these parameters all over the years.

3. STUDY AREA

Dhaka, the capital of Bangladesh is bounded by a network of 3 rivers; the Buriganga on South-West, the Turag on West & the Balu on East. In addition to surrounded rivers, the city has a number of medium & small khals, with hydrologic functions of draining & detaining storm-sewer water of the city. The city lies on the lower reaches of the Ganges Delta & covers a total area of 360 sq. kilometers. It consists of mainly 24 thanas, 130 wards & 725 mohallas. Tropical vegetation & moist soil are the characteristics of the land, which is flat & close to sea level. Dhaka experiences a hot, wet, humid tropical climate. Annual average temperature of the city is around 26-28°C having maximum 35.5°C and minimum 18.5°C temperatures. Average annual rainfall is 1854 mm.

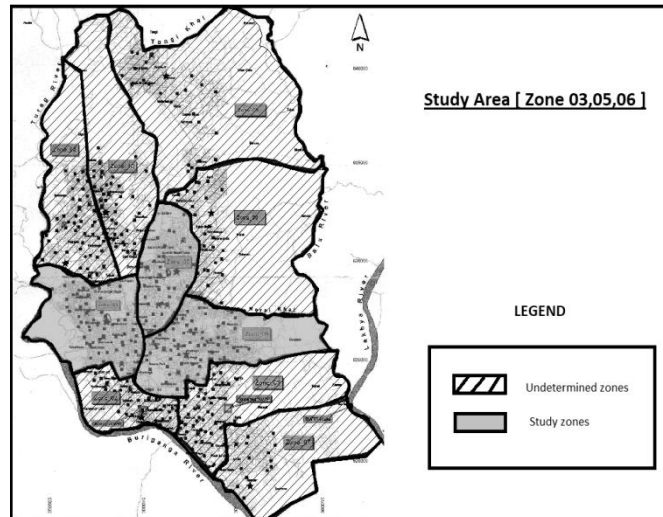


Figure 1: Location of Study Area (Central Dhaka)

4. METHODOLOGY

4.1 Data & Sample Collection

The groundwater quality data of Dhaka city were collected from the Groundwater Hydrology Department of Bangladesh Water Development Board for the year 1985 to 2017 of several parameters of Dhaka city for investigating the temporal variation of groundwater quality.

Water samples were collected from 3 Dhaka WASA mod zones (Tejkunipara water pump, Lalmatia water tank, Fakirapool water tank) of Dhaka city for investigating the suitability & vulnerability of groundwater quality of various locations among Dhaka city. Samples were collected in bottles (one normal bottle & other one acidified) provided by Department of Public Health & Engineering laboratory.





Photo 1: (a) Sample collecting bottles; (b)Tejkunipara water pump ; (c)Lalmatia water tank.

4.2 Water Sample Investigation

Water samples that were collected was submitted in the laboratory of Department of Public Health & Engineering & was then examined. Table 1 shows the water quality lab tests that were conducted (APHA 1985).

Table 1: Water Sample Parameters Tests

Parameters	Analysis Method	Unit
pH	pH meter	
TDS	Multimeter	mg/L
Sodium	AAS	mg/L
Potassium	AAS	mg/L
Calcium	AAS	mg/L
Magnesium	AAS	mg/L
Iron	AAS	mg/L
Arsenic	AAS	mg/L
Chloride	Titrimetric	mg/L
Coliform	MFM	N/100mL
Silica	UVS	mg/L
Nitrogen	UVS	mg/L
Sulphate	UVS	mg/L

4.3 Classification Based on Piper Diagram

The piper diagram is suitable for comparing the ionic composition of a set of water samples, but does not lend itself to spatial comparisons. The cations and anions are shown by separate ternary plots (Piper, 1953).

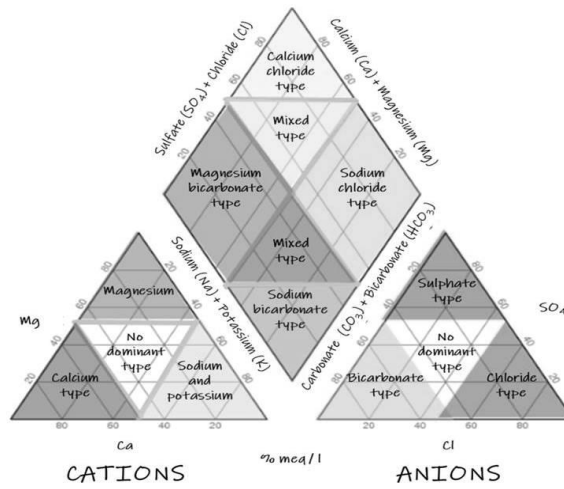


Figure 2: Piper Diagram

4.4 Dietary Reference Intake Analysis

Dietary reference intakes (DRI) are a set of reference values for vitamins, minerals, and other nutrients important to human health. DRIs provide guidance about the appropriate amount & safe upper limit intake of each nutrient. DRIs are specific to age group, gender, and for women, reproductive-status (Lawrence Appel, 2004).

Table 2: Dietary Reference Intake values for Sodium , Potassium , Chloride , Water

Nutrients	Intake(g/day)
Sodium	1.5
Potassium	4.7
Chloride	2.3
Water	3

5. RESULTS

5.1 Comparison with WHO , BS guidelines

Table 3 shows the comparison of the water sample tests & datas with the values of WHO guidelines & BS limits. The parameters which were found above the guideline values were identified.

Table 3:Statistics of Water Quality Parameters

	Unit	WHO	BS limit	MOHAKHALI Sample	MOTIJHEEL Sample	MOHAMMADPUR Sample
Temperature	°C			28.6	29	29
pH		6.5-8.5	6.5-8.5	7.5	7.2	7.8
Arsenic	mg/L	0.01	0.05	0.001	0.001	0.001
Calcium	mg/L	75	75	20	50	40

	Unit	WHO	BS limit	MOHAKHALI Sample	MOTIJHEEL Sample	MOHAMMADPUR Sample
Sodium	mg/L	200	200	23	35	29.8
Potassium	mg/L	50	12	1	2.63	1
Magnesium	mg/L	50	30-35	10	19.23	23
Chloride	mg/L	250	150-600	12	6.35	35
Sulphate	mg/L	250	400	1	2.26	6
TDS	mg/L	1000	1000	158	290	358
Silica	mg/L	10	50	65.1	25.1	48
Iron	mg/L	0.3	0.3-1.00	1.08	0.28	0.5
Nitrogen	mg/L	50	10	1.4	2	2.2
Coliform	N/100mL	0	0	48	65	74
HCO₃	mg/L			185	189	240
CO₂	mg/L			45	58	90
Manganese	mg/L	0.05-0.1	0.1	0.1	0.15	0.06

5.2 Changing Trends of Water Quality Parameters (Temporal Analysis)

In order to observe the trends of groundwater quality parameters in last 40yrs, secondary data were collected from BWDB of Mohammadpur, Motijheel area of Dhaka city which were available in Dhaka region.

Value of **Total Dissolved Solids** seemed to remain quiet same for Motijheel area while it tends to increase a bit for Mohammadpur area. **pH value** seemed to fall slowly in last 20yrs. **Temperature** is increasing slowly in last 20yrs. Value of **Sodium** seemed to fall in last 40yrs in both areas. **Potassium** had some unusual high values but it remained quite same otherwise. In both areas, value of **Calcium** has been increasing since 1980s. **Magnesium** value has fallen in Motijheel area although it remain quite same in Mohammadpur in last 40yrs. Change in **Chloride** value is different in 2areas. In Mohammadpur it has decreased in amount in last 40yrs but in Motijheel it increased in first 20yrs & then decreasing in last 20yrs. **Carbon Dioxide** is increasing in both areas significantly. **Flouride** value is falling at a very slow rate. Value of **Manganese** is falling in Mohammadpur area but it's remained quiet same for Motijheel in last 20yrs. Amount of **Silica** seemed to remain quiet same in last 40yrs in both areas. In both areas, amount of **Iron** was observed very high in the 1980s but it falled significantly to such low amount in 1990s which is started to increase at a very slow rate in last 10yrs. Change of values of **Sulphate** was found to be unusual in both areas. In both areas, Value of **Nitrate** was observed to high in early 1980s then it started to decrease in late 1990s which has began to increase again in last 20yrs. Amount of **Bi-Carbonate** is increasing at a very slow rate in last 40yrs in both areas.

Major results that were obtained from temporal analysis are represented in fig 3(a-h) :

Changing Patterns of Parameters Shown in Graphs

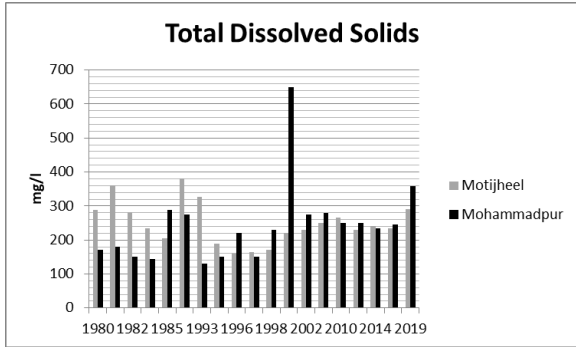


Figure 3(a): Temporal variation of TDS

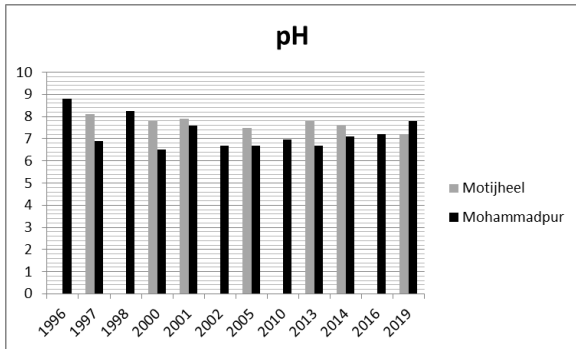


Figure 3(b): Temporal variation of pH

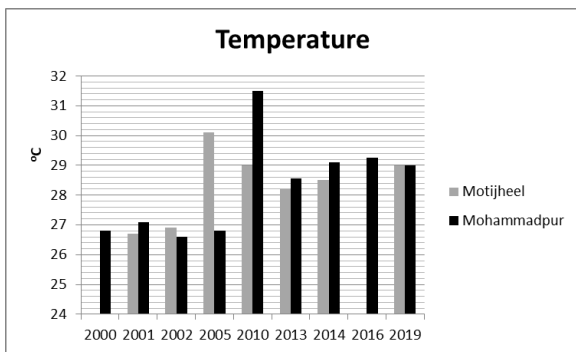


Figure 3(c): Temporal variation of Temperature

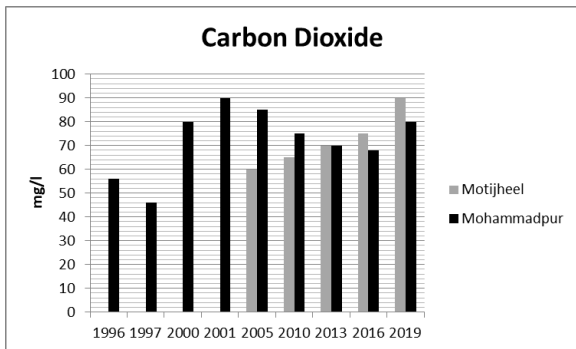


Figure 3(d): Temporal variation of Carbon Dioxide

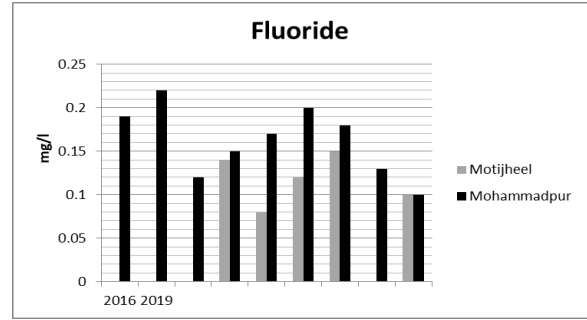


Figure 3(e): Temporal variation of Fluoride

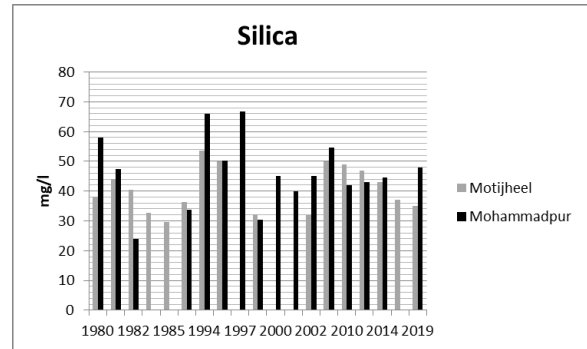


Figure 3(f): Temporal variation of Silica

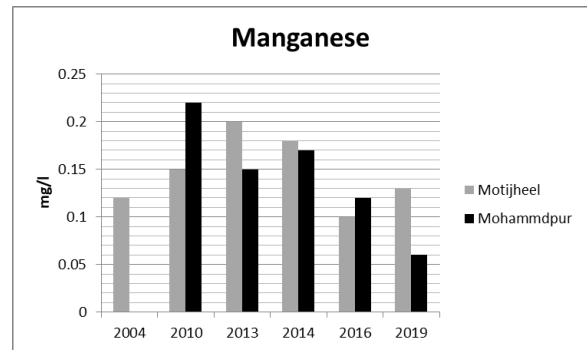


Figure 3(g): Temporal variation of Manganese

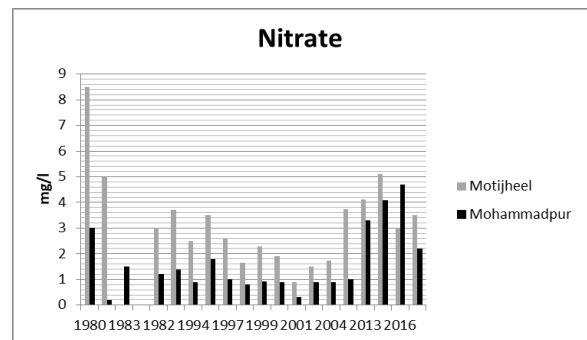


Figure 3(h): Temporal variation of Nitrate

4.3 Comparing Present Groundwater Condition with WHO, BS values (Spatial Analysis)

In order to compare water quality with BS values groundwater samples were collected from Tejkunipara , Mohammadpur , Motijheel area of Dhaka city which cover almost the central Dhaka.

Coliform bacteria was found in number of 48 , 65 , 75 in Tejkunipara, Motijheel , Mohammadpur groundwater respectively. The presence of these bacteria indicates that groundwater is contaminated with feces or sewage, and it has the potential to cause disease. **pH** values were observed in nominal range (6.5-8.5) in Tejkuniapra , Motijheel, Mohammadpur groundwater. Values of **Sodium, Calcium, Potassium, Magnesium** were observed well below the BS value. **Silica** present in groundwater of Tejkunipara (65.1mg/L) is exceeding the BS value. Value of **Iron** in groundwater of Tejkunipara (1.08mg/L) is just above BS value. **Arsenic** is in negligible amount (.001mg/L) in Tejkunipara, Motijheel, Mohammadpur. **Sulphate, Nitrate, Chloride** were found in amount which is much lower than their BS limiting values. The value of **Manganese** was found to be quiet equal to its BS limiting value in Tejkunipara & Mohammadpur while it exceeds in Motijheel. In previous studies, no heavy metal were reported in significant amount in all around Dhaka city but a few were traced in location of Hazaribag Tanneries. Severe contamination of groundwater wasn't observed except for tannery area.

Major results that were obtained from spatial analysis are represented in fig 4(a-g) :

Variation of Parameters Shown in ArcGIS Map:

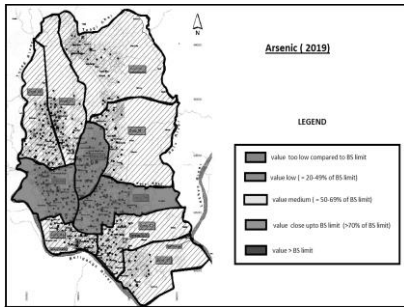


Figure 4(a): Spatial variation of Arsenic

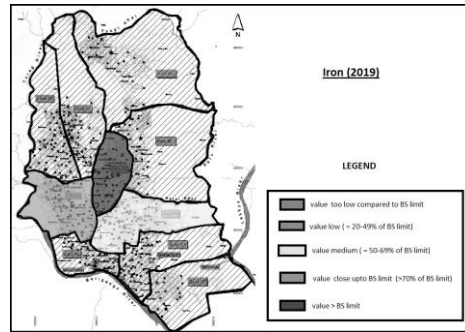


Fig 4(c): Spatial variation of Iron

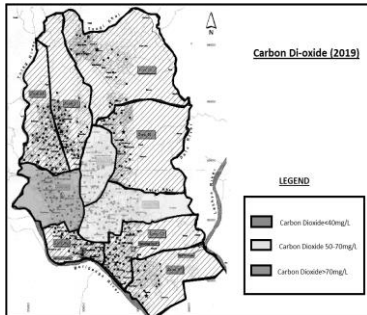


Fig 4(b): Spatial variation of CO₂

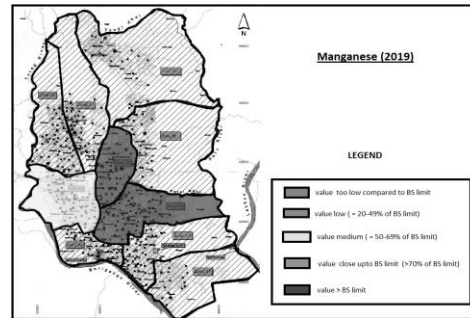


Fig 4(d): Spatial variation of Mn

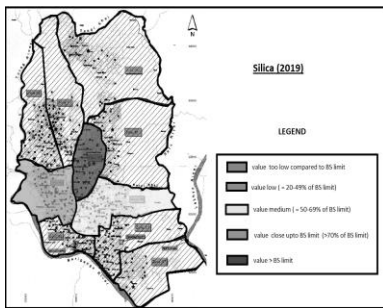


Fig 4(e): Spatial variation of SiO₂

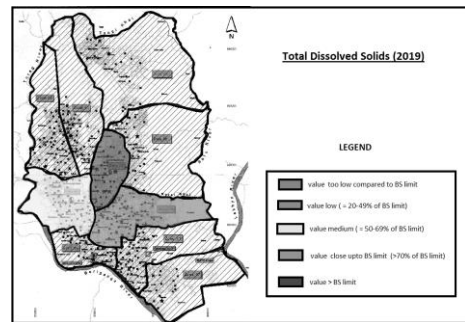


Fig 4(f): Spatial variation of TDS

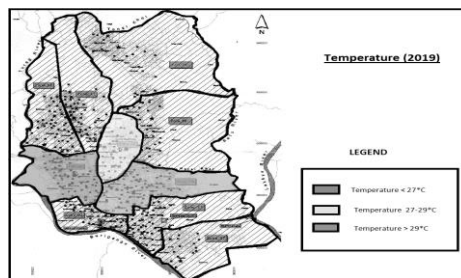


Fig 4(g): Spatial variation of Temperat

4.4 Piper Diagram Analysis

Tejkunipara – Na & HCO₃⁻ dominant type

Mohammadpur – Ca & HCO₃⁻ dominant type

Motijheel – Ca & HCO₃⁻ dominant type

4.5 DRI Analysis

Sodium: Groundwater samples contribute **6-10%** of the total intake recommended.

Potassium: Groundwater samples contribute **1-3%** of the total intake recommended.

Chloride: Groundwater samples contribute **2-6%** of the total intake recommended.

Sulphate: Groundwater samples contribute upto **1%** of the total intake recommended.

5. CONCLUSION

The major objective of this study was to monitor the groundwater quality of Dhaka city to compare the present water quality with WHO, Bangladesh Standards values & to show the trends of physical & chemical parameters using previous data. The major findings obtained from the study were –

- Most of the parameters are within nominal range of BS limiting value.
- Mn, Fe, Si – these parameters exceed the BS limiting value.
- Heavy metals weren't observed in Dhaka except in Hazaribag Tannery areas. (previous study)
- Mineral intake level is much lower than the required intake level for an individual.
- Arsenic is in negligible amount all around Dhaka city(.001mg/L).
- Severe contamination of groundwater wasn't observed except for tannery area.(previous study)
- Temperature, Carbon Di-oxide is increasing while pH is decreasing.
- Coliform bacteria were found in the samples of central Dhaka in significant amount.

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