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Assessment of Groundwater Quality in Tangail Sadar Upzilla, Dhaka, Bangladesh and Its Suitability for Agricultural Use

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Introduction

Water resource has played a critical and vital role throughout the history in the growth and development of human civilization.[1] Due to rapid industrialization and increasing human population, the stress on natural resources is increasing and their conservation is one of the major challenges for mankind.[2] The concentration of chemical constituents which is greatly influenced by geological formations and anthropogenic activities determine the groundwater quality. Increased agricultural activities in Bangladesh are likely to have an impact on the groundwater quality.[3,4] In this context irrigation water quality is also important for successful crop production.

Aim

In this study, the physico-chemical quality of groundwater has been assessed and the quality of groundwater was evaluated for irrigation purpose.

Study Area

Tangail Sadar Upazilla is located in between 24'10' and 24'22' north latitudes and in between 88'46' and 89'59' east longitudes. The upazilla is situated on the bank of Jamuna River. Sampling has done from April 2017 to August 2017.

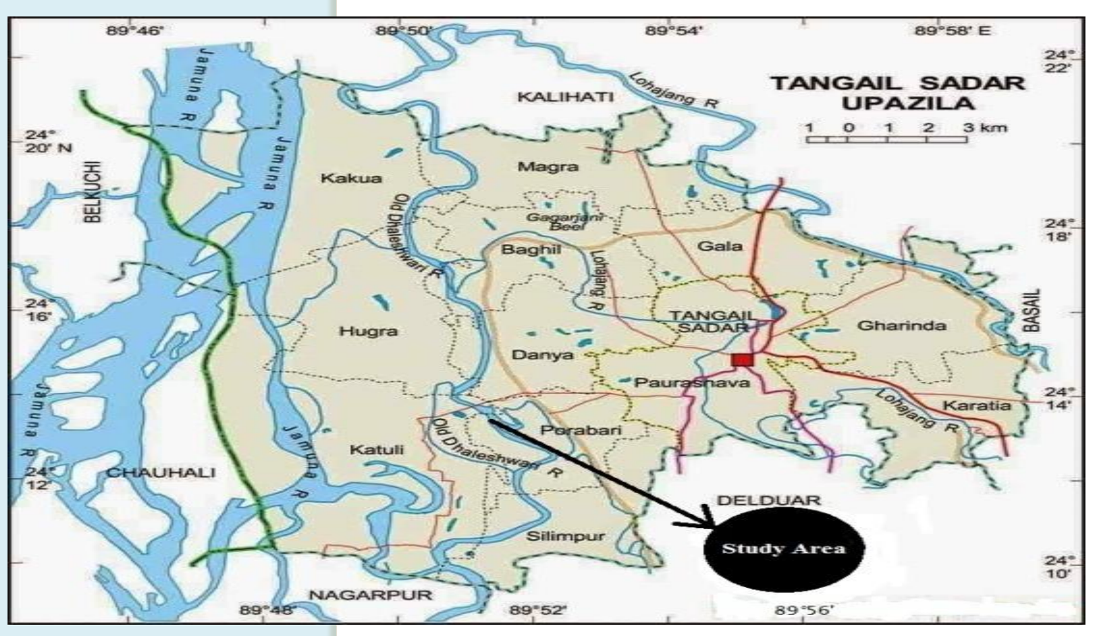

Fig 1: Study Area of Tangail Sadar Upazilla

Materials and Methods

The depths of selected tube wells were varying from 30 ft to 220ft. A total of 10 samples has been collected from different region of Tangail sadar upazilla and physico-chemical properties of the samples have been measured.

The parameter like pH, Electrical conductivity (EC) and Dissolved Oxygen (DO) were instantly measured by portable pH meter (SD 300 pH), EC meter (SD 320 Con) and DO meter (SD 310 Oxi) and preserved the samples for measuring cations and anions. Flame Atomic Absorption Spectrophotometer (FAAS) was used to determine the concentration of Na^+, K^+, Ca^{2+} and Mg^{2+} ions and UV-Visible Spectrophotometer were used to assess the concentration of SO_4^{3-} and NO_3^- present in the samples. Chloride was determined by the argentometric titration method and Bicarbonate was estimated by standard method.

To assess the suitability of groundwater for irrigation uses, the following irrigational quality parameters were computed.[5,6]

Sodium adsorption ratio (SAR): The excess of sodium with calcium and magnesium is evaluated by SAR. Sodium replacing adsorbed calcium and magnesium is a hazard, as it causes damage to the soil structure resulting in compact and impervious soil.

$$\mathrm{SAR} = \frac{\mathrm{Na}^+}{\sqrt{(\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+})/2}}$$

Soluble sodium percentage (SSP): The sodium in irrigation water is usually expressed in %Na. When concentration of sodium ion is high in irrigated water, it tends to be absorbed by clay particles, dispersing magnesium and calcium ions.

$$Na\% = \frac{(Na^+ + K^+)X100}{(Ca^{2+} + Mg^{2+} + Na^+ + K^+)}$$

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Residual sodium carbonate (RSC): RSC values were calculated to determine the hazardous effect of CO_3^{2-} and HCO_3^- on the water quality for agricultural purpose.

$$\mathrm{RSC} = (\mathrm{HCO_3^-} + \mathrm{CO_3^{2-}}) - (\mathrm{Ca^{2+}} + \mathrm{Mg^{2+}})$$

Kelley's Index (KI): Kelly index is used for the classification of water for irrigation purposes. A Kelley's index of more than 1 indicates an excess level of sodium in waters.

$$\mathrm{KR} = \frac{\mathrm{Na}^+}{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+}}$$

Permeability Index (PI): The permeability of soil is affected by long-term use of irrigation water and is influenced by sodium, calcium, and magnesium and bicarbonate contents in the soil.

$$PI = \frac{Na^+ + \sqrt{HCO_3^-}\,X100}{(Ca^+ + Mg^+ + Na^+)}$$

Magnesium Adsorption Ratio (MAR): Excess of magnesium in the soil easily affects the crop yield. High magnesium ratio may be due to the passage of surface water and subsurface water through different types of rocks.

$$\mathrm{MR} = \frac{\mathrm{Mg}^{2+} \times 100}{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+}}$$

Chloro-Alkaline Indices I & II (CAI-I and CAI-II): Changes in chemical composition of groundwater along its flow path can be understood by studying the Chloro-Alkaline Indices (CAI).[7] Positive CAI indicate exchange of Na and K from the water with Mg and Ca of the rocks and is negative when there is an exchange of Mg and Ca of the water with Na and K of the rocks.

$$\mathrm{CAI-I} = \frac{(\mathrm{Cl}^- - (\mathrm{Na}^+ + \mathrm{K}^+))}{\mathrm{Cl}^-}$$

$$\mathrm{CAI-II} = \frac{(\mathrm{Cl}^- - (\mathrm{Na}^+ + \mathrm{K}^+))}{\mathrm{SO_4^{2-}} + \mathrm{HCO_3^-} + \mathrm{CO_3^{2-}} + \mathrm{NO_3^-}}$$

Results and Discussion

The chemical compositions of the groundwater samples were statistically analyzed, and the results are given in **Table 1.**

Table-1: Descriptive statistics for the chemical analysis of groundwater samples.

Parameters	Max	Min	Average	STD	WHO STND.
pH	7.50	7.02	7.29	±0.15	6.5-8.5
EC	728.00	192.00	382.10	±5.00	>2000
TDS	364.00	96.00	191.05	±2.68	>1500
DO	5.10	1.70	2.85	±0.05	4.00
TH	292.00	122.00	200.80	±10.00	500
Na^+	105.20	4.00	41.609	±1.67	200
K^+	3.03	0.51	1.494	±0.02	10
Ca^{2+}	60.40	10.70	31.04	±0.10	200
Mg^{2+}	26.00	6.84	15.62	±0.07	150
HCO_3^-	266.00	126.00	196.60	±8.22	600
SO_4^{3-}	8.87	ND	5.94	±0.08	400
Cl^-	3.75	0.41	1.081	±0.31	600
NO_3^-	12.10	0.69	5.34	±0.20	50

All values are in mg/L, except pH, EC (µS/cm).

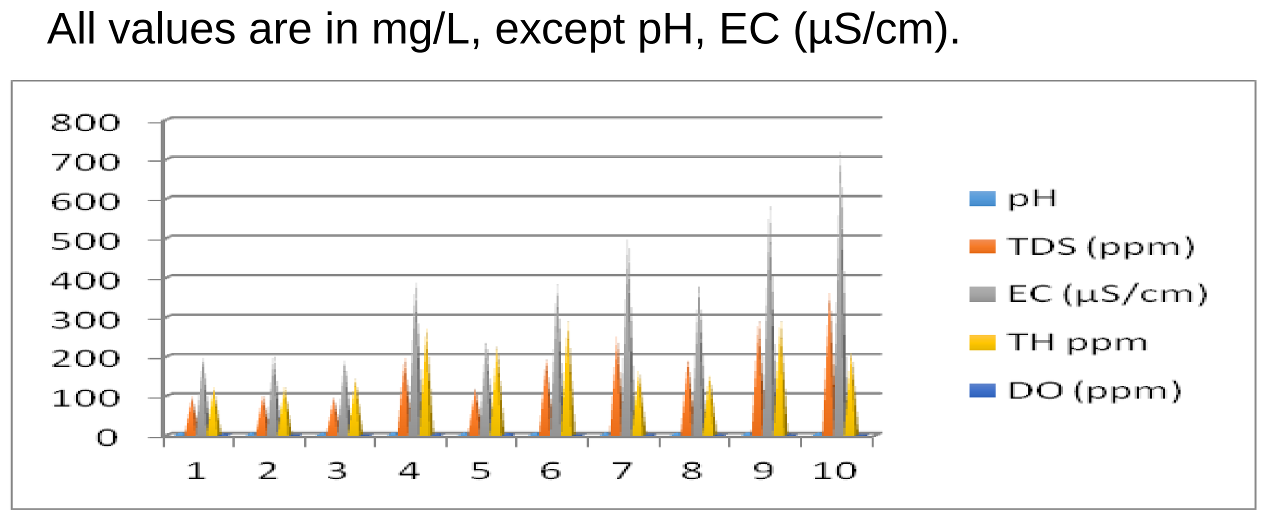

Fig-2: Different physico-chemical parameters of the collected samples.

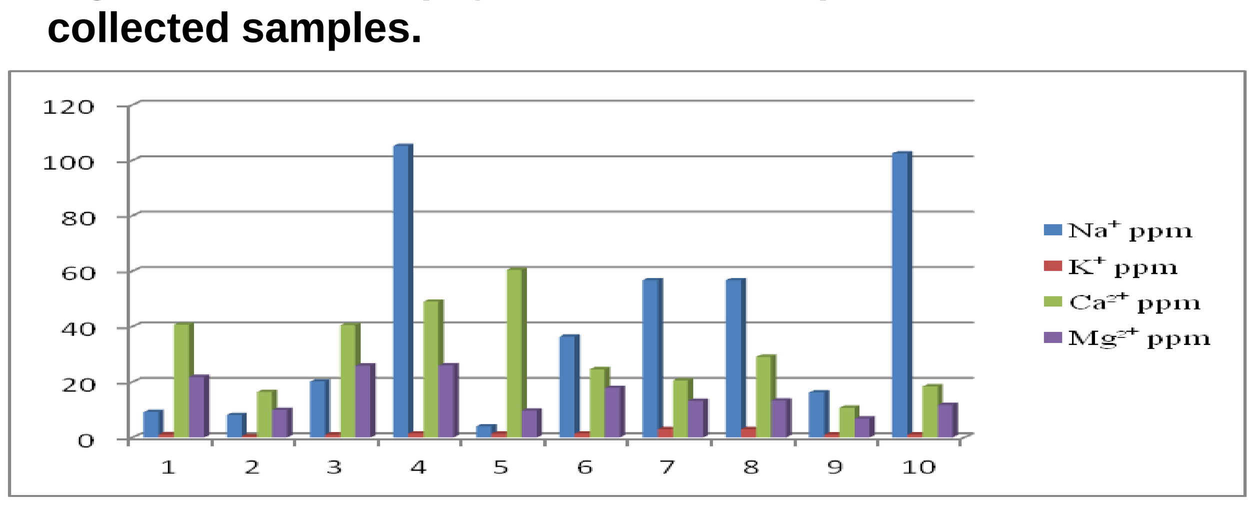

Fig-3: Concentration of cations in collected samples.

The calculated parameters results of the collected groundwater samples for irrigation purpose and summary statistics of different indexes of groundwater quality are presented in **Table-2.**

Results and Discussion– Con't

Table-2: Calculated parameters for irrigation quality.

Parameter	Range	Class	Samples
EC (Electrical Conductivity)	<250	Excellent	1, 2, 3, 5
	250-750	Good	4, 6, 7, 8, 9, 10
	750-2000	Permissible	
	2000-3000	Doubtful	
TH (Total Hardness)	<75	Soft	
	75-150	Moderately Hard	1, 2, 3
	150-300	Hard	4, 5, 6, 7, 8, 9, 10
	>300	Very hard	
SAR (Sodium Adsorption Ratio)	0-10	Use for all soil types	1, 2, 3, 5, 6, 9
	10-18	Preferably use on coarse textured soil	4,7, 8
	18-26	May produce harmful effects	
	>26	Unsatisfactory	10
SSP (Soluble Sodium Percentage)	<20	Excellent	1, 5
	20-40	Good	2, 3
	40-60	Permissible	4, 6, 8, 9
	60-80	Doubtful	7, 10
	>80	Unsuitable	
RSC (Residual Sodium Carbonate)	<1.25	Safe	1, 3, 4, 5, 8
	1.25-2.5	Marginally suitable	2, 6, 7, 9, 10
	>2.5	Unsuitable	
KI (Kelly's Ratio)	<1	Suitable	1, 2, 3, 5, 6, 9
	>1	Unsuitable	4, 7, 8, 10
PI (Permeability Index)	Class I (<75%)	Excellent	7, 9, 10
	Class II (75-25%)	Good	1, 2, 3, 4, 5, 6, 8
	Class III (>25%)	Unsuitable	
MAR (Magnesium Adsorption Ratio)	<50	Suitable	All samples
	>50	Unsuitable	
CAI-I and CAI-II (Chloro Alkaline Indices)	Positive	No Base exchange	
	Negative	Base exchange	All Samples

A graphical representation was shown in **Fig-4** based on one of the above result described.

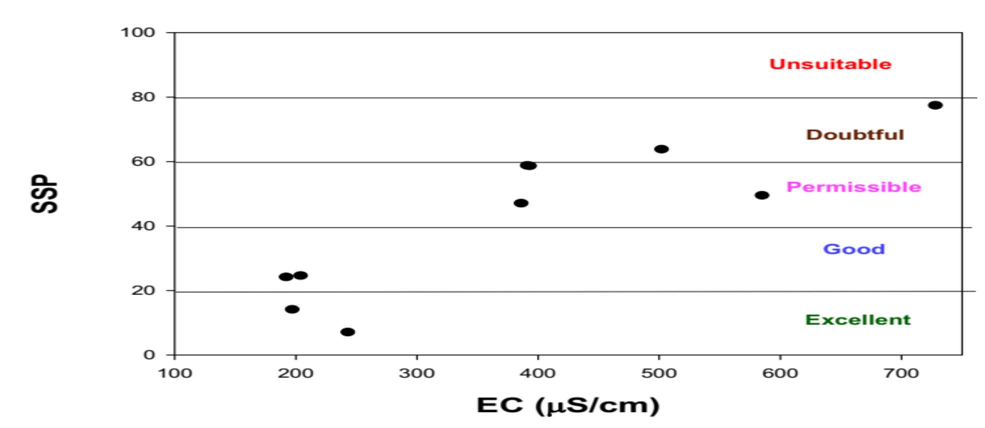

Fig-4: Suitability of groundwater for irrigation.

Conclusions

- All the physical parameters measured and the cations and anions were far below than the WHO standard limit. So, in that logic the collected samples may be suitable for drinking purpose.
- Some parameters were calculated for irrigation purpose and it was found that except two or three samples, most of samples couldn't be used for irrigation directly. Before using those water, it should be gone through some pre-treatment processes.

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