



Title: Groundwater Quality for Irrigation, Drinking, and Livestock Consumption in Gournadi Upazila, Barishal, Bangladesh

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### ABSTRACT

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Bangladesh is a riverine country. There is plenty of surface water, but people cannot use it for all purposes. Most people use groundwater every day for various purposes. A research work was conducted to observe the quality of groundwater of Gournadi upazila of Barishal District for irrigation, drinking, and livestock consumption. Twenty groundwater samples were collected from different locations in Gournadi and the pH, EC, TDS, Ca, Mg, K, Na, S, and P were analyzed in the Department of Agricultural Chemistry, Patuakhali Science and Technology University. The water pH (6.70-8.28) indicated that groundwater samples were neutral to alkaline in nature and they are suitable for irrigation, drinking, and livestock consumption purposes. Based on EC values (0.188- 0.815 mS cm<sup>-1</sup>), all the samples were found non-saline and suitable for all purposes. The TDS values in groundwater samples collected from Gournadi upazila ranged from 28.8 to 721.6 mgL<sup>-1</sup> which is below the permissible limit for using in the said purposes. The concentration of Ca, Mg, Na, P, S, and K ions ranged from 3.17-7.67, 2.07-8.77, 6.20-14.65, 0.064-0.80, 3.76-13.81, and 3.34-9.47 mgL<sup>-1</sup>, respectively. On the basis of Ca, Mg, Na, P, S, and K concentrations all the groundwater samples were rated suitable for irrigation, drinking, and livestock consumption and could be recommended for these purposes.

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## INTRODUCTION

Water is an essential matter for life. Bangladesh is a riverine country. Though there is plenty of surface water, we cannot use it for all purposes. About 97% of the people in Bangladesh depend on groundwater for drinking and 80% of people use groundwater for irrigation (Shamsudduha, 2013; Qureshi et al., 2015). Sometimes many problems occur due to the use of bad quality or polluted water by human beings, livestock, and even plants. The water quality is dependent on many factors. Groundwater quality is dependent on chemical constituents and their concentration (Selvakumar et al., 2017).

The main cations of water are  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$  and  $\text{K}^+$  and the anions are  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{HCO}_3^-$ , and  $\text{CO}_3^{2-}$ . There are some elements like Cu, Mn, Fe, Cr, Pb, Mo, and B, etc. in minor quantities (Michael, 1997). Some of these ions are beneficial and some are very harmful when they are excess in concentration. When a higher concentration of Na is present in water then exerts osmotic pressure in plants and high blood pressure in humans (Kattan, 2018). It is essential to observe the water quality before use. The quality of water can be evaluated by analyzing the salt concentration, the content of cations and anions, and the concentration of toxic elements such As, Cd, Pb, Hg, etc. The WHO gave limits on the concentration of chemicals safe for human beings, animals, and plants. When the limit is crossed, it may be harmful to the consumers.

The stakeholders of Gournadi Upazila mainly use groundwater for irrigation, drinking, and livestock farming purposes. Considering the above points in mind water from different tube wells of the different unions of Gournadi upazila of Barishal district was collected to evaluate their quality and suitability.

## METHODOLOGY

### *Collection of water samples*

Twenty groundwater samples (Table 1) were collected from different locations of

Gournadi upazila. Geographically, the experimental area is situated at  $22^{\circ}45' - 23^{\circ}4' \text{N}$  to  $90^{\circ}12' - 90^{\circ}18' \text{E}$  (Figure1). The samples were collected in 50 mL plastic bottles. The bottles were cleaned at first with diluted HCl followed by tap water and finally by distilled water. Samples were collected at about 2-3 Kilometer intervals. Rinsing the bottles with sampling water 3 to 4 times water samples were collected. The bottles were tightly sealed immediately to avoid exposure to air. The pH and EC were measured by taking the sample in laboratory and they were filtered with Whatman No. 42 filter paper. The samples were kept in before sampling, containers were again rinsed 3 to 4 times with water to be sampled. The collected samples were tightly sealed immediately to avoid exposure to air. The filtered samples were kept in freeze with proper labeling. All the sampling procedures were followed as described by Hunt and Wison (1986).

### *Analytical procedures*

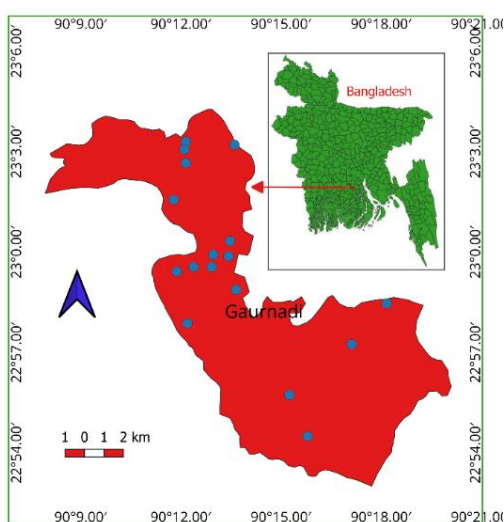
The pH was determined by following the methods outlined by Eaton et al. (1995) using a pH meter (Model: METTLER TOLEDO). The EC was determined by the method outlined by Tandon (1995). The total dissolved solid (TDS) was determined by an electrical conductivity meter following the procedure given by Richard (1968). The chemical analyses were done following the instructions of APHA (2005). The content of phosphorus was measured by spectrophotometer (Model: T60 U) at 660 nm wavelength after 15 minutes of the addition of ascorbic acid within 12 hours. The content of potassium and sodium was determined by a flame emission spectrophotometer. Sulfur was analyzed with the help of a spectrophotometer by the turbidimetric method.

**Table 1. Information on groundwater samples**

Sl No	Sampling area (Union)	Depth (Feet)
1	Torki	960
2	Rajapur	900
3	Gournadi	1100
4	Changutia	950
5	Barthi	950
6	Sundardi	1200
7	Basail	960
8	Ella	1050
9	Mahilara	920
10	Kosba	1020
11	Baurgathi	800
12	Batajor	1100
13	Sarikal	900
14	Hosnabad	820
15	Gaila	850
16	Gurgata	880
17	Kamlapur	920
18	Dandoba	850
19	Ramsiddi	900
20	Chadsi	1050

Calcium and Mg were determined by the atomic absorption spectrophotometric method. The sodium adsorption ratio (SAR) was measured using the following formula.

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$



**Figure 1. Sampling sites (blue marks) of different unions of Gournadi upazila**

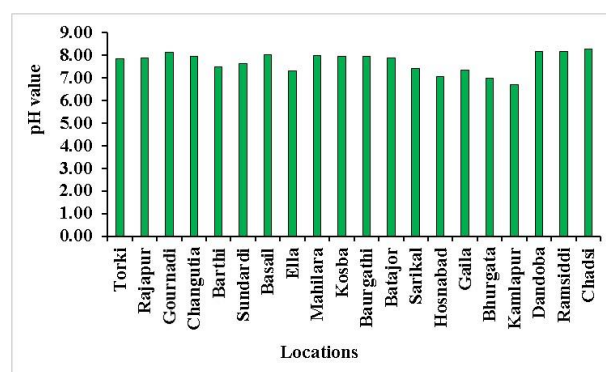
*Statistical analysis*

The mean values of all the collected data on the parameter were calculated with the help of SPSS computer program and presented in tables and graphs.

**RESULTS AND DISCUSSION**

*The pH values in groundwater*

In the Gournadi upazila of the Barishal district, the ground water pH value ranged from 6.7 to 8.28 and the mean pH value was 7.71 (Figure 2). The highest value (8.28) was found in Chadsi and the lowest value (6.7) was found in Kamlapur.



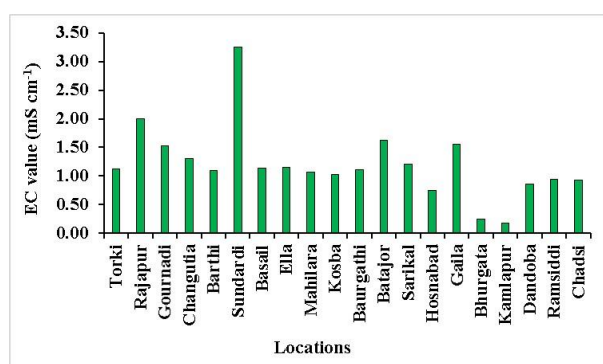
**Figure 2. Groundwater pH value of different unions of Gournadi**

For drinking purposes, the highest desirable ranged from 7.00 to 8.5 and the maximum permissible ranged from 6.5 to 9.2 of pH value for drinking purposes (WHO, 1971). According to WHO standards, the samples were suitable for drinking purposes. According to Ayers and Westcot (1985) the acceptable range of pH is 6.5 to 8.4 for irrigation and all the samples were within the range indicated as suitable for irrigation purposes. The recommended range of pH in water is 6.5 to 9.2 for livestock consumption (WHO, 1971). According to WHO standards, all the water samples were within the acceptable limit for livestock consumption purposes.

*Electrical conductivity (EC) in groundwater*

In the Gournadi upazila of the Barishal district, the electrical conductivity of the water samples collected from different unions was within the range of 0.188 to

0.815 mS cm<sup>-1</sup> (Figure 3) and the mean EC value was 0.336 mScm<sup>-1</sup>. The value of EC 0.4 mScm<sup>-1</sup> is suitable for drinking purposes and more than 0.5 mS cm<sup>-1</sup> is unsuitable for drinking purposes (WHO, 1971). According to WHO standards, most of the water samples collected from the different unions of Gournadi upazila were within the safe limit. Irrigation water is classified into 4 types, such as low salinity (0-0.25 mS cm<sup>-1</sup>), medium salinity (0.25-0.75 mS cm<sup>-1</sup>), high salinity (0.75-2.25 mS cm<sup>-1</sup>), and very high salinity (>2.25 mS cm<sup>-1</sup>) on the basis of EC Values (Richards, 1968).



**Figure 3. EC (mScm<sup>-1</sup>) values of ground water of different unions of Gournadi**

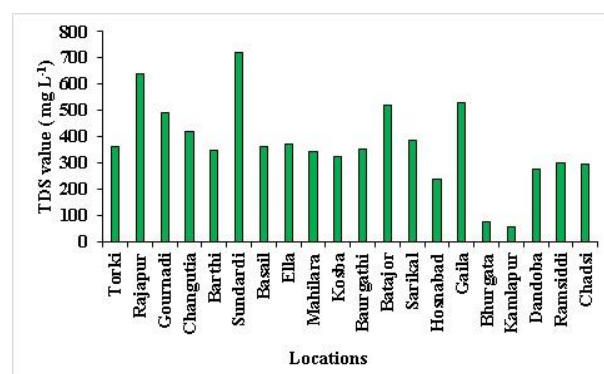
According to Richard's standard, the majority of the collected groundwater was found medium saline (Figure 3). The EC values from 0.05 to 0.6 mScm<sup>-1</sup> are acceptable for livestock consumption purposes and more than 0.6 mScm<sup>-1</sup> is harmful (unacceptable) for livestock consumption purposes (WHO, 1971). According to WHO standards, most of the collected groundwater samples were suitable for livestock consumption purposes.

#### **Total Dissolved Solid (TDS) value in groundwater**

The TDS values in groundwater samples collected from Gournadi upazila ranged from 28.8 to 721.6 mgL<sup>-1</sup> (Figure 4). The highest TDS value was found (721.6 mgL<sup>-1</sup>) in Sundardi and the lowest value (28.8 mgL<sup>-1</sup>) was observed in Kamalpur.

TDS value less than 1000 mgL<sup>-1</sup> is classified as fresh water in quality (Freeze and Cherry,

1979). All the water samples were suitable for drinking purpose as the values were within the limit of WHO (1771) standards. As most of the water TDS values were below 1000 mgL<sup>-1</sup> they would not be harmful for irrigation because in this TDS range it would not affect the osmotic pressure of the soil solution. As the TDS value over 3000 mgL<sup>-1</sup> is harmful to livestock consumption, these samples are appropriate for livestock consumption.



**Figure 4. Ground water TDS (mg L<sup>-1</sup>) value of different unions of Gournadi**

#### **Calcium (Ca<sup>+2</sup>) in groundwater**

In the different unions of Gournadi upazila of Barishal district, the value of Ca concentration ranged from 3.17 to 7.67 mg L<sup>-1</sup>. The highest concentration of Ca (7.67 mg L<sup>-1</sup>) was observed in Sarikal on the other hand the lowest values (3.17 mg L<sup>-1</sup>) were found in Kosba, Kamalpur, and Sundardi (Table 2).

According to WHO standard, the collected water samples were fit for drinking purposes at Gournadi upazila of Barishal district. The acceptable limit of Ca in irrigation water is 0 to 20 mgL<sup>-1</sup> (Ayers and Westcot, 1985). All the collected water samples were suitable for irrigation purposes. Calcium content less than 100 mgL<sup>-1</sup> is suitable for raising crop plants (Todd, 1980). According to WHO, 75 mgL<sup>-1</sup> Ca is recommended for livestock consumption, and the range of Ca was within the limit in the study area.

#### **Magnesium (Mg<sup>+2</sup>) in groundwater**

In the research area of Gournadi upazila of Barishal district, the Mg concentration varied

from 2.07 to 8.77 mgL<sup>-1</sup>. The highest value of Mg (8.77 mg L<sup>-1</sup>) was observed in Hosnabad and the lowest concentration was found in Mahilara (Table 2). For drinking purposes, the highest desirable limit of Mg is 30 mg L<sup>-1</sup> and the maximum permissible limit is 150 mg L<sup>-1</sup> (WHO, 1971; Al-Zarah, 2007). All the collected groundwater samples were suitable for drinking purposes. The maximum limit of Mg for irrigation purposes is 35 mgL<sup>-1</sup> (DoE, 1997). According to FAO standards, all collected groundwater samples were acceptable for

irrigation. Irrigation water containing less than 99.6 mgL<sup>-1</sup> Mg is suitable for raising crop plants (Todd, 1980). According to this limit, all collected groundwater samples were suitable for irrigation. The recommended maximum limit of Mg for livestock consumption is 150 mgL<sup>-1</sup> (WHO, 1971; Al-Zarah, 2007). According to WHO standards, all collected water samples of Gournadi upazila of Barishal district were suitable for livestock purposes.

**Table 2. The concentration (mgL<sup>-1</sup>) of Ca, Mg, Na, and K in groundwater of different union of Gournadi**

Sampling area	Ca <sup>+2</sup> (mgL <sup>-1</sup> )	Mg <sup>+2</sup> (mgL <sup>-1</sup> )	Na <sup>+</sup> (mgL <sup>-1</sup> )	K <sup>+</sup> (mgL <sup>-1</sup> )	SAR
Torki	4.00	3.75	7.70	5.10	3.91
Rajapur	3.33	4.06	6.20	4.92	3.23
Gournadi	5.83	8.29	7.75	4.36	2.92
Changutia	3.83	3.98	7.24	4.59	3.66
Barthi	3.50	3.51	7.58	3.99	4.05
Sundardi	3.17	6.52	14.65	8.31	6.65
Basail	3.33	4.99	13.09	3.81	6.42
Ella	4.33	4.91	14.13	4.13	6.57
Mahilara	3.33	2.07	9.30	3.62	5.66
Kosba	3.17	2.63	6.20	3.71	3.64
Baurgathi	3.33	3.35	9.82	3.90	5.37
Batajor	5.83	5.74	12.41	4.50	5.16
Sarikal	7.67	6.42	8.44	5.71	3.18
Hosnabad	5.67	8.77	9.87	9.47	3.67
Gaila	5.33	8.46	10.34	4.92	3.94
Bhurgata	5.33	8.52	6.20	6.13	2.36
Kamlapur	3.17	6.22	11.2	3.34	5.17
Dandoba	3.67	3.67	11.72	3.81	6.12
Ramsiddi	4.33	5.50	11.72	4.08	5.28
Chadsi	4.00	3.43	7.93	3.99	4.11
Mean	4.31	5.24	9.67	4.82	4.55
Range	3.17-7.67	2.07-8.77	6.20-14.65	3.34-9.47	2.36-6.65

#### ***Sodium (Na<sup>+</sup>) in groundwater***

In the research area of Gournadi upazila of Barishal district, the concentration of Na ion ranged from 6.20 to 14.65 mgL<sup>-1</sup>. The highest concentration of Na<sup>+</sup> (14.658 mgL<sup>-1</sup>) was observed in Sundardi and the lowest value was 6.20 mgL<sup>-1</sup> found in Kosba (Table 2). For drinking purposes, the highest desirable limit is 17.25 mgL<sup>-1</sup> and the highest permissible limit of Na is 200 mgL<sup>-1</sup> (WHO, 1971). According to WHO standards, all

collected groundwater samples were fit for drinking purpose. The recommended value of Na for irrigation is less than 40 mgL<sup>-1</sup> (Ayers and Westcot, 1985). So, the collected samples were suitable for irrigation purposes. The existing average limit of sodium for livestock consumption is less than 34.5 mgL<sup>-1</sup> and the recommended highest limit is less than 200 mgL<sup>-1</sup> (WHO, 1971; Al-Zarah, 2007). According to WHO standards, all

collected groundwater samples were suitable for livestock consumption purpose.

#### **Potassium ( $K^+$ ) in groundwater**

The amount of total potassium in groundwater samples of different unions of Gournadi upazila ranged from 3.34 to 9.47  $mgL^{-1}$  (Table 2). The highest value of K (9.47  $mgL^{-1}$ ) was found in Hosnabad and the lowest concentration (3.34  $mgL^{-1}$ ) was found in Kamlapur. For drinking purposes, the highest desirable limit is 19.5  $mgL^{-1}$  and the highest permissible limit is 55  $mgL^{-1}$  (WHO, 1971). The recommended concentration of K for irrigation is 20.0  $mgL^{-1}$  (Ayers and Westcot, 1985). According to FAO standards, all the collected samples are suitable for irrigation. The potash-bearing minerals like sylvite and niter might be responsible for the higher concentration of K in the sample (Kumar et al., 2017). The existing average limit of potassium for livestock consumption is < 20  $mgL^{-1}$  and the highest recommended limit is 31.2  $mgL^{-1}$  (WHO, 1971). According to WHO standards, all collected samples were suitable for livestock consumption.

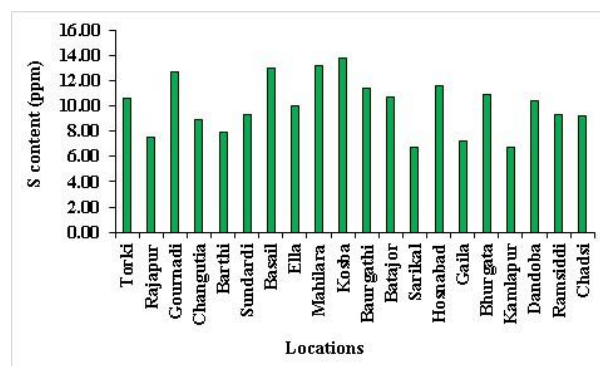
#### **Sulfur ( $SO_4^{2-}$ ) in groundwater**

In the research area of Gournadi upazila of Barishal district, the concentration of S ion ranged from 6.32 to 13.9  $mgL^{-1}$  (Figure 9). The highest value of S ion 13.9  $mgL^{-1}$  was found in Kosba and the lowest value was 6.32  $mgL^{-1}$  found in Sarikal and Kamlapur. For drinking purpose, the highest desirable limit is 200  $mgL^{-1}$  and the maximum permissible limit is 400  $mgL^{-1}$  (WHO, 1971). So, according to WHO, all the samples were safe for drinking purpose. For irrigation purpose, the highest limit of S is 20  $mgL^{-1}$  (Ayers and Westcot, 1985).

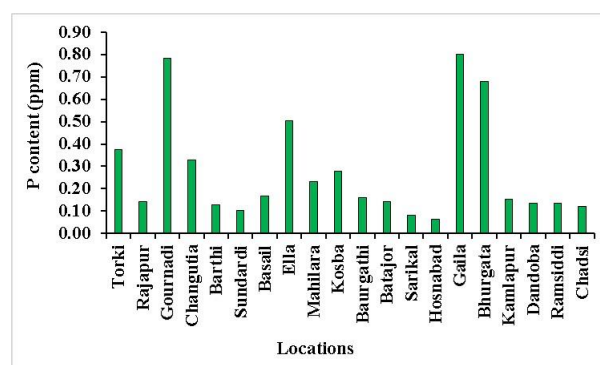
All the groundwaters were suitable for irrigation purpose. The existing average limit of sulfur for livestock consumption is 400  $mg L^{-1}$  and the maximum recommended limit is 200  $mgL^{-1}$  (WHO, 1971). According to WHO standards, the water samples collected from different unions of Gournadi were suitable for livestock consumption.

#### **Phosphorus ( $PO_4^{3-}$ ) in groundwater**

The amount of total phosphorus in groundwater samples of different unions of Gournadi upazila varied from 0.064 to 0.80  $mgL^{-1}$  (Figure 10). The highest concentration of P (0.080  $mgL^{-1}$ ) was found in Gaila and the lowest value (0.064  $mgL^{-1}$ ) found in Hosnabad.



**Figure 5. Ground water S content ( $mgL^{-1}$ ) of different unions of Gournadi**



**Figure 6. P content ( $mgL^{-1}$ ) value of ground water of different unions of Gournadi**

For drinking purpose, the suitable range of P is 0.00 to 3.00  $mgL^{-1}$ , (WHO, 1971). According to WHO standards, all collected groundwater samples were fit for drinking purpose. For irrigation, the maximum limit of phosphorus for irrigation purposes is 2  $mgL^{-1}$  (Ayers and Westcot, 1985). As of FAO standards, all collected samples were acceptable for irrigation purpose. For livestock purpose, the existing average limit is 1  $mgL^{-1}$  and the recommended limit is 5  $mgL^{-1}$  (WHO, 1971). According to WHO standards, all collected samples were suitable for livestock purpose.

**Sodium absorption ratio (SAR)**

In the research area of the different unions of Gournadi upazila, 20 groundwater samples were tested and the SAR values varied from 2.36 to 6.65, respectively (Table 2). According to Wilcox (1955) the water which have the SAR value within 0-10 are classified as excellent. So, all the water samples were suitable for irrigation (Wilcox, 1955).

**CONCLUSION**

The pH (6.70-8.28) indicated that groundwater samples were neutral to alkaline in nature and they were suitable for irrigation, drinking, and livestock consumption purposes. Based on EC (0.188- 0.815 mS cm<sup>-1</sup>), all the samples were found non-saline and suitable for all purposes. The TDS values in groundwater samples collected from Gournadi upazila ranged from 28.8 to 721.6 mgL<sup>-1</sup> which is suitable for all purposes. The concentration of Ca, Mg, Na, P, S, and K ion ranged from 3.17-7.67, 2.07-8.77, 6.20-14.65, 0.064-0.80, 3.76-13.81, and 3.34-9.47 mgL<sup>-1</sup>, respectively. On the basis of Ca, Mg, Na, P, S, and K ion concentrations all the groundwater samples were rated suitable for irrigation, drinking, and livestock consumption and could be recommended for these purposes.

**DISCLOSURE STATEMENT**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**DATA AVAILABILITY STATEMENT**

Anonymized data can be made available on reasonable request.

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