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ASSESSMENT OF GROUNDWATER QUALITY FOR DRINKING PURPOSES IN SONAGAZI UPAZILA, FENI

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ABSTRACT

The goal of this study is to assess the groundwater quality of Sonagazi Upazilla which is used for drinking purposes. For this study 13 samples were collected from 13 different stations in the study area in time period of September 2021. Samples were collected in sterilized plastic bottles. The Biomaterials Research Laboratory (BRL) which is situated at the Applied Chemistry and Chemical Engineering Department, in the University of Chittagong, was used for the analysis of the collected sample. Physicochemical parameters such as Temperature, Total Dissolved Substances (TDS), Electrical Conductivity (EC), pH, Turbidity, Salinity, and Arsenic (As) were considered for the analysis. A digital multi-meter was used to detect these parameters. TDS, EC and Turbidity were found above the acceptable limit based on WHO and BSTI standards, p^H and temperature were in the acceptable limit according to both WHO and BSTI standard, and in some station amount of Arsenic (As) was above WHO standard. The correlation matrix is also calculated to evaluate the relationship among the parameters. Overall, the groundwater quality of the study area is not 100% safe for drinking purpose. The Authority of Sonagazi upazilla should take proper steps to provide safe drinking water in the considered area and should identify tube well with red mark which are polluted by Arsenic (As).

Keywords: Groundwater, BSTI, WHO, Pollution, Water Quality Index.

I. INTRODUCTION

Water is an essential component of natural resources and plays an important role for the purposes of drinking, irrigation, aquaculture and livestock usages. It is needless to say that without enough good water our survival will be threatened. Water occurs 97.2 percent in ocean as salt water, 2.09 percent in icecaps and glaciers, 0.6 percent ground water, 0.11 percent runoff and surface water(Delgado et al. 2010; Mohsin et al. 2013). Groundwater is regarded as one of the most vital source of water for domestic, industrial, and agricultural purposes (Islam et al. 2017). More than 1.5 billion inhabitants around the globe depend on the groundwater for agriculture usage and industrialization consumption (Zahedi 2017). Groundwater is the water that lies beneath the ground surface, filling the pore space between grains in bodies of sediment and elastic sedimentary rocks and filling cracks and cavity in all types of rocks(Meride and Ayenew 2016). Observations have shown that a good deal of surplus rainfall runs-off over the surface of the ground while the other part of it infiltrates underground and becomes the groundwater responsible for the springs, lakes and wells(Wu et al. 2017). Groundwater is often withdrawn for agricultural, municipal and industrial use by constructing and operating extraction wells(Shahid et al. 2006).

We have plenty of both surface and ground water supply to support the entire population in Bangladesh(Bhuiyan et al. 2016). In fact, after human resources water is the most abundant resource in Bangladesh. About 97% of the population of Bangladesh use tube well water for drinking and cooking purposes(Hasan et al. 2019). In Bangladesh, ground water has become increasingly important source of irrigation, human drinking and other uses(Rahman et al. 2012). With the ever increasing demand of water in this country, the importance of utilization of ground water is increasing now-a-days at an accelerated rate. More recently, about 80% of the requirement of irrigation water and about 97% of the portable water of this country are being met by modern tubewell technologies(Rifat et al. 2021).

Safe drinking water is a basic need for good health and it is also a basic right of humans. Clean and safe water is an absolute need for health and productive life(Rahman et al. 2018). The quality of the water supplied is important in determining the health of individuals and whole communities (Mostafa et al. 2017). The assessment of groundwater quality is one of the important tools for sustainable development and provides decisive information for water management (Alam et al. 2017). The term water quality is applied universally to refer to the water status that meets the universal standards set for legitimate and vital water use at any scale i.e. local, regional and international levels (WHO, 2004). Unfortunately, in developing countries (i.e. Bangladesh,India, Pakistan etc.) the drinking quality of water is continuously being contaminated and hazardous for human use due to high growth of population, expansion in industries, throwing away of waste water and chemical effluents into canals and other water sources(Nickson et al. 2005; Srinivasamoorthy et al. 2011). According to recent estimates, the quantity of available water in developing regions of South Asia, Middle East and Africa is decreasing sharply while quality of water is deteriorating rapidly due to fast urbanization, deforestation, land degradation etc(Balaji et al. 2017).Water pollution may not cause immediate effect on the health of the individual but can prove fatal in the long run. Water pollution can be damaging to the economy as it can be expensive to treat and prevent contamination (Tiwari et al. 2017).

Water quality monitoring and assessment is the foundation of water quality management(Saraswat et al. 2019). Thus, there has been an increasing demand for monitoring water quality of both surface and ground water by regular measurements of various water quality parameters. The aim of water quality management is usually to minimize the health risks associated with either direct or indirect use of water(Omo-Irabor et al. 2008). Standards and guidelines in water quality stem from the need to protect human health. Contamination of water has increasingly become an issue of serious environmental concern after years of pollution. Natural water contains many dissolved substances: contaminants such as bacteria, viruses, heavy metals, nitrates and salt have polluted water supplies due to inadequate treatment and disposal of wastes from humans and livestock, industrial discharges and over use of limited water resources (Singh et al. 2020; Tripathi and Singal 2019). The pollution of drinking water is responsible for large number of mortalities and morbidities due to water borne diseases like typhoid, cholera, diarrhoea, dysentery, hepatitis, as well as many protozoan and helminthes infections(Islam et al. 2018).

The present study intends to assess the physicochemical and microbiological quality of drinking water from different tube wells in Sonagaziupazilla of Feni district, Southern Bangladesh. The primary goal of this research is to analyze the drinking water quality parameters to ensure that the water is safe for drinking.

II. METHODOLOGY

2.1 sampling

The groundwater samples were collected from 9 union of Sonagaziupazila, Feni during September, 2021. Total 13 samples were collected. The sources of water comprised shallow tube wells. Samples were collected in sterilized plastic bottles. Before collecting samples bottles were rinsed for three times by desired sample water. Samples were transferred to the Biomaterials Research Laboratory (BRL), Applied Chemistry and Chemical Engineering, University of Chittagong for analysis. Table 2.1 shows the sample collection sites.

Table 2.1: Geographical Location of Groundwater Sampling Stations in Sonagazi.

Sampling ID	Sampling Station	Latitude (degree)	Longitude (degree)
S-1	Regional Rice Institute	22.810896	91.388130
S-2	Regional Rice Institute	22.819135	91.367761
S-3	Shawdagor Hat	22.823789	91.345487
S-4	Olama Bazar	22.841636	91.368785
S-5	Char Darbesh	22.835526	91.351958
S-6	Char Majlishpur	22.901318	91.333795
S-7	Baktermushi	22.905083	91.395827
S-8	Nowabpur	22.928165	91.443148
S-9	Amirabad	23.895466	91.448918
S-10	Motiganj	22.889019	91.402212
S-11	Sonagazi Municipality	22.851210	91.393654
S-12	Sujapur	22.847359	91.422463
S-13	Shonapur	22.848295	91.445585

Figure 2.1: Collection and preservation of Groundwater sample

III. MODELING AND ANALYSIS

3.1 Methods

Table 3.1: Methods at a glance

Parameters	Unit	Methods/Instruments
Temperature	ºC	Thermometer
pH	-	Combometer (Hanna portable combometer,Modelno:HI 9813-6)
Total Dissolved Substances (TDS)	mg/L	Combometer (Hanna portable combometer,Modelno:HI 9813-6)
Electrical Conductivity (EC)	mg/L	Combometer (Hanna portable combometer,Modelno:HI 9813-6)
Salinity	ppt	Hand Refractometer (Model no: REF201/211/201bp)
Turbidity	NTU	Turbidity Meter (Model no: TU-2016)
Arsenic (As)	Mg/L	Test kit

Hand Refractometer

Combometer

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Turbidity Meter


Arsenic Test Kit

Figure 3.1: Instruments use to determine different parameters

3.2 Temperature

Temperature was determined by thermometer.

3.3 Total Dissolved Substance (TDS)

TDS was determined by Hanna portable combometer, Model no: HI 9813-6.

Procedure:

1. Pour the probe approximately 4 cm into a calibrated solution of 1500 ppm and wait for the reading to stabilize.
2. After calibration the probe submerged into the sample solution and then press "ppm" key and wait for the reading to stabilize.
3. And note down the reading.

3.4 Electrical Conductivity (EC)

EC was determined by Hanna portable combometer, Model no-HI 9813-6.

Procedure:

1. Pour the probe approximately 4 cm into a calibrated solution of 1413µS/cm and wait for the reading to stabilize.
2. After calibration the probe submerged into the sample solution and then press " mS/cm" key and wait for the reading to stabilize.
3. And note down the reading.

3.5 Turbidity

Turbidity was determined by turbidity meter Model no- TU 2016.

Procedure:

1. Switch on the power supply and check the battery of the turbidity meter.
2. Press the 1 NTU button and coincide the scale with zero using the focusing template.
3. Then calibrate the turbidity meter by using 1 NTU and 100 NTU standard solutions.
4. Water sample is taken into the test cell and measure the turbidity of water.

3.6 pH

pH was determined by Hanna portable combometer, Model no-HI 9813-6.

Procedure:

1. Connect the probe and switch the meter on, then press the pH key to display the pH measurement.
2. Remove the protective cap from the probe, rinse and immerse it in the pH-7 solution to calibrate it. Wait a couple of minutes for the reading to stabilize.
3. After calibration the probe submerged approximately 4cm into the sample solution and wait for the reading to stabilize.
4. Then note down the reading.

3.7 Salinity

Salinity was determined by Hand Refractometer Model no-REF201/211/201bp.

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Procedure:

1. Aim the front end of the refractometer to the direction of bright light, and adjust the adjusting ring until the reticle can be seen clearly.
2. Open the cover plate, drop distilled water one or two drops on the surface of the prism.
3. Close the cover plate, rotate and adjust the correcting screw to make the light/dark boundary coincide with null line.
4. Open the cover plate and clean the water on the prism surface by soft cotton flannel, then drop one or two drops liquid which is needed to be checked on the prism surface and cover the cover plate.
5. The corresponding dial reading of the light/dark boundary can get the percent of the salt content of the liquid.

3.8 Arsenic (As)

Principal:

The most common field-based method for the determination of arsenic is the Gutzeit method, which has been used for over one hundred years. The Gutzeit method is based on the creation of arsine gas from an aqueous sample solution. One variation of this method is currently used by the Hach Company.

Reagents: The reagents used for arsine gas generation provided with the EZ Arsenic Field Kit were

1. Sulfamic acid
2. Zinc Chapter

Procedures:

1. A water sample of 50 mL containing arsenic is placed in a reaction vessel.
2. Sulfamic acid is added to the container and gently shakes the container.
3. Then, zinc is added to the container and shakes the container again gently.

A mercuric bromide impregnated test strip is applied to the gas, changing the strip from white to a yellow brown color in proportion to arsenic content. Strips were removed 30 after the addition of the second reagent, zinc powder. The color is related to the concentration of arsenic in solution, which is reported by comparing the color of the strip with colors on a printed chart provided by the manufacturer

IV. RESULTS AND DISCUSSION

A comparative statistical evaluation of different physico-chemical parameters of drinking water in Sonagaziupazilla is shown in **Table 4.1** with BSTI and WHO standards.

Table 4.1: Descriptive statistics of groundwater quality at Sonagazi.

Parameters	Unit	Min	Max	Mean	Standard deviation	BSTI standard	WHO standard
Temp	°C	24.40	25.30	24.88	0.29	20.0-30.0	20.0-30.0
TDS	mg/L	480.00	2205.00	1170.15	489.75	1000.0	500.0
EC	μS/cm	680.00	6580.00	1906.92	1493.67	500.0	500.0
pH	-	7.10	7.60	7.28	0.15	6.5-8.5	6.5-8.5
Turbidity	NTU	0.41	41.38	13.44	11.33	10.0	5.0
Salinity	ppt	0.00	0.30	0.03	0.09	-	-
As	mg/L	0.00	0.05	0.02	0.02	0.05	0.01

4.1 Temperature

Temperature is the most important factor which influences chemical, physical and biological characteristics of water. Mean temperature of this study area was 24.88 °C with range of 24.40-25.30 °C**(Table 4.1).** All the sample stations were fall in the range of BSTI and WHO standard**(Figure 4.1)**.

4.2 Total Dissolved Substances (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc. (Rifat et al. 2021b). These minerals produced un-wanted taste and diluted color in appearance of water. This is the important parameter

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for the use of water. The water with high TDS value indicates that water is highly mineralized (Meride and Ayenew 2016). The concentration of TDS in present study was observed in the range of 480.0 and 2205.0 mg/L. The mean total dissolved solids concentration in the present study was found to be 1170.15 mg/L, and it is crossed the limit of WHO and BSTI standards **(Table 4.1)**. Except S-11 all other sample stations were crossed the WHO limit where 7 samples were crossed the BSTI standard limit **(Figure 4.2)**. According to WHO (2004), 7.69, 23.07, 30.77 and 38.46% of water were good, fair, poor and unacceptable respectively based on TDS value **(Table 4.2)**.

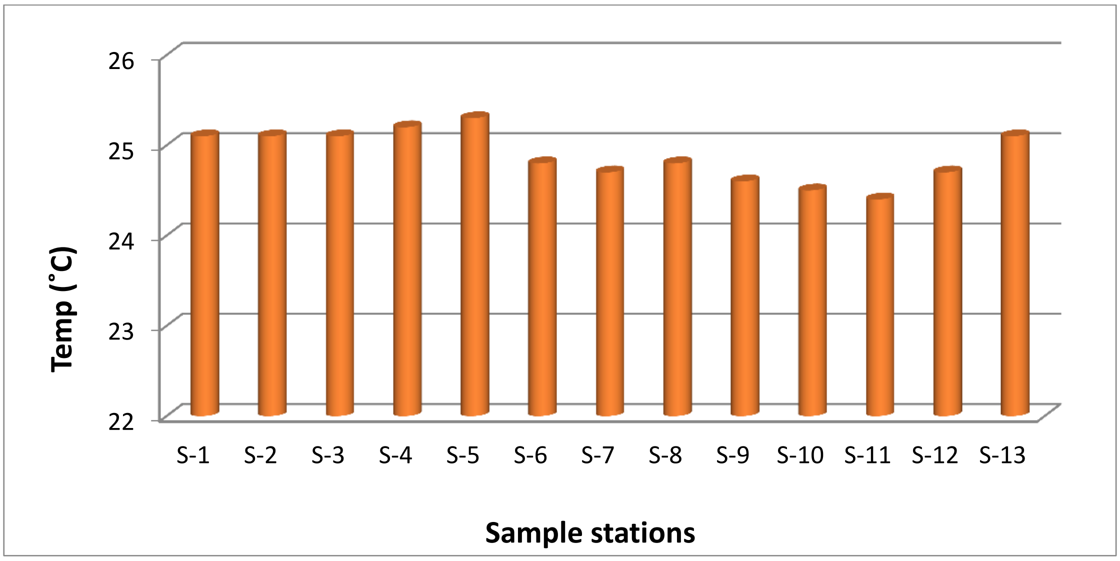

Figure 4.1: Graphical distribution of temperature value of Sonagazi.

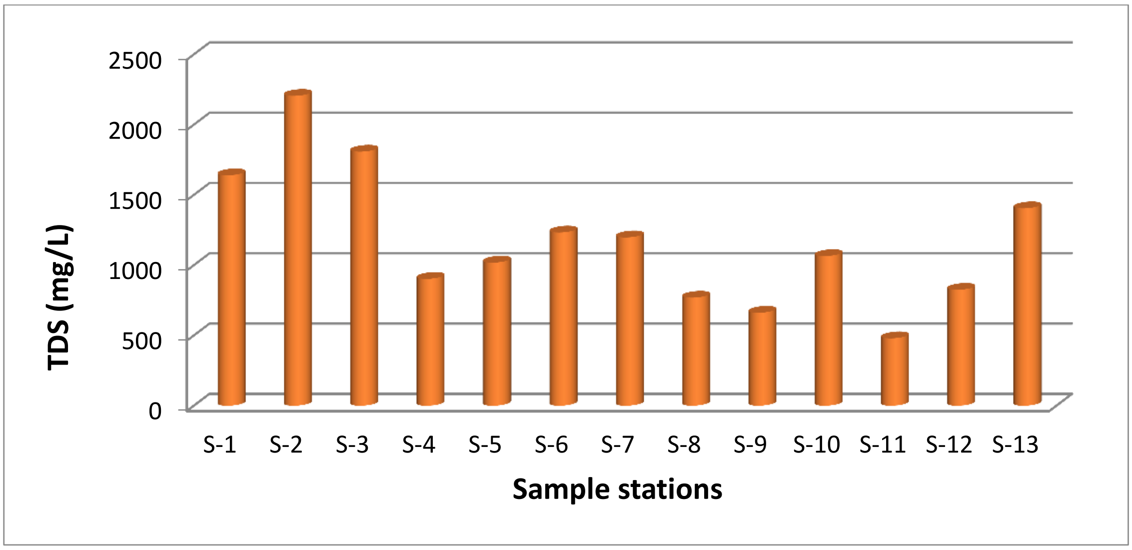

Figure 4.2: Graphical distribution of TDS value of Sonagazi.

Table 4.2: Groundwater classification based on TDS (WHO 2004).

Category	Grade	Number of samples	%
Excellent	<300	-	-
Good	300-600	1	7.69
Fair	600-900	3	23.07
Poor	900-1200	4	30.77
Unacceptable	>1200	5	38.46

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4.3 Electrical Conductivity (EC)

Pure water is not a good conductor of electric current rather's a good insulator(Meride and Ayenew 2016). Increase in ions concentration enhances the electrical conductivity of water. Generally, the amount of dissolved solids in water determines the electrical conductivity(Wu et al. 2017). Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current(T A Prosun, M S Rahaman, S Y Rikta, M A Rahman 2018). According to WHO standards, EC value should not exceeded 400 µS/cm. The current investigation indicated that EC value was 680.0-6580.0 µS/cm with an average value of 1906.92µS/cm which was above the permissible limit according to WHO and BSTI standard **(Table 4.1)**. All the sample stations were crossed the limit **(Figure 4.3)**. 15.38% of water was fall in unacceptable categories based on EC according to Wilcox (1955) andRichards (1954) classification **(Table 4.3)**. On the basis of WHO (2004) 7.69% of water were fall in very high saline and extensively high saline water categories respectively **(Table 4.3)**.

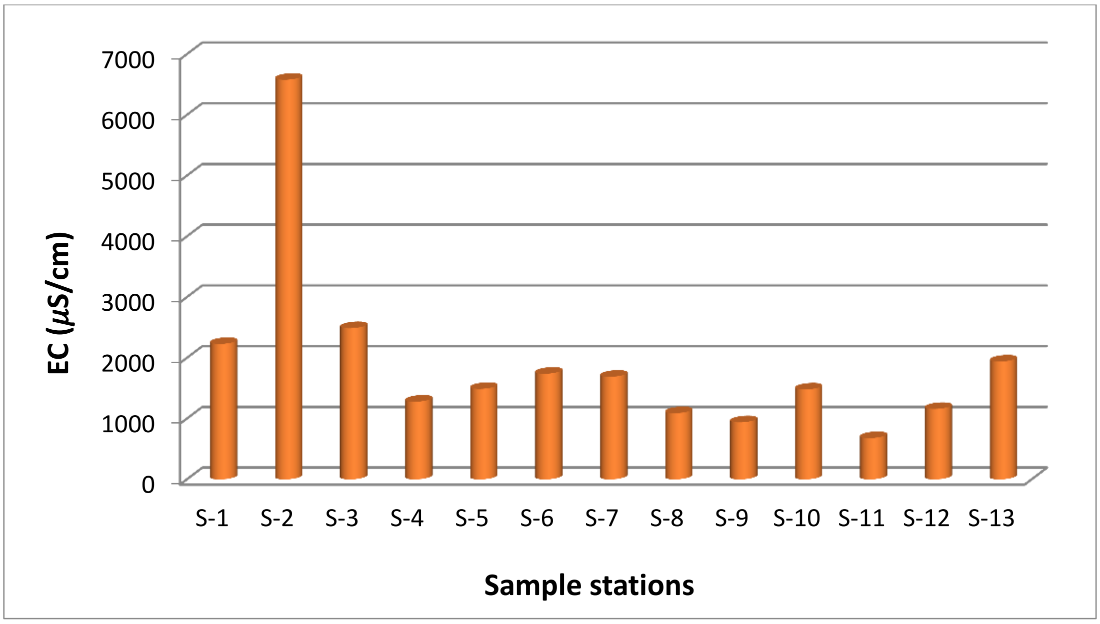

Figure 4.3: Graphical distribution of EC value of Sonagazi.

Table 4.3: Groundwater classification based on EC.

Category	Grade	Number of samples	%
EC (Wilcox 1955)			
Excellent	<250	-	-
Good	250-750	1	7.69
Permissible	750-2250	10	76.92
Unsuitable	> 2250	2	15.38
EC (Richards 1954)			
Excellent	<250	-	-
Good	250-750	1	7.69
Permissible	750-2250	10	76.92
Unsuitable	> 2250	2	15.38
EC (WHO 2004)			
Low salinity	0-250	-	-
Medium salinity	250-750	1	7.69
High salinity	751-2250	10	76.92
Very high salinity	2251-6000	1	7.69
Extensively high salinity	6001-10000	1	7.69
Brine	>10000	-	-

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4.4 pH

The pH is a measure of the acidic or alkaline condition of water and serves as an important indicator of water quality and determines the suitability of water for various purposes (Lkr et al. 2020). The lower the pH value higher is the corrosive nature of water (Rifat et al. 2021). Mean pH value of the study area was observed 7.28 with the range of 7.10-7.60 **(Table 4.1)**. On the basis of WHO and BSTI standard all the sample stations were fall within the limit **(Figure 4.4)**.

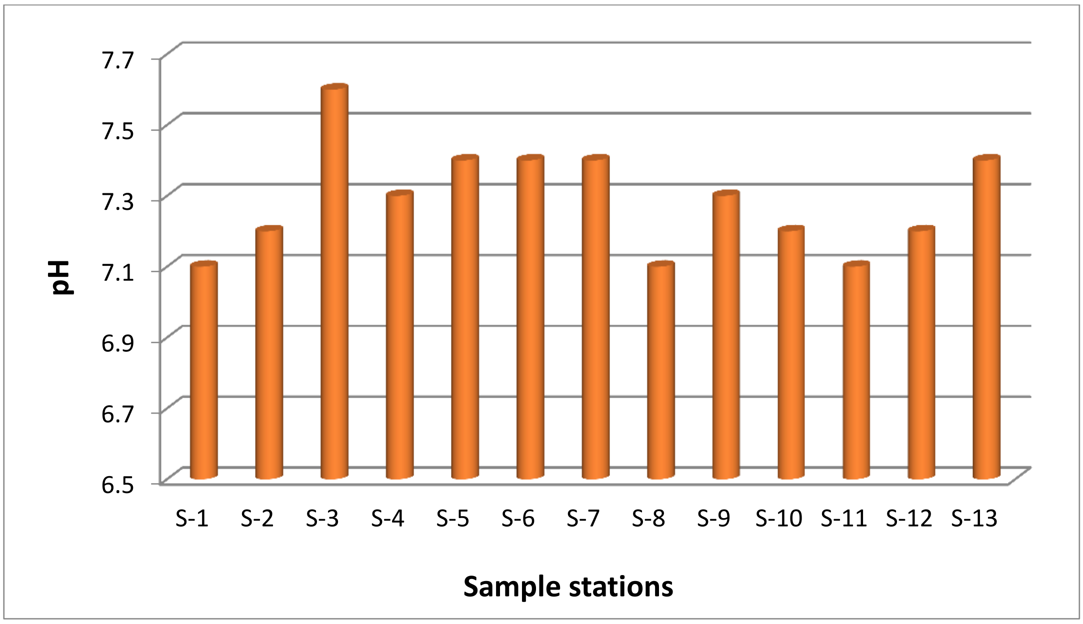

Figure 4.4: Graphical distribution of pH value of Sonagazi.

4.5 Turbidity

The presence of tiny suspended particles in water measures the turbidity. The opaque and cloudy characteristics indicates the presence of suspended particles in water (Solangi et al. 2019). The size, shape, and refractive index of the clay, colloidal particles and the micro-organisms are the factors that affect the turbidity (Asadullah et al. 2013). The range of turbidity in our study was 0.41-41.38 NTU where mean value was 13.44 NTU which is above the permissible limits **(Table 4.1)**. 6 samples were fall in acceptable limit of WHO where 7 samples were below the limit according to BSTI standard **(Figure 4.5)**.

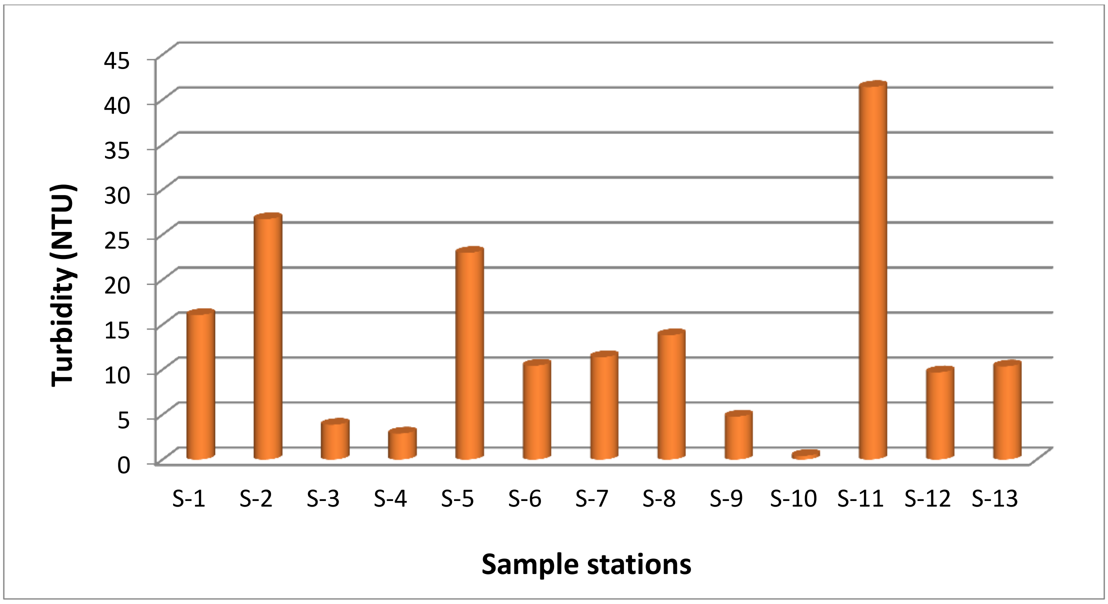

Figure 4.5: Graphical distribution of turbidity value of Sonagazi.

4.6 Salinity

Salinity refers to the concentration of dissolved salt (NaCl) in a given volume of water. Besides, BSTI and WHO do not specify a range of salinity for drinking water.In present study salinity was found in two study areas only. 0.3 and 0.1 ppt salinity were observed in S-2 and S-3 respectively (**Figure 4.6**).

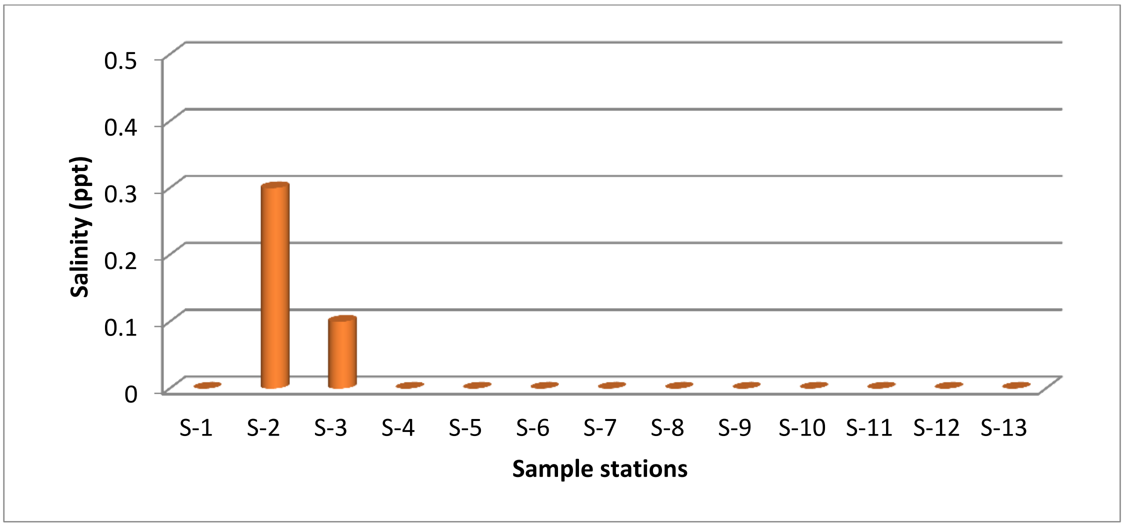

Figure 4.6: Graphical distribution of salinity value of Sonagazi.

4.7 Arsenic (As)

Arsenic (As) is a ubiquitous element and is ranked 20th in abundance within the earth's crust, ranked 14th in seawater, and ranked 12th in the human body (Huq et al. 2020). It is a toxic element and classified as a human carcinogen (Chakraborty et al. 2015). Groundwater of Bangladesh is contaminated with arsenic, which poses a threat to health of many areas (Rifat et al. 2021). However, As values of all the sample stations were fall below the permissible limit of BSTI standard **(Figure 4.7).** On the other hand, based on WHO standard 7 samples were crossed the acceptable limit **(Figure 4.7).** Mean value of As in the study was 0.02 mg/L with range of 0.0-0.05 mg/L **(Table 4.1)**.

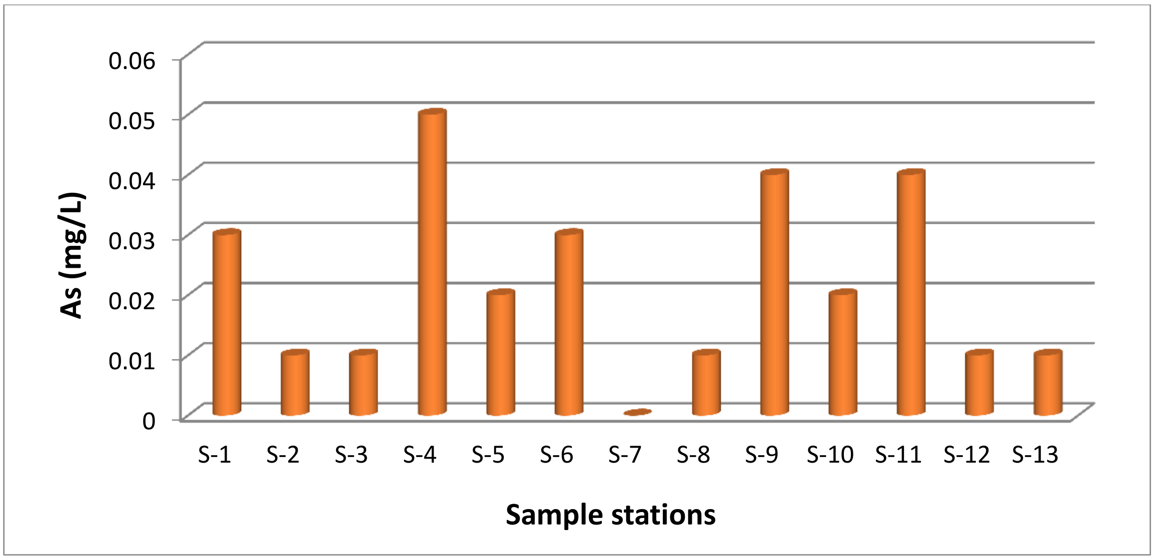

Figure 4.7: Graphical distribution of As value of Sonagazi.

4.8 Statistical Analysis

4.8.1 Correlation Matrix of Water Quality Parameters

The correlation matrix is used to identify the relation and variation among the ground water samples with the help of physico-chemical parameters (Arulbalaji and Gurugnanam 2017). Significant and non-significant trend observed in correlation matrix. Significant and positive trend indicates the relation between two variables in such way that they move in the same direction, and when two variables move in inverse direction is indicate the non-significant trend. A correlation of +1 indicates a perfect positive relationship between two variables. A correlation of -1 indicates that one variable has inverse relationship with the other. A correlation of zero indicates that there is no relationship between the two variables. The correlation matrices of all ground water variables are shown in **Table 4.4**. Significantly positive trend of correlation is observed between Temp and TDS (0.572, $p<0.05$), TDS and EC (0.860, $p<0.01$), TDS and salinity (0.745, $p<0.01$); and EC and salinity (0.953, $p<0.01$).

Table 4.4: Correlation matrix of physicochemical parameters of Sonagazi.

Parameters	Temp	TDS	EC	pH	Turbidity	Salinity	As
Temp	1						
TDS	**0.572***	1					
EC	0.412	**0.860****	1				
pH	0.390	0.308	0.034	1			
Turbidity	-0.088	-0.047	0.212	-0.415	1		
Salinity	0.301	**0.745****	**0.953****	0.039	0.260	1	
As	-0.086	-0.435	-0.345	-0.242	0.065	-0.296	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

V. CONCLUSION

To check the suitability of drinking water at Sonagaziupazilla we assessed the groundwater quality for the first time. Temperature and pH values were found within acceptable range according to WHO and BSTI standard. TDS was observed above the permissible limit in all the sample stations according to WHO standard and most of the sample stations were fall above the limit based on BSTI. In addition, EC was crossed the limit on the basis of both WHO and BSTI standard. Most of the sample stations were fall above the permissible limit according to WHO and BSTI standard. Salinity was found in only two samples. Moreover, As was detected below standard limit based on BSTI standard and few samples crossed the WHO standard. From correlation matrix significant correlation was observed in few parameters. Overall, it can be concluded that groundwater quality of Sonagaziupazilla is not so good for drinking where few data is alarming for the water quality.

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