Chemical and Microbial Analysis of Potable Water in Public Water Supply of Greater Noakhali, Bangladesh

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Abstract— A complete analysis of 32 drinking water samples was carried out to develop a database on the quality of water being consumed in different areas of Noakhali, Lakshmipur, and Feni district. The qualitative and quantitative analysis of water samples were conducted to determine the exact amount of pollutants present in water. Samples were taken from the main water sources where maximum peoples were using them for drinking purpose. The pH of potable water in circulation fell within recommended limits (6.4-7.4) but for Uchkhali shallow water that had pH of 5.88 which suggested a high degree of public health concern. Levels of TDS, salinity, iron, calcium, and magnesium detectable in the circulating drinking water were far above the WHO recommended limits. However, the more potentially dangerous discovery was the level of Coliform contamination in tested samples which far exceeds the WHO standards. This indicates certain sources of water-borne diseases. The results of the present research work showed that drinking water collected from different areas of greater Noakhali district was not found to be suitable for human health due to chemical and microbiological issues. To avoid the consumption of unwholesome biological agents, it is advised to boil water before drinking.

Key words: Groundwater, salinity, iron, coliform, Noakhali.

1 Introduction

Water is an excellent solvent which dissolves the minerals in the geological system. The quality of water resources is a subject of ongoing concern. The term groundwater means the subsurface water that occurs beneath the water table in soils and geologic formation [1]. It is believed to be comparatively much clean and free from pollution than surface water. Groundwater quality depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. But continuous discharge of domestic sewage, industrial effluents, and solid waste dump pollutes the groundwater and creates health problem [2]. Contamination of heavy elements, metal ions and harmful microorganisms with the water resources available for household and drinking purposes is one of the serious major health problems.

Groundwater is difficult to remediate. So the knowledge of the extent of pollution and the status of water become essential to preserve this valuable source of water for next generation. Moreover, the drinking water quality parameters should be checked at the regular time of interval. Because consumption of contaminated drinking water suffers human health from various water-borne diseases. Freedom from contamination with fecal matter is the most important parameter of water quality. It is generally considered to be a greater risk to human health as it is more likely to contain dangerous enteric pathogens [3].

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The present study is focused on analyzing the quality parameters of groundwater in and around the Noakhali region.

2 Materials and Methods

2.1 Materials

Chemicals involved in all chemical tests were of analytical grade and purchased from Merck, India.

2.2 Research Location

All of the experiments were carried out at laboratories of Applied Chemistry and Chemical Engineering (ACCE) and Microbiology Department of Noakhali Science and Technology University (NSTU) except arsenic analysis. The arsenic analysis was carried out at DPHE local laboratory, Noakhali.

2.3 Sample Collection

During water quality investigation, the selection of sampling points is more important than actual chemical analysis of water. However various natural and man-made factors are responsible for water pollution. For this purpose, all different locations/sampling sites were outlined and samples were collected. The samples were collected in polyethylene terephthalate (PET) bottle of 1 L capacity. Before sampling, the bottles were washed thoroughly with the detergent, acid (1: 1 HNO_3 and H_2O v/v), tap water, and then distilled water. Chemical parameters were determined by using standard methods immediately after taking them into the laboratory. Usual preservative methods were used to preserve the samples. The samples were analyzed as soon as it was possible. A total of 32 water samples were collected. The sources and locations of samples are given in Table 1.

Table 1: Location of water samples.

Sample no.	Location	Source
S1	NSTU supply water	Deep Tubewell
S2	NSTU park	Shallow Tubewell
S3	Sonapur terminal	Shallow
S4	Katpotti	Shallow
S5	Sonapur	Shallow
S6	Zero point	Shallow
S7	Municipal supply (Noakhali)	Deep
S8	Uzzalpur	Shallow
S9	Mohabbatpur	Shallow
S10	Dinomoni bazar	Shallow
S11	Bottoli bazar	Shallow
S12	Kalitara bazar	Shallow
S13	Shaheberhat	Shallow
S14	Dumbapatoari	Shallow
S15	Mannan nagar	Shallow
S16	Municipal supply (Begumganj)	Deep
S17	Miroarishpur	Shallow
S18	BSCIC	Shallow
S19	Globe pharmaceutical	Deep
S20	Kabirhat bazar	Shallow
S21	Kabirhat school	Shallow
S22	Companiganj	Shallow
S23	Boshurhat	Shallow
S24	Khasherhat	Shallow
S25	Uchkhali	Shallow
S26	Moju chowdhury ghat	Shallow
S27	Alexander	Shallow
S28	Ali bazar	Shallow
S29	Koromullah	Shallow
S30	Feni station	Shallow
S31	Municipal supply (Feni)	Deep
S32	Mohipal	Shallow

2.4 Methods

The appearance of water samples was confirmed by visual observation for color and inhaled for odor. The taste was also determined physically. Chemical analysis of groundwater samples taken from different bore wells in and around Noakhali region was analyzed by referring 'standards methods' [4].

2.4.1 Measurement of pH and temperature

The pH of all water samples was measured at the time of collection by using digital pH meter Model Lutron-222. The calibration was carried out with three standard buffer solution of pH 4.0, 7.0 and 10.0. The sample temperature was determined at the same time. The reading was taken after the indicated value remains constant for about 1 min.

2.4.2 Total dissolved solid

Solids refer to matter suspended or dissolved in water or wastewater. The total dissolved solid (TDS) of the samples was measured using pre-calibrated conductivity meter model Hanna-98302.

2.4.3 Total suspended solid

For total suspended solid (TSS), 100 ml of the water sample of each was filtered through a pre-weighed filtered paper. The filtered papers were dried at 103 – 105°C in oven and TSS was determined by the following formula.

$$\text{TSS (mg/L)} = \frac{\text{Filter post weight} - \text{Filter pre weight} \times 1000}{\text{V sample (ml)}}$$

2.4.4 Electrical conductivity

Electrical conductivity (EC) was measured using combined TDS/ conductivity meter model Hanna-98302 by shifting one of the four buttons of the instrument. The measurement was taken at room temperature. Before measuring the probes were rinsed with distilled water and purity of distilled water was checked. Then the probe was immersed in a beaker containing water sample and moved up and down taped on the beaker to be free the electrodes from any bubbles. Then data was recorded for each sample.

2.4.5 Alkalinity

Alkalinity is the measure of hydroxide and carbonate ion content of water sample. 3 drops of the phenolphthalein indicator were added to 50 mL of each water samples. The sample was titrated with 0.02N H_2SO_4 to pH 8.3 and alkalinity was estimated (phenolphthalein indicator was changed color from pink to colorless at pH 8.3). Finally, the alkalinity of water was calculated as follows,

$$\text{Alkalinity} = \frac{\text{Volume of } H_2SO_4 \times \text{Normality} \times 50 \times 1000}{\text{V sample (ml)}}$$

2.4.6 Total hardness

Total hardness of water samples was measured by EDTA titration. 20 mL of each of the water samples was pipette out in a washed conical flask. 5 mL ammonia buffer solution and 2-3 drops of Eriochrome Black-T indicator were added, the color of the solution turned wine red. This solution was titrated against previously standardized EDTA solution taken in the burette until the color changes from wine red to sky blue which indicated the endpoint. The final reading of the burette was noted and the titration was repeated to get concordant value. Finally, total hardness (TH) of water sample was calculated in terms of mg/L of $CaCO_3$, where 0.1ml EDTA Equivalent to 10.01 mg $CaCO_3$.

$$\text{TH} = \frac{\text{Burette reading} \times \text{Equivalent wt. of } CaCO_3 \times 1000}{\text{V sample (ml)}}$$

2.4.7 Determination of iron

50 mL of water sample was taken in a 125mL Erlenmeyer flask. 2 mL concentrated HCl and 1 mL $NH_2OH.HCl$ solutions were added and the solution was heated to boiling in presence of boiling chips to ensure dissolution of all the iron. Boiling

was continued until the volume was reduced to 15-20 mL. The solution was cooled and transferred quantitatively to a 50 mL volumetric flask. Then 10 mL ammonium acetate buffer and 4 mL phenanthroline solution was added and the solution was mixed and allowed to stand at least 10 –15 minutes for maximum color development. The absorbance of the solution was measured at 510 nm against a reagent blank, prepared by the same procedure with distilled water instead of water sample. A calibration curve was constructed by accurately pipetting calculated volumes of standard iron solutions (1-10 µg portions) into 125mL Erlenmeyer flasks, diluting to 50 mL by adding measured volumes of water and carrying out the steps followed for sample. Amount of iron in samples were calculated directly from the calibration curve.

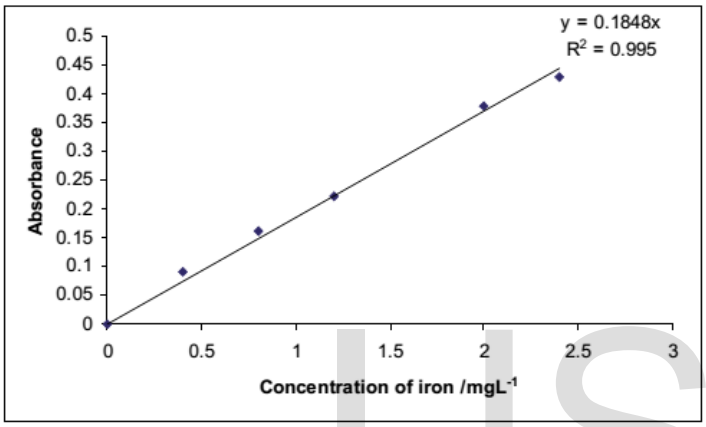

Fig. 1 Calibration curve for the determination of iron.

2.4.8 Determination of chloride ion

10 mL of each water sample was taken in conical flask. pH was measured and adjusted in between 7-9. After that 1 mL of 5% K_2CrO_4 indicator was added to and titrated with previously standardized silver nitrate solution to brick red color precipitate end point and noted down volume of titrant used as V_1. Similarly a blank titration was done by taking 10 mL of distilled water instead of sample and precedes the same procedure as the sample and recorded the final volume as V_2. Finally the concentration of chloride present in the sample was calculated using the following equation.

$$\text{Chloride ion concentration (mg/L)} = \frac{V_1\text{-}V_2 \text{ X } 35.5 \text{ X } 1000}{\text{V sample (ml)}}$$

2.4.9 Determination of arsenic

The arsenic was determined by Atomic Absorption Spectroscopy in Department of Public Health Engineering laboratory in Noakhali. To determine the concentration, a calibration curve was made with the standard solutions. Then the metal ion of the sample was found out from the calibration curve.

2.4.10 Total coliform count

The typical coliform colony has a pink to dark red color with a metallic surface sheen. The sheen area may vary in size from a small pinhead to complete coverage of the colony surface. Typical colonies can be dark red or nucleated without sheen. Calculation of the coliform density is as follows:
Total coliform colonies/100 ml = [Coliform colonies counted/ Sample used (ml)] × 100

3 Results and Discussion

The qualities of a water resource depend on the management of anthropogenic discharges as well as the natural physico-chemical characteristics of the catchment areas [5]. Various water quality parameters were studied and are given in table 2, table 3 and table 4.

The water quality of all collected sources from Noakhali, Lakshmipur and Feni area were compared with Bangladesh Drinking Water Standards (BDWS), World Health Organization Drinking Water Standards (WHODWS) and EPA (Environmental Protection Agency) [6] and presented in the table 5.

Chemical analysis of water supplies is necessary to guarantee the quality. The pH is a measure of the hydrogen ion concentration in water. Drinking water with a pH between 6.5 to 8.5 is generally considered satisfactory. The pH of the tested water fell within WHO limits (Table 1) but for the water of Uchkhali area (sample 25) which tends to be more acidic (5.88). Among the samples taken from the different places ranges from 26 to 32°C. But, the maximum permitted standard temperature of drinking water is 25°C. It won't be a surprise to experience burning sensation while such water is tasted.

Hardness is the property of water which prevents the lather formation with soap and increasing the boiling points of water [7]. The hardness of groundwater of all sites was ranged Ca^{2+} 12.83 to 202.87 mg/l, Mg^{2+} 3.40 to 86.58 mg/l.

The concentration of iron and total hardness in tube well water of the study area were very high. However, the permissible limits for iron and total hardness are 0.3-1 ppm and 200-500 ppm, respectively in the Bangladesh standard. Water having hardness above 300 ppm is considered very hard [8].

Chloride is a widely distributed element. Its affinity towards sodium is high. Chloride concentration in groundwater samples were found to be ranged between 444.50 to 3640 mg/l indicating that such water cannot be used directly for any purposes without treatment [9].

Electrical Conductivity is a measure of water capacity to convey electric current. EC in groundwater samples was recorded within the range of 452 to 5129 µS/cm.

Total dissolved solid is a measure of the combined content of all inorganic and organic substances [10]. TDS was found to be ranging between 311 to 2630 mg/l.

The result of arsenic in tested samples met the Bangladesh standard.

Presence of Coliform bacteria was found in tested samples. But, high microbial counts in water are undesirable because these organisms may find access to foods and drink thereby causing spoilage.

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Table 2: Results of physical and chemical parameters of different groundwater samples.

Sample no.	pH	Temp. (°C)	TDS	TSS	EC	Alkalinity	TH	Ca^{2+}	Mg^{2+}	Fe^{2+}	Cl^-
S1	7.12	31.4	1287	9.32	2578	No change in color	780.25	202.87	69.44	2.09	2086
S2	6.93	30.6	2564	10.10	5129	No change in color	764.76	132.01	68.89	2.87	3432.5
S3	7.43	31.8	1780	13.09	2960	No change in color	654.34	50.4	42.77	2.02	1645
S4	7.25	31.2	1129	63.73	2264	500	316.25	87.2	52.97	1.76	2422
S5	7.85	31.4	311	13.34	622	150	310.31	72.8	44.23	1.45	2457
S6	7.62	31.2	1183	3.25	2366	175	284.28	102.4	19.32	1.35	-
S7	7.55	30.9	651	17.51	1302		154.87	92.89	20.41	0.46	444.50
S8	7.55	31.5	1714	20.31	3428	350	316.32	15.25	25.28	1.74	-
S9	7.54	31.6	427	19.63	854	750	346.87	80.16	24.32	1.67	2513
S10	7.64	31.3	1557	19.92	3114	250	294.29	177.96	26.54	2.21	3528
S11	7.87	31.1	2630	2.96	5260	No change in color	832.83	94.59	74.89	2.55	3640
S12	7.69	31.5	1720	4.09	3440	375	222.22	101.80	18.89	3.22	1904
S13	7.15	31.7	971	50.32	1942	875	308.31	80.16	24.02	4.42	1225
S14	7.49	31.6	1720	0.36	3440	325	354.35	94.59	30.45	1.07	2086
S15	7.24	31.6	662	0.76	1324	1375	390.39	124.93	31.23	1.95	2405.4
S16	7.01	31.7	1543	2.34	3089	No change in color	659.98	132.01	53.65	2.89	3021.5
S17	7.47	31.0	1270	2.41	2545	1000	780.25	128.54	62.42	3.12	2652.3
S18	7.16	31.3	1780	1.36	2960		740.54	125.25	59.34	2.81	2141
S19	7.25	26.1	365	1.71	730	No change in color	302.15	78.35	24.16	2.25	2411
S20	7.43	26.6	1307	3.94	2616	No change in color	265.23	36.58	21.23	2.45	2135
S21	7.21	28.3	558	31.08	1119	No change in color	276.28	91.38	11.67	2.68	917
S22	7.54	27.2	1183	0.94	2373	No change in color	70.07	22.45	3.40	3.35	1638
S23	6.54	26.8	1075	1.53	2152	No change in color	149.39	80.96	19.46	3.41	1806
S24	7.21	26.7	751	9.32	1505	No change in color	216.22	20.04	40.37	2.35	2597
S25	5.88	26.5	226	10.10	452	No change in color	122.21	28.59	9.78	1.45	2513
S26	7.26	28.5	459	1.46	918	No change in color	272.27	25.65	50.58	2.08	2807
S27	7.01	28.7	446	1.13	893	No change in color	86.07	21.64	7.78	1.67	3584
S28	7.47	28.1	1209	1.31	2418	No change in color	452.25	112.22	36.18	2.87	511.50
S29	7.16	30.9	781	3.42	1562	No change in color	510.51	23.85	10.98	4.02	444.50
S30	7.24	31.2	431	34.08	854	250	160.16	59.32	2.92	2.14	1678
S31	7.45	30.8	1263	0.22	2523	No change in color	760.76	61.72	10.21	2.21	890
S32	8.07	31.1	338	0.50	679	1000	388.39	12.83	86.58	2.81	3584

Table 3: Results of arsenic in groundwater samples.

Sample No.	Arsenic (ppm)
Sample 1	<0.002
Sample 2	0.034
Sample 10	0.004

Table 4: Results of coliform bacteria.

Sample no.	Dilution			MPN/g
	0.10	0.01	0.001	
Sample 2	3	1	0	43
Sample 6	3	1	2	120

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Table 5: Water quality standards of different parameters.

Parameter	WHO standard	Bangladesh standard	EPA guidelines
pH	6.5 – 9.5	6.5 – 9.5	6.5 – 9.5
EC	-	-	2500 us/cm
TDS	250	1000	-
Hardness	200 ppm	300 ppm	< 200 ppm
Ca^{2+}	100 ppm	100 ppm	-
Mg^{2+}	150 ppm	30 ppm	16 ppm
Iron	0.3 ppm	0.3 -1 ppm	-
Cl^-	250 ppm	250-600 ppm	250 ppm
Arsenic	0.01 ppm	0.05 ppm	0.01 ppm
MPN	Nil	Nil	Nil

4 Conclusions

The study shows that contamination of coliform bacteria and high concentrations of iron, TDS, total hardness are the major constraints for drinking water supply in greater Noakhali area. Most of the physicochemical parameters of groundwater are at the alarming stage and the condition of the pathogenic bacteria is also threatening. These facts disclose that the drinking water situation of tested samples of Noakhali, Lakshmipur and Feni is not in a favorable condition for public health. So, water from any source, either groundwater or surface water must be treated before use.

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Acknowledgment

The authors wish to thank all persons who contributed a little to this work.

Competing Interests

The authors declare that they have no competing interests.

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