International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 7 Number 5 (2018): Pages 1676-1687
ISDS Article ID: IJDS18040902

Drinking water quality assessment from ground water sources in Noakhali, Bangladesh

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Abstract

The study was conducted for assessing drinking water quality of groundwater sources in Noakhali. Total twelve water samples were collected from three different locations (NSTU Campus, Sonapur and Maijdee). Each sampling location consists of four separate sampling points. The sampling points were Bibi Khadiza Hall, Tong, Maa General Store, Rahat Traders for the location of NSTU Campus; Sonapur Railway Station, Zero Point, Sonapur Bazar and Motipur for Sonapur location and for the Maijdee location the sampling points were Pouro Bazar, Zilla School, Town Hall and Sudharam Thana. Physicochemical parameters of the collected samples like Color, Taste, Odor, Temperature, pH, Electric Conductivity (EC), Total dissolved solid (TDS), Hardness and Salinity were measured and Microbial parameters like Total Viable Bacterial Count (TVBC), Total Coliform (TC), *E.coli* and *Salmonella spp.* were also examined. All the analyzed parameters compared with national and international drinking water quality standards to understand the overall ground water quality status of the study area. The study showed that the water samples almost all the locations were contaminated by microbial contamination and the range of the physicochemical parameters were not suitable for consumption. Preliminary treatment needed prior to use the ground water for drinking purposes and necessary steps should be taken for alternative safe source of drinking water.

Keywords: Physicochemical; Microbiological; Groundwater; Contamination

Cite this article as: Prosun, T.A., Rahaman, M.S., Rikta, S.Y. and Rahman, M.A. (2018), "Drinking water quality assessment from ground water sources in Noakhali, Bangladesh", *International Journal of Development and Sustainability*, Vol. 7 No. 5, pp. 1676-1687.

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1. Introduction

First life on the earth comes from water. Water is extremely essential for the survival of all living organisms and also essential for our health and our economy. Water is vital for human needs, for homes and gardens, for agriculture, industry, and the environment. Fresh water is the major need of human life. Drinking water quality is a vital concern for mankind since it is directly linked with public health. Drinking water quality has always been a major issue in many countries, especially in developing countries like Bangladesh (Moe and Rheingans, 2006). Although safe drinking water is a basic demand for the people of all over the world, a huge percentage of people of the world are deprived from the pure drinking water including Bangladesh (Chowdhury et al., 2014). Ground water is depleting day by day prominently in Asia, South America, North America and ecosystems are threatened (Gleeson et al., 2012).

Bangladesh is a low lying country and is a delta of great three big rivers- The Ganges, the Brahmaputra and the Meghna. In Bangladesh, there are various sources of drinking water such as surface water, ground water and rain water. Surface and ground water are considered as the main sources of drinking water. There is no safe drinking water supply system in rural areas, except some large cities (such as 'WASA' in Dhaka city). In Bangladesh most of the people think that ground water or water from tube wells is free from contamination. For this reason Hand pumped tube-well water is used as primarily source of safe drinking water in Bangladesh. Almost 90% of the households use this Hand pumped tube-well technology in Bangladesh (Emch et al., 2010). In rural area, most of the people are depended on untreated groundwater and tube wells. There is an estimation that about 11% of all deaths in rural area of Bangladesh are caused by diarrheal disease (Streatfield et al., 2001). It has been estimated that about 80% of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water (WHO, 2004).

Recent studies suggesting that persistent levels of diarrheal disease are caused in part by drinking untreated groundwater (Escamilla et al., 2011; Wu et al., 2011; Escamilla et al., 2013). Natural water resources such as groundwater in coastal areas of Bangladesh are contaminated by salinity and other metal ions because of salt water intrusion, storm surges and withdrawal of fresh water for using various purposes (Khan et al., 2011). In Noakhali region, contaminated groundwater is used by people for their drinking purposes and affected by hypertension, heart failure, kidney failure, skin diseases, carcinogenic diseases, diarrhea and other water borne diseases. For this reason, a detailed study of drinking water quality of Noakhali region is important (Miah et al., 2015). Although several reports on the assessment of drinking water quality based on physicochemical and Microbiological parameters in Noakhali region have been published by several researchers separately (Chowdhury et al., 2014; Miah et al., 2015; Mahmud et al., 2016) very little information is available about the overall status of water quality of this area. That's why an investigation was initiated, whose primary objective was to examine the present overall status of drinking water quality of groundwater sources in Noakhali region.

2. Materials and methods

2.1. Study area

Twelve drinking water samples were collected from three different locations. These locations were NSTU campus, Sonapur and Maijdee. From each location four drinking water samples were collected from four different sampling points. The sampling points were Bibi Khadiza Hall, Tong, Maa General Store, Rahat Traders for the location of NSTU Campus; Sonapur Railway Station, Zero Point, Sonapur Bazar and Motipur for Sonapur location and for the Maijdee location the sampling points were Pouro Bazar, Zilla School, Town Hall and Sudharam Thana. The study areas lie between the latitude 22°46'40"- 22°53'10" North and longitude 91°05'11.2"- 91°07'11.2" East. The map of the study area is presented in Fig 1.

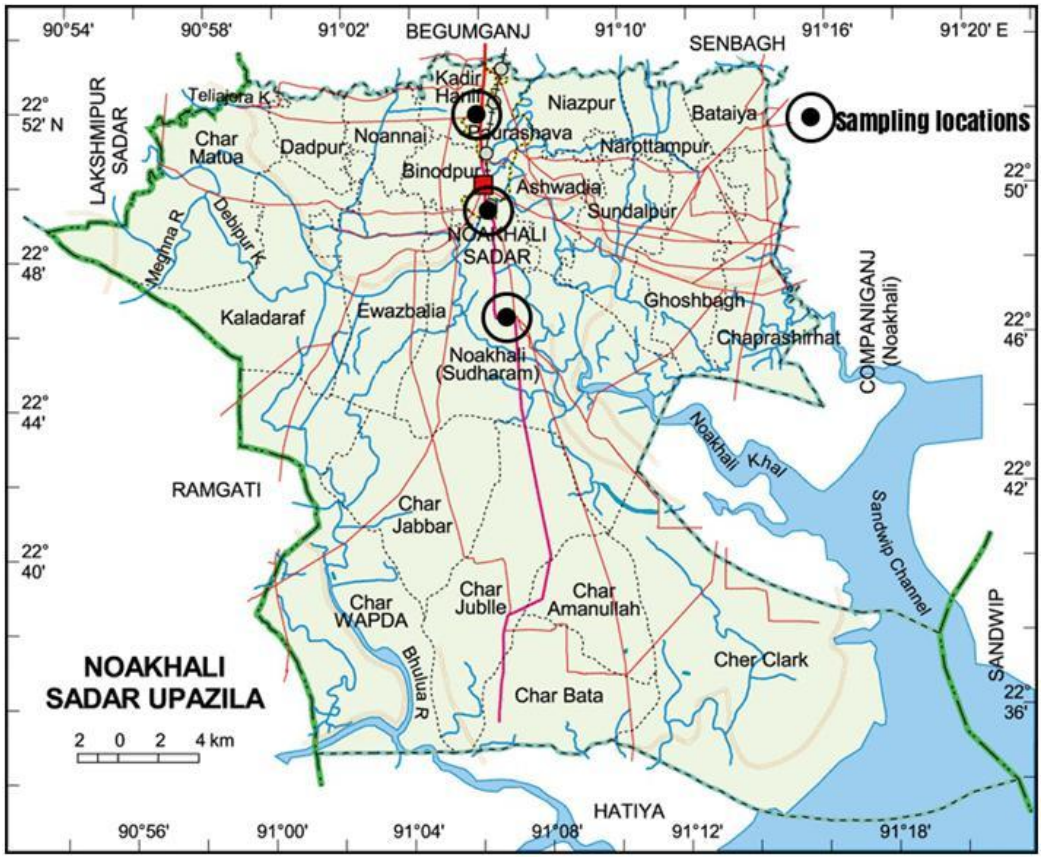

Figure 1. Map of the Study Area

2.2. Sampling

Total 12 water samples were collected from 12 tube-wells. Water samples were collected from continuously pumped tube-wells for one minute to clear the way of opening in labeled sterile container that rinsed repeatedly with distilled water. Before taking the water samples the sterile container were rinsed three

times with sample water for finding the accurate result. All the collected samples were stored in ice box with proper aseptic technique and transported to the laboratory immediately for the experimental analysis.

Table 1. Labeling and Sample ID

Location		Point of location	Sample ID
NSTU	Campus	Bibi Khadiza Hall	S-1
		Tong	S-2
		Maa General Store	S-3
		Rahat Traders	S-4
Sonapur		Railway Station	S-5
		Zero Point	S-6
		Sonapur Bazar	S-7
		Motipur	S-8
Maijdee		Pouro Bazar	S-9
		Zilla School	S-10
		Town Hall	S-11
		Sudharam Thana	S-12

2.3. Analysis

2.3.1. Physicochemical parameters analysis

Color of the sample was determined by visual inspection. Odor was analyzed through physical inspection by taking smell directly and taste was tasted by direct drinking the water sample. Other physicochemical parameters of drinking water were measured by different digital meters. Temperature, EC and TDS were measured by the TDS Meter (Hanna-HI8730N), pH was determined by using glass electrode pH meter (Hanna-H986107). Salinity for drinking water samples was determined by portable hand Refractrometer. Total hardness of water samples were measured by hardness test kit (HANNA-HI 3812). The measuring procedure of all the physicochemical parameters was repeated three times and the mean value of the three readings was recorded as final value.

2.3.2. Microbiological analysis

Spread plate technique was performed for direct counting of Total viable bacterial count (APHA, 2003). 0.1 ml of water sample is transferred by a micropipette and spread on agar plats with a sterile bent glass rod. All

the plates were inoculated at 37°c for 24 hours. Total count is expressed as colony forming unit per ml (cfu/ml). Nutrient agar media was used as culture media for enumeration of total viable bacteria in sample dishes. Total coliform (TC) was measured by MPN-Most Probable Number method and MacConkey agar plate was used for the enumeration of gram negative bacteria count at 37°C for 48 hours presumptive test and BGLB at 37°C for 48 hours for conformation. Fecal coliform were analyzed by the same procedure of total coliform bacterial count. Xylose-Lysine Deoxycholate agar (XLD) for *Salmonella spp.* was used as a selective media to isolate *salmonella spp.* from water samples.

3. Results and discussion

3.1. Physical properties of water

Summary of the Physical properties of waters collected from of the study areas are given in Table 2.

Table 2. Summary of measured physical properties of water

Sample ID	Color	Taste	Odor	Temperature
S-1	Transparent	Nil	Odorless	26.3±2
S-2	Yellowish	Saltish	Odorless	26.3±2
S-3	Yellowish	Saltish	Odorless	26.7±2
S-4	Transparent	Saltish	Odorless	27.1±2
S-5	Transparent	Nil	Odorless	27.3±2
S-6	Yellowish	Saltish	Odorless	27.3±2
S-7	Transparent	Saltish	Odorless	27.6±2
S-8	Yellowish	Nil	Odorless	27.6±2
S-9	Yellowish	Saltish	Odorless	28.5±2
S-10	Transparent	Nil	Odorless	28.6±2
S-11	Yellowish	Saltish	Odorless	28.6±2
S-12	Transparent	Nil	Odorless	28.6±2

3.1.1. Color

Some of the collected drinking waters were found colorless, clean and transparent and some were yellowish may be due to excessive amount of Iron content.

3.1.2. Taste and odor

Drinking water collected from various locations showed no bad odor and its taste was good in some samples, and rests were the saltish. All the samples were found odorless which is similar in temperament with WHO's guideline.

3.1.3. Temperature

Temperature is the most important factor which influences chemical, physical and biological characteristics of water. Table 2 Shows that the minimum temperature was 26.3±2ºC and maximum temperature was 28.6±2ºC. The temperature was valid under standard value for drinking water which is recommended by WHO (1996) and ECR (1997).

3.2. Physicochemical properties of water

Summary of the physicochemical properties of waters collected from of the study areas are given in Table 3.

Table 3. Physicochemical parameters of different sampling points

Sample ID	pH	Salinity (%)	EC (µs/cm)	TDS (mg/l)	Hardness (mg/l)
S-1	7.2	1	702	130	30
S-2	7.8	2	111	1450	570
S-3	8.3	4	9711	1660	348
S-4	8.1	3	161	1580	336
S-5	8.4	1	6201	260	204
S-6	8.4	3	115	128	420
S-7	8.0	3	1211	175	465
S-8	7.1	1	351	260	390
S-9	8.3	3	151	187	321
S-10	7.8	1	9243	390	243
S-11	7.5	3	1942	830	315
S-12	8.2	1	6318	270	195
Max.	8.4	4	9711	1660	570
Min.	7.1	1	111	128	30
BD STD.	6.5-8.5	0	600-1000	250	200-500
WHO STD.	6.5-8.5	0	1000	<1000	500

[Max.=Maximum] [Min.= Minimum] [BD STD.= Bangladesh Standard] [WHO STD.= WHO Standard]

3.2.1. pH

The pH is an important parameter which determines the suitability of water for various purposes. The pH value indicates the acidic or alkaline nature and the concentration of hydrogen ion in water. In this study, maximum value of pH from different location of drinking water was 8.4 and minimum value of pH was 7.1 which are within the recommended limit. The normal range for pH in groundwater is 6 to 8.5 (ECR, 1997).

3.2.2. Salinity

Salinity indicates all the salts dissolved in water. Usually standard limit of salinity for drinking water is zero (recommended by WHO, 1996). Present study revealed that maximum salinity value 4%, and minimum value was 1% which was not in line with recommended limit. Result was shown that all the locations had very slight to slight salinity which is not within the acceptable limits. The result indicated that NSTU campus water was more saline than Sonapur and Maijdee.

3.2.3. Electrical Conductivity (EC)

Electrical conductivity (EC) is usually used for indicating the total concentration of charged ionic species in water. Generally standard limit of EC for drinking water is 1000µs/cm (WHO, 1996). The maximum EC value was 9711 µs/cm at Maa General Store sampling points near NSTU campus and 111 at Tong. EC values of Maa General Store, Sonapur Railway Station, Sonapur Bazar, Zilla School, Town Hall and Sudharam Thana sampling points were greater than 1500 µs/ cm, which means water has medium concentration of salts; therefore, water can be categorized as slightly-saline and the result is similar with the previous findings of InamUllah *et al,* 2014.

3.2.4. Total Dissolve Solid (TDS)

The total dissolved solids (TDS) mainly indicate the presence of various kinds of minerals like ammonia, nitrite, nitrate, phosphate, alkalis, some acids, sulphates and metallic ions etc which are comprised both colloidal and dissolved solids in water. It is also an important chemical parameter of water (Kabir, 2002). TDS values indicate the general nature of water quality and are usually related to conductivity (Ahmed et al., 2010). Generally standard limit for TDS is <1000 mg/l which is recommended by WHO. The maximum TDS value was 1660 mg/l recorded at Maa General Store sampling point and the minimum TDS value was 128 mg/l at Zero point in Sonapur. TDS of samples from Tong, Maa General store, Rahat Traders, Sonapur Railway Station, Motipur, Zilla School, Town hall and Sudharam Thana were not in acceptable limit.

These values are determined the higher amount of TDS, Higher amount of TDS in Ground water may be due to the seawater intrusion in the coastal region (Miah et al., 2015).

3.2.5. Hardness

Hardness indicates the amount of dissolved calcium and magnesium in the water. Standard limits for hardness is 200-500 mg/l which is recommended by WHO and ECR. The maximum value from Tong was 570

mg/l and the minimum value was 30 mg/l at Bibi Khadiza Hall. In this study, all the values were found within acceptable limits according to ECR (1997) and WHO (2006) which is 200-500 mg/l and 500 mg/l respectively, except 570 mg/l from Tong. Total hardness was found positively correlated with TDS (Ahmed et al., 2010).

3.3. Bacterial density of drinking water

The microbial quality of drinking water in consumer level were examined. Total Viable Bacterial Count (TVBC), Total Coliform Count (TCC) and *E.coli* were examined quantitatively and *Salmonella spp.* was examined qualitatively. The following Table 4 shows the microbial analysis of drinking water from various locations in Noakhali. Incidence of water borne disease were occurred such as, diarrhea, dysentery, typhoid, hepatitis etc. for contamination of water. This can be transmitted by fecal oral route from animal or human excreta to environment. So personal hygiene is very much important to prevent contamination of drinking water.

3.3.1. Total Viable Bacterial Count (TVBC)

The highest value of TVBC was found in NSTU campus at Maa general store (6.73×10^3 cfu/ml). Present study showed that all samples are contaminated by microorganisms. Islam et al., also reported in 2001 that there is no contamination free tube-well water in Bangladesh. According to WHO guideline value, the values of TVBC should remain within 1.0×10^3 but the result showed the values were excessively above than the WHO guideline. There is a common believe in Bangladesh that groundwater is relatively free of microorganisms and, therefore, most of the people in rural area consume tube-well water without any treatment. However, the results of this study show clearly that all water samples in rural Bangladesh that were examined not only contained high counts of bacteria but also some pathogenic bacteria such as Escherichia coli as a indicator of coliform, *Vibrio cholerae*, *Vibrio parahemolyticus* (Mahmud et al., 2016).

3.3.1.1. Total Coliform

Total Coliform and Fecal Coliform are indicators for pathogenic organisms. According to EPA (U.S.EPA, 2009), every water sample that has coliform must be analyzed for either fecal coliforms or *E. coli*. Many authors have reported waterborne disease outbreaks in water meeting the coliform regulations (Gofti et al., 1999). The highest value of TC was found near NSTU campus at Maa general store (7.6×10^3cfu/ml) and lowest value were respectively in NSTU at BKH hall (0 cfu/ml), and in Maijdee at Sudharam Thana (0 cfu/ml) and Zilla school (0 cfu/ml) from the result shown in Table 4. According to WHO guideline value, the value of TC should remain within 0 but the result showed the values were excessively above than the WHO guideline. So total coliforms of water samples are beyond the permissible limit and were not suitable for drinking purpose without pretreatment. This contamination can be occurred from the poor sanitation and leakage around the tube-wells where the contaminants can enter through the leakage and can mix up with water lifting pathway.

Table 4. Microbiological parameters of different sampling points

Sample ID	TVBC. (CFU/ml)	TC (CFU/ml)	*E.coli* (CFU/ml)	*Salmonella spp.*
S-1	3.75×10^3	0	0	Absent
S-2	5.3×10^3	4×10^2	4×10^2	Absent
S-3	6.73×10^3	7.6×10^3	1.9×10^3	Absent
S-4	4.47×10^3	2×10^2	4×10^1	Absent
S-5	2×10^3	5.3×10^2	6×10^1	Absent
S-6	8.8×10^2	2.7×10^2	0	Absent
S-7	9.6×10^2	1.9×10^2	0	Absent
S-8	2.36×10^3	1×10^1	1.07×10^3	Absent
S-9	4.75×10^3	6×10^2	3×10^1	Absent
S-10	4×10^3	0	0	Absent
S-11	3.5×10^3	7×10^1	0	Absent
S-12	2×10^3	0	0	Absent
BD STD.	-	0	0	0
WHO STD.	-	0	0	0

Table 5. Water quality counts per 100 mL and the associated risk

Count per 100 ml	Risk Category
0	In conformity with WHO guidelines
1 –10	Low risk
11 –100	Intermediate risk
101 –1000	High risk
> 1000	Very high risk

3.3.1.2. E. coli

The presence of *E. coli* in water indicates that the water was contaminated by fecal material of humans or other warm-blooded animals. The highest *E.coli* found near NSTU campus at Maa general store (1.9×10^3 cfu/ml). From all the sampling points, water samples of Tong, Maa General Store, Rahat Traders, Sonapur Railway Station, Motiur and Pouro Bazar contain E*. coli*. According to the World Health Organization's guidelines, drinking water with a concentration of FC or *E. coli* larger than 0 cfu/ml is classified as 'unacceptable' (WHO, 1997). Table 5 shows the risk category associated with the presence of *E. coli.*

3.3.1.3. Salmonella spp.

All the samples were free from *salmonella spp.* and according to WHO (1996) and ECR (1997) it is acceptable for drinking purposes.

4. Conclusion

The present study aimed exposing drinking water samples for determining the physico-chemical parameters and bacteriological analysis of groundwater samples. Results were then compared with drinking water standards given by World Health Organization (WHO). From the result, it was assessed that almost all the physicochemical parameter of sample water were not within acceptable limit, and also the microbial parameter were not match with recommended level. The study result indicated that almost all the samples from different locations were not suitable for drinking purposes or consumption without any primary treatment like adding bleaching powder in water, boiling, filtering etc. Government as well as NGO's should come forward to supply safe and adequate drinking water in this coastal region. Still now the overall groundwater and surface water quality of the greater Noakhali region is poorly understood. Due to time constrain, our study does not cover surface water quality status of the study area. Further intensive research and continuous monitoring is required to know overall groundwater and surface water quality of the greater Noakhali region.

Acknowledgement

Authors are thankful to the Department of Microbiology and Department of Fisheries and Marine Science, Noakhali Science and Technology, Bangladesh for lifting the facilities for water quality analysis and experiments.

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