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Article

Status of drinking water quality and sanitation facilities in Subarnachar and Maijdee in Noakhali, Bangladesh

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Abstract: The study was executed in Noakhali sadar (urban) and Subarnachar upazil (rural) to determine the drinking water quality and sanitation facilities. The baseline data was collected based on questionnaire survey. And the physicochemical and ionic constituents of drinking water were determined by analyzing water samples. The result showed that in rural areas about 87.5% families utilized tube-well water and the rest used polluted pond water, while in the urban areas, 91% families utilized supplied water by paying monthly. The sanitation situation in the rural area was not at satisfactory level. The mean values of several critical parameters from the two areas (rural and urban) were found to be the following. pH values were 7.10 and 7.63, respectively. Electric conductivity was found to be 530.17 and 768.76 µS/cm, respectively. Salinity value was 0.23 and 0.35 ppt, respectively. Total dissolved solid (TDS) was found to be 264.91 and 372.82 ppm, respectively. Elemental composition of the sampled water from the two areas were also obtained. Mean values of the amount of dissolved oxygen (DO) from the two areas were found to be 7.24 and 7.52 mg/l, respectively. Among the other elements, amount of phosphorus was 0.55 and 0.46 ppm, potassium was 43.82 and 35.82 mg/l, sulfate was 10.03 and 1.00 mg/l, chloride was 42.15 and 149.95 mg/l, and iron was 5.57 and 1.30 mg/l, respectively. It is clear that the drinking water quality for both areas was not good for direct consumption. The situation in the rural areas is worse than that in the urban areas.

Keywords: ionic parameter; physiochemical parameter; sanitation facility; water quality; Bangladesh

1. Introduction

More than one billion people in the planet suffer from lack of available safe drinking water, mostly in the developing countries. Besides, there are other challenges involved in providing safe, adequate and reliable water supply in many parts of the world (Ahsan *et al*., 2017; Islam *et al*., 2015). People suffer from many water-borne diseases due to lack of clean drinking water supply. It is a standard practice to provide the public with safe and reliable drinking water, as safe drinking water is recognized as a basic human right and a cost effective measure of reducing disease in the most industrialized countries (Islam and Gnauck, 2010; Joarder *et al*., 2008). There are many desert areas where water supply is scarce, e.g. – sub-Saharan and Middle Eastern countries. Consequently, the population in those areas suffer from lack safe drinking water supply (Ahsan *et al*., 2017). Access to safe drinking water has improved over last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion to adequate sanitation (Gaayam *et al*., 2011; Pawari *et al*., 2013). Some observers have estimated that by 2025, more than half of the world population will face water-based vulnerability. By 2030, water demand will exceed supply by 50% in some developing regions of the world (Esrey *et al*., 1991; Prosun *et al*., 2018). Water quality guidelines and regulations are needed to ensure that all human beings have access to safe drinking water. It is estimated that over 80% of the diseases are caused by contaminated drinking water in developing countries (Alam *et al*., 2007; Mosley, 2005). Dkhar *et al*. (2014) stated that water quality varies from source to source, which are largely influenced by natural and artificial factors. Treatment techniques are applied before or at the point where water enters into the distribution system for elimination of microbial and chemical contaminants. Polluted water can be very dangerous for human health and cases of serious diseases are often caused by various bacteria and viruses (Akter *et al*., 2016; Dindar, 1996). Metallic pollution of fresh water may take place from large scale discharge of industrial effluents into the rivers, posing potential health hazards (Wahid *et al*., 2017). Supply of safe-drinking water in Bangladesh occasionally suffers from various technical and institutional constraints which need to be addressed in a systematic manner with a comprehensive strategic planning (Hoque *et al*., 1996). Therefore, improving water quality, hygiene practices and safe excreta disposal- all of these need to be taken into consideration with a holistic approach for reducing transmission of water-borne diseases (Hossain *et al*., 2017; WHO, 2011). Surface water and ground water are basically utilized as drinking water. Natural water resources such as rivers, underground and rain water in the coastal areas are contaminated by salinity and other metal ions because of salt water intrusion, storm surges, pollution and withdrawal of fresh water for using various purposes (Anon, 2014). About 80% of all diseases and over one third of deaths in the developing countries like Bangladesh are caused by the consumption of contaminated water (Bhattacharya *et al*., 1997). Contamination of drinking water, depletion of water resources and loss of aquatic biodiversity are prominent features in the coastal areas of Noakhali like other coastal zones. Contaminated water is used by people for domestic usage such as cooking, washing, taking bath and drinking, which may cause several ailments such as hypertension, heart failure, kidney failure, skin diseases, carcinogenic diseases and other water-borne diseases (Akter and Jakariya, 2004; Miah *et al*., 2015; Shittu *et al*., 2008). The living standard of the people is miserable due to lack of safe water supply in the coastal region of Noakhali (Islam *et al*., 2017; Sakai *et al*., 2016). So it is of utmost importance that the matter needs to be taken care of immediately. When the water quality parameters are above the standard limits then it is not suitable for drinking. This is the major causes of water related health effects (Hanchett *et al*., 2003; Raihan and Alam, 2008). However, the entire water related problems can be resolved by ensuring better quality of drinking water. For this reason, a detailed study on drinking water quality of Noakhali region is essential. This study is aimed at assessing the drinking water quality, status of waste management practices, sanitation facility and people's perception about hygiene in the rural and urban areas.

2. Material and Methods

2.1. Background of study area

Noakhali is a district in the south-eastern region of Bangladesh. It is located in Chittagong division. Its earlier name was Bhulua and established in 1821, which was renamed as Noakhali in 1868. It is bordered by Comilla district to the north, the Meghna estuary and the Bay of Bengal to the South, Feni and Chittagong districts to the east, and Lakshmipur and Bhola district to the west. The district has an area of 4202 km^2. The area represents an extensive flat, coastal and delta land, located on the tidal floodplain of the Meghna River delta, characterized by flat land and low relief. The study areas are located at the Noakhali zilla sadar and Subarnachar upazila (Figure 1). Noakhali Sadar upazila occupies an area of 336.06 km^2. It is located between 22º38´ and 22º59´ north latitudes and between 90º54´ and 91º15´ east longitudes. Subarnachar upazila occupies an area of 575.47 km^2. It is located between 22º23´ and 22º45´ north latitudes and between 90º54´ and 91º20´ east longitudes (Miah *et al*., 2015; Prosun *et al*., 2018). It has tropical climate and it has significant rainfall during most of the year, with a short dry season. The average annual temperature is 25.6 °C and the average annual rain fall is about 3,302 mm. With an average of 45.6 °C, May is the warmest month. At 19.5 °C on average, January is the coldest month of the year. The driest month is January with 8 mm of precipitation. In July, the rainfall reaches its peak, with an average of 671 mm (Hussain, 2008).

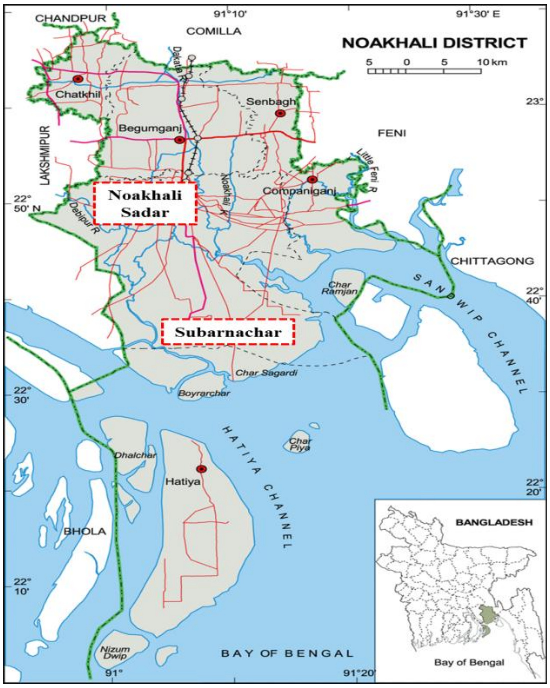

Figure 1. Map of Noakhali district (rectangular dotted red colored marks indicate study area).

2.2. Questionnaire survey

A semi-structured questionnaire was designed to collect the required data and information about different aspects of drinking water and sanitation issues from the study areas. Between the two selected upazilas of Noakhali, three areas of Noakhali sadar were selected for conducting this study. They are Guptanko, Lakshmi Narayanpur and government residential area; and in Subarnachar upazila, three villages were selected for carrying out this study. They are Charbata, Charmojid and Shibcharam. Among them, responses from 400 families were collected on current status of drinking water availability, alternative sources and sanitation facilities.

2.3. Sample collection

Total 22 water samples were collected from the six selected villages and areas. The water samples were collected in sterilized plastic bottles by taking precautions such as using hand gloves to avoid contamination. Before putting the sample into plastic bottle, it was rinsed with distilled water and sample water to remove impurities. Water samples were collected from different sources such as supply, pond, deep tube-well and shallow tube-well. The samples were collected by leaving ample air space in the bottle (at least 2.5 cm) to facilitate mixing by shaking and then preparing for test. Finally, the collected water samples were tested in Soil Resource and Development Institute (SRDI), Dhaka and Applied Chemistry and Chemical Engineering Department, Noakhali Science and Technology University (NSTU).

2.4. Required apparatus and reagents

The following materials and equipment were used for determining the physicochemical and ionic parameters of drinking water such as DO and pH electrode, sension156 Portable Multi-parameter Meter, 250 ml beaker, pipette, stirrer, flame photometer, thermometer, TDS meter, plastic bottle, conical flask and spectrophotometer. The required reagents were distilled water, seed (mixed micro-organisms solution solution), Na_2O_3, H_2SO_4, potassium, dichromate and standard buffer solution.

2.5. Analytical procedures

2.5.1. Physicochemical properties test

All the physicochemical parameters of water samples were measured by different digital meters. The pH value of water samples was measured by taking 50 ml of water in a 100 ml beaker and immersing the electrode of pH meter (Adwa-AD1000). A rapid determination of electric conductivity (EC) and Total Dissolved Solid (TDS) of water samples were performed by digital meter (MARTINI-Mi 170 Bench meter). Dissolved oxygen (DO) of the samples was measured by DO meter (HACH-HQ30d). Then salinity was calculated through the EC meter.

2.5.2. Ionic properties test

Total phosphorus content (P) in the samples was determined calorimetrically by using visible spectrophotometer (DR 3800-HACH) according to standard methods for examination of water (APHA, 1998). Chloride (Cl^-) content was measured volumetrically by silver nitrate titrimetric method and using potassium chromate as indicator (AOAC, 2002). Flame photometer (JENWAY PFP7) was used for measuring the potassium (K) contents. Spectrophotometric method with $BaCl_2$ is used to determine sulfate (SO_4^{2-}). Spectrophotometric method was also used to determine the concentration of iron (Fe) in a water sample.

2.6. Data analysis

Microsoft Office Excel 2010 was used for data analysis and presentation. Several descriptive statistical measures such as minimum, maximum and mean were analyzed for categorizing and describing the variables. The significant difference between the studies in case of each parameter was also analyzed.

3. Results and Discussion

3.1. Basic information of the study area

Among the studied 400 families, 85.25% respondents were male and 24.75% were female. 1.5% of the respondents were under the age of 20, 14.50% were within 21 to 30 years, 27.75% were within 31 to 40 years and the remaining 56.25% respondents were above 40 years of age. The education levels of the respondents were the following - 6% had no schooling, 32.5% had primary education, 10.25% completed Secondary School Certificate (S.S.C.) examination, 17.25% completed Higher Secondary Certificate (H.S.C.) examination, and the rest (34%) had university education. 16% of the respondents were farmer (mostly from village), 5% were wage laborers, 6.11% were housewife and 32.25% were businessman and the remaining 40.25% were service holders (mainly living in town). The income levels of 25.25% of the respondents were found to be below BDT. 7000.00, 25.25% had income level within BDT. 7000.00-15000.00, and 49.50% had income level above BDT. 15000.00. Here, most of the people from higher income group live in the town and details are shown in Table 1.

Table 1. Socio-demographic status of the study areas.

Factor	Noakhali Sadar (Urban)		Subarnachar Upazila (Rural)	
	Frequency (N=200)	Percent	Frequency (N=200)	Percent
Gender				
Male	170	85	171	85.5
Female	30	15	29	14.5
Age				
<20	0	0	6	3
21-30	17	8.5	41	20.5
31-40	38	19	73	36.5
>40	145	72.5	80	40
Education				
No schooling	0	0	24	12
Primary	10	5	120	60
S.S.C.	20	10	21	10.5
H.S.C.	50	25	19	9.5
University	120	60	16	8
Occupation				
Farmer	0	0	64	32
Wage labor	8	4	12	6
Housewife	15	7.5	11	5.5
Businessman	60	30	69	34.5
Job	117	58.5	44	22
Income				
<7000	10	5	91	45.5
7000-15000	45	22.5	56	28
>15000	145	72.5	53	26.5

3.2. People's perceptions about drinking water and sanitation facilities

3.2.1. Source of drinking water, associated problems and solutions

Basically four types of sources of drinking water were found in the study areas such as supply water, pond water, deep tube-well water and shallow tube-well water (Table 2). Most of the people use deep tube-well water for drinking purpose, which is setup by the Government in the rural areas. Some people do not have the access to deep tube-well water facility due to the community tube-wells being far away from locality. Deep tube-well users are mostly from low income families, who are not capable of setting up their own tube-well. In contrast, most of the families depend on supply water in the urban areas. About 12.5% respondents experienced salinity in drinking water in the rural area, while 12% respondents faced the same in the urban areas. The main difference between the rural and urban people is that urban people have to pay for using supply water, i.e., BDT. 150-500/month depending on consumption. The results showed that drinking water in the studied areas were responsible for various water-borne diseases. Some diseases attack through intake of supply water and pond water namely diarrhea, dysentery, skin disease, cholera and others (Table 2). 13.5% respondents opined that they suffered from diarrhea through drinking water and 86.5% respondents replied negative in the rural areas. On the other hand, from the urban areas, 26% respondents replied that they suffered from diarrhea, while 17.5% suffered from dysentery, 25% from cholera, 9% from skin diseases and 45% from others issues. It was observed that people suffer more from water-borne diseases in the urban areas. Most of the rural people use government or community deep tube-well water, so their drinking water is free from arsenic. Only 1.5% respondents acknowledged that they found arsenic in their shallow tube-well while 5.5% did not know that arsenic was present or not (Table 2). In contrast, 21% urban people opined that their drinking water is arsenic free because it is pretreated. However, most of the dwellers said that their drinking water contain arsenic in the urban area. They complained that the urban authority did not pay attention to the supply water and proper treatment, i.e., it may contain arsenic. Besides, 87.5% respondents faced water scarcity in the summer season, while 12.5% faced this problem during rainy season in the urban areas. In contrast, 84% respondents also faced water scarcity problem during summer season, while 16% faced this problem during rainy season in the rural areas. The respondents in the studied areas adopted several treatment methods to avoid drinking water related problems such as boiling, using medicine and direct consumption without any treatment (Table 2). Urban people are more concerned about drinking water treatment and prefer to adopt boiling method. About 70% respondents used boiling method to make water free from pathogens and harmful elements. 7.5% respondents utilized medicines to treat drinking water, while 22.5% drank the supplied water directly without any treatment. On the other hand, 87.5% respondents drank water without any treatment in the rural area because they thought that deep tube-well water is pure. 12.5% respondents utilized boiled water for drinking. However, most of the rural people did not like to purify their drinking water by using medicine. To deal with water scarcity, people utilize alternative sources of drinking water in the studied areas. 91.61% respondents used pond water as an alternative source in the rural area, while 8.39% used rain water. Rain water harvesting is not a popular method as an alternative source because of technical complexity and cost (Islam *et al*., 2010). However, urban people have tendency to preserve rain water as an alternative source. 52.05% respondents wanted to reserve rain water for future use, while 47.95% wished to use rain water as their alternative source (Table 2). The main difference between rural and urban areas is that rural people mostly utilize pond water, while urban people utilize rain water as alternative sources.

Table 2. Sources of drinking water and associated problems and their solutions.

Category	Types/name	Subarnachar (rural) (%)	Noakhali sadar (urban) (%)
Sources of water	Supply	-	91
	Pond	12.5	-
	Deep tube-well	80.5	5
	Shallow tube-well	7	4
Infectious diseases	Diarrhea	13.5	26
	Dysentery	-	17.5
	Skin disease	-	9
	Cholera	-	2.5
	Others	-	45
	None	86.5	-
Arsenic availability	Yes	1.5	59
	No	93	21
	Unknown	5.5	20
Water treatment methods	Boiling	12.5	70
	Medicine	-	7.5
	Direct	87.5	22.5
Alternative sources of water	Pond	91.61	47.95
	Rain water	8.39	52.05

3.2.2. Sanitation facility

Generally sanitation refers to washing, bathing, toilet, bathroom and kitchen washing etc. Among them, latrine facilities are quite unsatisfactory in most of the developing countries, though sanitary latrine usage is a precondition for safe environment and human health. It was found that five types of latrines were used in the study areas such as modern sanitary latrines (having septic tank), other sanitary latrine, paaka (only base and side wall made by brick), kacha (simple latrine made of bamboo, tin and polythene) and open latrines on fallow land or roadside. 84.5% respondents were found to be using healthy latrine in the rural area, while 100% respondents use covered healthy latrine in the urban area (Figure 2). In contrast, most of the respondents utilized kacha latrine in the rural area. Furthermore, rural people also have a tendency to utilize open spaces as latrine because low income families cannot setup their own sanitary latrine. Rural people mostly utilized pond and tube-well water for their sanitation purposes while urban people mostly used supply water for most of the purposes (Figure 2). It is clear that pond water is mostly used for sanitation purpose in the rural area and urban people mostly use supply water.

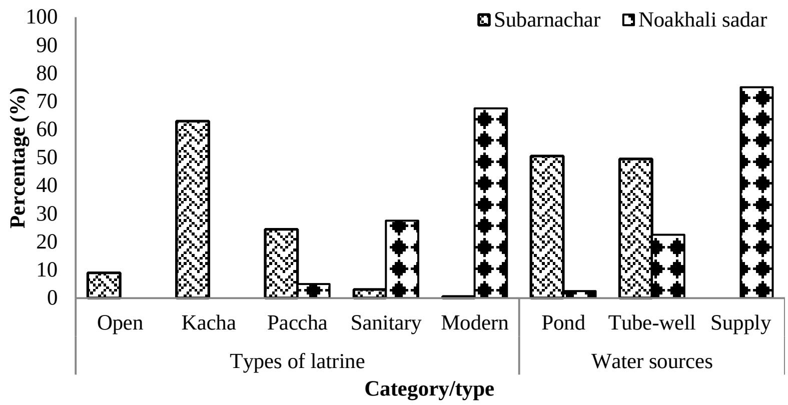

Figure 2. Latrine facilities and usage of water sources for sanitation purposes.

3.2.3. Waste generation and disposal

According to the respondents, the solid waste generation rate was categorized into four classes such as (a) <2 kg/day, (b) 2-4 kg/day, (c) 4-6 kg/day and (d) 6-8 kg/day (Figure 3). Most of the generated waste were organic, namely food waste, leaves, twigs and agricultural residues. However, generation of discarded plastic polybags and packaging materials is higher in the urban areas. All the respondents said that their waste generation was less than 2 kg/day in the rural area. Almost 100% people disposed of their generated waste within their own yard and a few families dumped their waste in open. Urban people have very little facility to dump their garbage daily in their own yard, and most of them (approximately 67.5%) store waste in a designated place and then municipal vans collect the waste and dump it in a particular dumping zone.

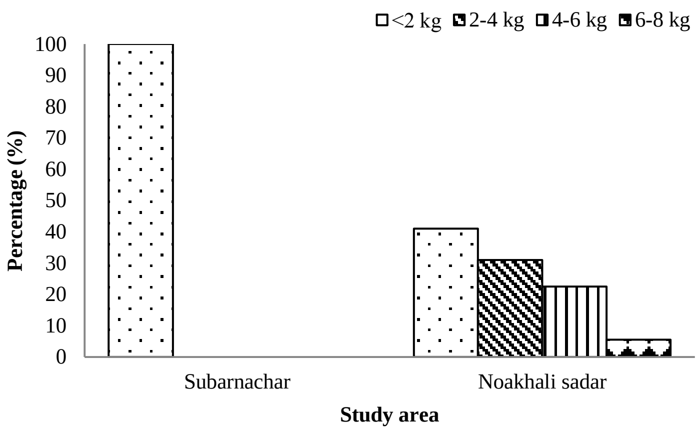

Figure 3. Approximate solid waste generation rate in the studied areas.

3.2.4. Health concern of the people

Urban people are more educated and aware of their health issues compared to rural people. 8% respondents had good knowledge about health, while 58% had medium level of knowledge and 34% a little knowledge (not well-educated) in the rural areas. On the other hand, most of the respondents were highly educated and concerned about health issue in the urban area. About 57.5% respondents had adequate knowledge about health issue while 30% had medium level of knowledge and 12.5% had low level of knowledge (Figure 4). Therefore, it is quite evident that urban people are highly concerned about health issues than rural people.

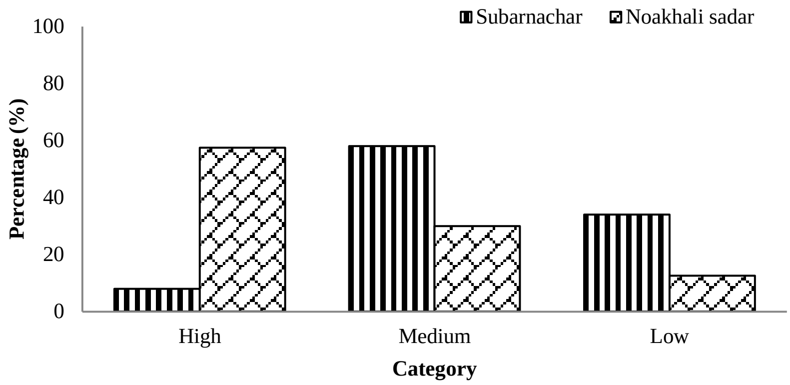

Figure 4. Level of public health concern in the studied areas.

3.3. Physicochemical properties of drinking water

Physic-chemical parameters such as total dissolved solid (TDS), pH, electrical conductivity (EC), Salinity and dissolved oxygen (DO) were studied for drinking water, which showed little variation based on collected points. Some parameters showed great variations from standard value, which suggests that these water sources are unsuitable for drinking purposes (Table 3). TDS is used to describe the inorganic salts and small amounts of organic material present in water. According to World Health Organization (WHO), TDS concentration <1000 mg/l is acceptable for consumable water but this factor may change due to TDS concentration which has a direct impact on the taste of water. The surface water is better than ground water with respect to TDS. TDS values indicate the general nature of water quality (Ahmed *et al*., 2010; Miah *et al*., 2015). The mean of TDS in drinking water in the rural and urban areas were 264.91 mg/l and 372.82 mg/l, respectively. These details are shown in Table 3. However, the TDS of drinking water in the study area is under acceptable limit prescribed by WHO. pH is one of the vital parameters of water, which should always be neutral or close to neutral. Generally, water having a pH range from 6.7 to 8.6 supports good fish culture when other parameters are favorable (Laluraj and Gopinath, 2006; Mohsin *et al*., 2013). In this study, the mean value of pH in the rural area was 7.10 while 7.63 in the urban area and details are presented in Table 3. The pH values of the ground water and surface water in Noakhali are within the standard limit (WHO) required for drinking, cultivation and survival of aquatic animals. There is no considerable difference in case of pH values of both the study areas. So the present values of pH indicate that water in this area is not objectionable for drinking and other purposes. EC of water is its ability to conduct an electric current. Generally, standard limit of EC for drinking water is 750 µs/cm recommended by WHO (Meride and Ayenew, 2016). EC found for rural area have a little variation of drinking water. The mean value of EC was 530.27 µS/cm for rural areas and 768.73 µS/cm for urban areas, whereas it was above the acceptable limit suggested by WHO in the urban areas and details are shown in Table 3. There is quite a bit of difference in terms of EC in both the study areas. These results clearly indicate that urban water is considerably ionized and has higher level of ionic concentration activity due to high amount of dissolved solids. Salinity is a measure of the concentration of salts dissolved in water. Generally, standard limit of salinity in drinking water is <0.5 ppt. In this study, the mean value of salinity is 0.23 ppt in the rural areas while 0.35 ppt in the urban areas, which is under acceptable limit suggested by WHO and details are stated in Table 3. There is also considerable difference in terms of salinity in both the study areas. However, there is no objection for salinity but in some cases salinity can vary in the coastal areas due to rainfall, flood and drought etc. (Akter *et al*., 2016). Between the two areas, the salinity range is high in the urban area than the rural area in drinking water. Dissolved Oxygen (DO) refers to the volume of oxygen that is present in water. According to WHO, the standard limit of DO for drinking water is > 6 mg/l. The mean value of DO was found 7.24 mg/l in rural area while 7.52 mg/l in the urban area, which are within or close to DO standard limit of WHO and details are mentioned in Table 3. The higher DO value indicates the better water quality of water. DO can vary due to various causes and temperature is one of them and this is the most common cause for the death of fish population, especially in the summer season (Alam *et al*., 2007). There is no substantial difference in case of pH values of both the study areas. So the DO content in drinking water of the study area indicates better quality of water.

Table 3. Physiochemical properties of drinking water in the studied areas.

Upazila	Sample area	Sample No.	Physiochemical parameters				
			pH	**EC (μS/cm)**	**Salinity (ppt)**	**TDS (ppm)**	**DO (mg/l)**
Noakhali Sadar	Guptanko	Sample-1	8.11	600	0.27	343	7.73
	Guptanko	Sample-2	7.57	567	0.25	288	7.69
	Guptanko	Sample-3	7.65	597	0.26	299	7.72
	Guptanko	Sample-4	7.75	563	0.25	297	7.73
	Lakshmi Narayanpur	Sample-5	7.62	598	0.26	303	7.6
	Lakshmi Narayanpur	Sample-6	7.68	608	0.27	308	7.63
	Lakshmi Narayanpur	Sample-7	7.8	598	0.26	301	7.62
	Lakshmi Narayanpur	Sample-8	7.02	1335	0.64	600	6.66
	Govt. residential area	Sample-8	7.71	582	0.26	296	7.79
	Govt. residential area	Sample-10	7.77	876	0.4	293	7.71
	Govt. residential area	Sample-11	7.2	1532	0.75	773	6.84
Minimum			7.02	563	0.25	288	6.66
Maximum			8.11	1532	0.75	773	7.79
Mean			7.63	768.73	0.35	372.82	7.52
Standard Deviation			0.29	342.74	0.18	160.48	0.39
WHO standard			6.5-8.5	750	<0.5	<1000	>6
Subarnachar	Charbata	Sample-1	6.72	668	0.3	332	7.61
	Charbata	Sample-2	7.15	429	0.18	215	7.57
	Charbata	Sample-3	7.2	446	0.19	225	7.31
	Charbata	Sample-4	7.14	442	0.19	221	7.35
	Shibcharam	Sample-5	7.12	397	0.17	199	7.98
	Shibcharam	Sample-6	7.06	387	0.16	195	7.3
	Shibcharam	Sample-7	7.1	392	0.16	198	7.48
	Shibcharam	Sample-8	7.08	1147	0.54	571	5.66
	Charmojid	Sample-9	7.15	395	0.17	199	7.34
	Charmojid	Sample-10	7.3	735	0.33	361	6.67
	Charmojid	Sample-11	7.05	395	0.17	198	7.4
Minimum			6.72	387	0.16	195	5.66
Maximum			7.3	1147	0.54	571	7.98
Mean			7.10	530.27	0.23	264.91	7.24
Standard deviation			0.14	236.73	0.12	116.60	0.61
WHO standard			6.5-8.5	750	<0.5	<1000	>6

Note: TDS=Total Dissolve Solid, ppm; EC = Electric Conductivity, mg/l; and DO = Dissolved Oxygen, mg/l.

3.4. Ionic properties of drinking water

Ionic parameter refers to the presence of positive and negative ions in water bodies. These parameters are relevant not only to drinking water but to industrial processes as well. Ionic parameters such as phosphorus (P), potassium (K), sulfates (SO_4^{2-}), chloride (Cl^-) and iron (Fe) contents were studied in the study area (Table 4). Phosphorus is an essential element for plant life, but when there is too much of it in water, then it can speed up eutrophication of the surface water. Phosphorus tends to attach to soil particles and thus moves into surface water bodies by runoff (Islam *et al*., 2017). The value of phosphorus level is quite high in the rural areas than the urban areas. The mean value of phosphorus was 0.55 mg/l in the rural area while 0.46 mg/l in the urban area and details are shown in Table 4. All the values for both rural and urban do not comply with the WHO standard value (0.02 mg/l), indicating that the water is not acceptable for drinking purpose. Generally, potassium content in water is very small. The concentration of K increases after treatment of the water. K maintains the electrolyte balance in blood and body fluids and also releases certain enzymes and hormones that prevent heart failure (Meride and Ayenew, 2016). The standard limit of K for drinking water is 100 mg/l. The mean value of K was found to be 43.82mg/l in the rural areas while 35.82 mg/l in the urban area and details are mentioned in Table 4. The maximum level of K does not comply with the WHO standard in the rural area, otherwise the results for both areas is acceptable. Water containing high levels of sulfates, particularly magnesium sulfate and sodium sulfates may have a laxative effect on people unaccustomed to this water. These effects vary among individuals and appear to last only until they become accustomed to using the water. High sulfate content also affects the taste of water and forms a hard scale in boilers and heat exchangers (Longe and Balogun, 2010). The upper limit recommended by WHO for sulfate is 250 mg/l. The mean value of SO_4^{2-} was found to be10.03 mg/l in the rural area, while 1.00 mg/l in the urban area and details are presented in Table 4. The SO_4^{2-} contents in both the study areas are significantly different. However, all the values are under WHO standard limit in both areas and so there is no objection for drinking purpose. High concentration of chloride ions can cause salty taste in water and corrode hot-water plumbing systems. High-chloride waters have a laxative effect on some people. An upper limit of 250 mg/l has been set for Cl^- by WHO. An increase in the normal Cl^- content of water may indicate possible pollution from human sewage and animal manure or industrial wastes (Shittu *et al*., 2008). The mean value of Cl^- was found 42.15 mg/l in the rural area while 149.95 mg/l in the urban area and details are stated in Table 4. The Cl^- contents in both the study areas are also highly significant different. The Cl^- level remains under WHO standard level in both the areas except the maximum level of Cl^- in the urban area. Iron is vital for living system and constituents of hemoglobin in blood. Deficiency of iron may cause anemia and other immunological deficiencies. Recently, it has been found that high dietary iron concentration enhances the formation of cholesterol oxidizing products in liver (Khalil *et al*., 2013; Laluraj and Gopinath, 2006). Generally, WHO recommended upper limit of iron for drinking as 0.3 mg/l. The mean value of Fe was found to be 4.57 mg/l in the rural area, while 1.30 mg/l in the urban area and details are shown in Table 4. Fe contents in both the study areas are also substantially different. It is found that Fe content in drinking water is non-compliant with regard to who standard in the rural area, otherwise acceptable for drinking purpose.

Table 4. Ionic properties of drinking water in the studied areas.

Upazila	Village	Sample No.	Ionic parameter				
			P (ppm)	K (mg/l)	SO_4^{2} (mg/l)	Cl^- (mg/l)	Fe (mg/l)
Noakhali Sadar	Guptanko	Sample-1	0.77	34	6.72	131.88	1
	Guptanko	Sample-2	0.46	26	0.21	119.12	0.8
	Guptanko	Sample-3	0.72	26	0.02	126.2	0.01
	Guptanko	Sample-4	0.43	26	0.04	129.3	1.4
	Lakshmi Narayanpur	Sample-5	0.28	24	0.12	137.55	2.6
	Lakshmi Narayanpur	Sample-6	0.24	24	0.21	143.28	1.2
	Lakshmi Narayanpur	Sample-7	0.14	26	0.02	133.3	0.8
	Lakshmi Narayanpur	Sample-8	0.41	84	0.28	212.7	0.8
	Govt. residential area	Sample-9	0.47	26	0.33	136.13	1.8
	Govt. residential area	Sample-10	0.35	26	0.32	126.2	2.4
	Govt. residential area	Sample-11	0.74	72	2.78	253.82	1.5
Minimum			0.14	24	0.02	119.12	0.01
Maximum			0.77	84	6.72	253.82	2.6
Mean			0.46	35.82	1.00	149.95	1.30
Standard deviation			0.21	21.19	2.05	42.69	0.76
WHO standard			0.02	100	<250	250	0.3
Subarnachar	Charbata	Sample-1	0.55	20	0.84	144.64	4.5
	Charbata	Sample-2	0.76	30	1.22	25.52	5.5
	Charbata	Sample-3	0.6	30	71.24	19.85	3.4
	Charbata	Sample-4	0.82	34	31.86	53.88	4.4
	Shibcharam	Sample-5	0.42	32	1.91	22.69	5.8
	Shibcharam	Sample-6	0.32	36	0.07	29.77	8
	Shibcharam	Sample-7	0.37	38	0.56	15.6	3
	Shibcharam	Sample-8	0.61	104	1.07	93.59	2.5
	Charmojid	Sample-9	0.42	38	0.67	17.01	5
	Charmojid	Sample-10	0.64	82	0.09	22.69	4.4
	Charmojid	Sample-11	0.55	38	0.78	18.43	3.8
Minimum			0.32	20	0.07	15.6	2.5
Maximum			0.82	104	71.24	144.64	8
Mean			0.55	43.82	10.03	42.15	4.57
Standard deviation			0.16	25.35	22.34	41.08	1.52
WHO standard			0.02	100	<250	250	0.3

Note: P= Phosphorus, mg/l; K= Potassium, mg/l; SO_4^{-2}= Sulfate, mg/l; Cl^-= Chloride, mg/l; and Fe= Iron, mg/l.

4. Conclusions

Supply of safe drinking water and adequate sanitation facilities is a great problem in Bangladesh, especially in the rural areas. Almost all the physicochemical and ionic parameters of the water samples were not under WHO recommended standards. It indicates that the water samples collected from different locations are not suitable for drinking purposes without any primary treatment. Due to lack of proper education and poverty most of the rural people suffer from scarcity of pure drinking water. Furthermore, they utilize open latrines (fallow land/roadside) instead of sanitary latrines. As a result, they are suffering from various health problems. However, the combined efforts of government, NGOs and local people can facilitate to overcome the severe water problems in the study areas. Appropriate measures should be taken for harvesting alternative drinking water such as rain water as well as ensuring proper utilization. This study recommends that inhabitants of the study areas should treat their water primarily before any kind of consumption. Primary treatments like boiling, filtering and bleaching powder etc. can be applied before drinking water.

Conflict of interest

None to declare.

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