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Assessment of Physico-Chemical and Microbiological Quality of Drinking Water in Three Upazilas of Noakhali District in Bangladesh

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Abstract

This study was driven for analyzing the drinking water quality of three upazillas at Noakhali district in Bangladesh. Nine different areas drinking water samples were collected from three upazilas (sadar-upazila, kabirhat upazila, Chatkhil upazila). Physical & chemical parameters of the collected samples like pH, electrical conductivity, salt, TDS, chloride-ion, iron content were measured and microbial parameters like Total Viable Bacterial Count (TVBC), Most Probable Number (MPN) of *coliforms*, *E. coli*, *Pseudomonas*, *Klebsiella*, *Enterobacter aerogenes* were also detected. All the parameters were compared with WHO drinking water quality standard ranges to understand the condition of drinking water in these areas. This study showed the pH of Chatkhil upazila was comparatively lower (6.18) than other upazilas. Electrical conductivity was also lower (252.1 μS/cm) in Chatkhil than other upazilas. Salt volume was comparatively higher (554.33 ppm) in sadar upazila sample than in others. TDS of all upazila samples were in an acceptable range. Chloride-ion was very much higher (7326.33 mg/L) in upazila-sadar. Iron content was mostly (3 mg/L) in Chatkhil upazila. Total bacterial load was comparatively higher (7.13×10^6 CFU/mL) in Kabirhat upazila. Most Probable Number (MPN) of Coliforms were comparatively higher (24.67 number of coliforms/100mL) in upazila-sadar than others. This study also showed the water samples that were collected almost all were contaminated by *E. coli* bacteria without supply water in upazila-sadar. As a result, water was not suitable for drinking. Water purification is very urgently needed for saving people from water-borne diseases. So necessary steps should immediately be taken for purifying the sources of drinking water.

Subject Areas

Food Science & Technology

Keywords

Physical & Chemical Parameters, Chloride-Ion, Most Probable Number, Serial Dilution, Coliforms, *E. coli*

1. Introduction

Water plays a vital role in maintaining human life and welfare. Pure drinking water is now recognized as a fundamental right of human beings. Around 780 million people do not have access to clean and safe water and around 2.5 billion people do not have proper sanitation. As a result, around 6 - 8 million people die each year due to water-related diseases and disasters [1]. Therefore, water treatment is a top-priority policy agenda in many parts of the world [2]. In today's world, water use in household supplies is commonly defined as domestic water. This water is processed to be safely consumed as drinking water and for other purposes. Water quality and suitability for using are indicated by its taste, odor, color, and concentration of organic and inorganic materials [3]. Contaminants in the water can affect the water quality and consequently human health.

Drinking water is the major need of human life. Freshwater 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 [4]. Although safe drinking water is a basic demand for people all over the world, a huge proportion of people in the world are deprived of pure drinking water including Bangladesh [5]. Groundwater is decreasing day by day prominently in Asia, South America, North America and ecosystems are threatened [6].

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 many sources of drinking water such as surface water, groundwater and rainwater. Surface and groundwater are considered the main sources of drinking water. There is no safe drinking water supply system in rural areas, except in some large cities (such as "WASA" in Dhaka city). In Bangladesh, most people consider that groundwater or water from tube wells is free from contamination. For this reason, Hand pumped tube-well water is used as the primary source of safe drinking water in Bangladesh. About 90% of the households use this Hand pumped tube-well technology in Bangladesh [7]. In rural area, most people are depended on untreated groundwater and tube wells. It is an estimation that about 11% of all deaths in the rural area of Bangladesh are caused by diarrheal disease [8]. Recent studies suggest that significant levels of diarrheal disease are caused in part by drinking untreated groundwater [9] [10]. Natural water re-

sources such as groundwater in coastal areas of Bangladesh are contaminated by salinity and other heavy metal ions because of saltwater intrusion, storm surges and withdrawal of freshwater for using various purposes [11]. In the Noakhali region, contaminated groundwater is used by people for their drinking purposes and is affected by hypertension, heart failure, kidney failure, skin diseases, carcinogenic diseases, diarrhea and other water-borne diseases. For this reason, a detailed study of the drinking water quality of the Noakhali region is very much important [12]. Although several reports on the assessment of drinking water quality based on physiochemical and Microbiological parameters in the Noakhali region have been published by several researchers separately [5] [12] [13]. Very little information is available about the overall status of water quality in 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 Methodology

2.1. Study Areas

In this study, three upazillas of Noakhali district in Bangladesh drinking water were analyzed. Three upazilas were upazila-sadar, Kabirhat upazila, Chatkhil upazila (**Figure 1**). Coordinates of Noakhali upazila-sadar is from 22˚50'N to 22˚833'N and from 91˚6'E to 91˚100'E. Coordinates of Kabirhat upazila is from 22˚50'N to 22˚833'N and from 91˚12'E to 91˚200'E. And Chatkhil upazila's coordinate is from 23˚3'N to 23˚5'N and from 90˚57.5'E to 90˚95'E.

2.2. Sampling

Total samples were nine in numbers. In upazila-sadar maximum people take supply water as drinking water. Some take motor water and some others take tube-well water for drinking. Drinking water samples were collected from three different areas of Noakhali upazila-sadar. The first sample was collected from maijdee and it was supply water (1000 feet deep and treated). The second sample was collected from Dattabari and it was motor water (500 feet deep). The third sample was collected from Sonapur and it was tube-well water (450 feet deep).

Most of the people at Kabirhat upazila take tube-well water for drinking. From kabirhat upazila three different areas drinking water samples were collected. The first sample was collected from Kabirhat-hospital road and it was tube-well water (60 feet deep). The second sample was collected from Kabirhat-kalamunshi road and it was tube-well water (70 feet deep). The third sample was collected from Kabirhat-college road and it was tube-well water (150 feet deep).

All most the people at Chatkhil upazila take tube-well water for drinking. From Chatkhil upazila three different areas drinking water samples were collected. The first sample was collected from Chatkhil thana road and it was tube-well water (35 feet deep). The second sample was collected from Abu tara nagar road and it was tube-well water (256 feet deep). The third sample was

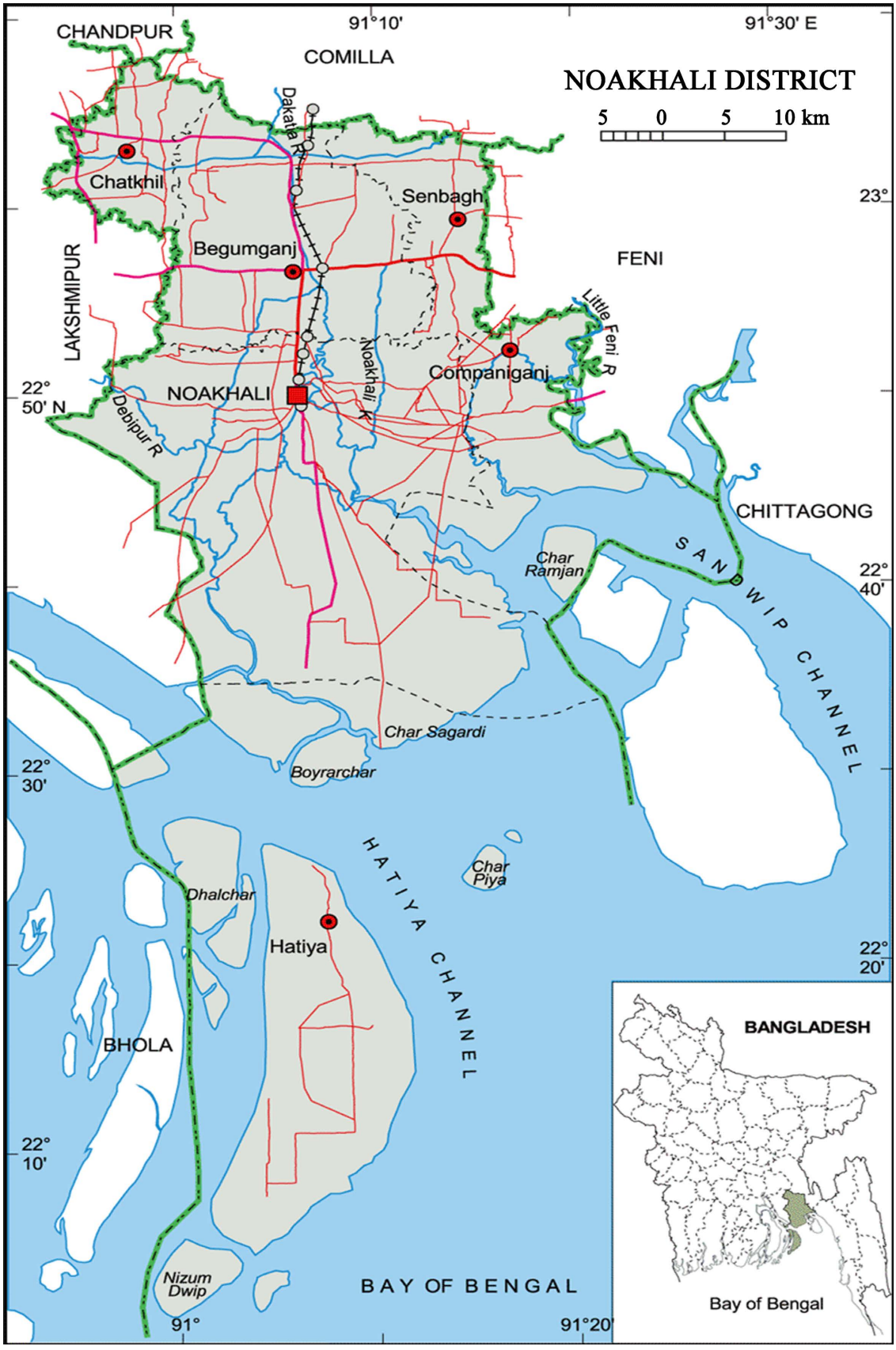

Figure 1. Noakhali district map.

collected from Bodolkot road and it was tube-well water (800 feet deep).

2.3. Study Duration

This study duration was from July to September 2018.

2.4. Analysis of Physical Parameters

The pH values, temperature, total dissolved solid, electrical conductivity (EC), salinity of the samples was measured by using pre-calibrated Multipara-meter, Model PL-700ALS.

2.5. Determination of Chemical Parameters

Chloride ion determined in a drinking water sample by "Muhr's Method". Iron content estimated by the packet of reagent in drinking water Sample.

2.6. Microbiological Test

Total viable bacterial count by serial dilution process. Total *coliform* count and *E. coli* detection by MPN (Most Probable Number) method.

3. Results

Physical Test Results: Tables 1-4;
Chemical Test Results: Table 5 and Table 6;
Microbiological Test Results: Tables 7-9.

4. Discussion

Drinking water quality at Noakhali district in Bangladesh is not satisfactory. Contamination, high amount of dissolved solids, higher amount of iron content were the regular scenarios. Though supply water was quite satisfactory in upazillas-sadar,

Table 1. Findings of pH from different drinking water samples of three upazilas.

Region	Sample-1	Samlpe-2	Sample-3	Average
Sadar	7.77 (1000 feet deep supply water sample)	7.44 (500 feet deep motor water sample)	8.22 (450 feet deep tube well water sample)	7.81
Kabirhat	6.72 (60 feet deep tube well water sample)	6.87 (70 feet deep tube well water)	6.34 (150 feet deep tube well water)	6.64
Chatkhil	6.57 (35 feet deep tube well water sample)	5.81 (256 feet deep tube well water sample)	6.16 (800 feet deep tube well water sample)	6.18

Table 2. Findings of electrical conductivity from different drinking water samples of three upazilas.

Region	Sample-1	Sample-2	Sample-3	Average
Sadar	674 µS/cm (1000 feet deep supply water sample)	1795 µS/cm (500 feet deep motor water sample)	849 µS/cm (450 feet deep tube well water sample)	1106 µS/cm
Kabirhat	1496 µS/cm (60 feet deep tube well water sample)	761 µS/cm (70 feet deep tube well water)	1056 µS/cm (150 feet deep tube well water)	1104.33 µS/cm
Chatkhil	128 µS/cm (35 feet deep tube well water sample)	523 µS/cm (256 feet deep tube well water sample)	105.3 µS/cm (800 feet deep tube well water sample)	252.1 µS/cm

Table 3. Findings of salts from different drinking water samples of three upazilas.

Region	Sample-1	Sample-2	Sample-3	Average
Sadar	350 ppm (1000 feet deep supply water sample)	890 ppm (500 feet deep motor water sample)	423 ppm (450 feet deep tube well water sample)	554.33 ppm
Kabirhat	744 ppm (60 feet deep tube well water sample)	376 ppm (70 feet deep tube well water)	527 ppm (150 feet deep tube well water)	549 ppm
Chatkhil	64.1 ppm (35 feet deep tube well water sample)	260 ppm (256 feet deep tube well water sample)	52.3 ppm (800 feet deep tube well water sample)	125.47 ppm

Table 4. Findings of TDS (Total Dissolved Solids) from different drinking water samples of three upazilas.

Region	Sample-1	Sample-2	Sample-3	Average
Sadar	463 ppm (1000 feet deep supply water sample)	1177 ppm (500 feet deep motor water sample)	559 ppm (450 feet deep tube well water sample)	733 ppm
Kabirhat	983 ppm (60 feet deep tube well water sample)	497 ppm (70 feet deep tube well water)	696 ppm (150 feet deep tube well water)	725.33 ppm
Chatkhil	84.5 ppm (35 feet deep tube well water sample)	343 ppm (256 feet deep tube well water sample)	69.2 ppm (800 feet deep tube well water sample)	165.57 ppm

Table 5. Chloride ion test results from different samples of three upazilas.

Region	Sample-1	Samlpe-2	Sample-3	Average
Sadar	2836 mg/L (1000 feet deep supply water sample)	14180 mg/L (500 feet deep motor water sample)	4963 mg/L (450 feet deep tube well water sample)	7326.33 mg/L
Kabirhat	1063.5 mg/L (60 feet deep tube well water sample)	2127 mg/L (70 feet deep tube well water)	709 mg/L (150 feet deep tube well water)	1299.83 mg/L
Chatkhil	354.5 mg/L (35 feet deep tube well water sample)	177.25 mg/L (256 feet deep tube well water sample)	177.25 mg/L (800 feet deep tube well water sample)	236.33 mg/L

Table 6. Iron test results from different samples of three upazilas.

Region	Sample-1	Sample-2	Sample-3	Average
Sadar	0 mg/L (1000 feet deep supply water sample)	1 mg/L (500 feet deep motor water sample)	2 mg/L (450 feet deep tube well water sample)	1 mg/L
Kabirhat	2 mg/L (60 feet deep tube well water sample)	1 mg/L (70 feet deep tube well water)	4 mg/L (150 feet deep tube well water)	2.33 mg/L
Chatkhil	2 mg/L (35 feet deep tube well water sample)	3 mg/L (256 feet deep tube well water sample)	4 mg/L (800 feet deep tube well water sample)	3 mg/L

Table 7. TVBC (Total Viable Bacteria Count) results from different samples of three upazilas.

Region	Sample-1	Sample-2	Sample-3	Average
Sadar	1.53×10^5 CFU/mL (1000 feet deep supply water sample)	1.98×10^6 CFU/mL (500 feet deep motor water sample)	1.77×10^6 CFU/mL (450 feet deep tube well water sample)	6.35×10^6 CFU/mL
Kabirhat	8.5×10^6 CFU/mL (60 feet deep tube well water sample)	1.13×10^5 CFU/mL (70 feet deep tube well water)	1.58×10^6 CFU/mL (150 feet deep tube well water)	7.13×10^6 CFU/mL
Chatkhil	3.1×10^6 CFU/mL (35 feet deep tube well water sample)	5.8×10^6 CFU/mL (256 feet deep tube well water sample)	8.9×10^7 CFU/mL (800 feet deep tube well water sample)	3.26×10^6 CFU/mL

Table 8. Bacterial Growth presence in E.M.B. (Eosin Methylene Blue) Media from different samples of three upazilas.

Region	Sample-1	Sample-2	Sample-3
Sadar	*Escherichia coli*: Absent *Pseudomonas*: Present *Klebsiella*: Present *Enterobacter aerogenes*: Absent (1000 feet deep supply water sample)	*Escherichia coli*: Present *Pseudomonas*: Present *Klebsiella*: Absent *Enterobacter aerogenes*: Absent (500 feet deep motor water sample)	*Escherichia coli*: Present *Pseudomonas*: Present *Klebsiella*: Absent *Enterobacter aerogenes*: Absent (450 feet deep tube well water sample)
Kabirhat	*Escherichia coli*: Present *Pseudomonas*: Absent *Klebsiella*: Present *Enterobacter aerogenes*: Absent (60 feet deep tube well water sample)	*Escherichia coli*: Present *Pseudomonas*: Absent *Klebsiella*: Present *Enterobacter aerogenes*: Present (70 feet deep tube well water)	*Escherichia coli*: Present *Pseudomonas*: Absent *Klebsiella*: Present *Enterobacter aerogenes*: Present (150 feet deep tube well water)
Chatkhil	*Escherichia coli*: Absent *Pseudomonas*: Present *Klebsiella*: Absent *Enterobacter aerogenes*: Absent (35 feet deep tube well water sample)	*Escherichia coli*: Absent *Pseudomonas*: Absent *Klebsiella*: Present *Enterobacter aerogenes*: Absent (256 feet deep tube well water sample)	*Escherichia coli*: Present *Pseudomonas*: Absent *Klebsiella*: Present *Enterobacter aerogenes*: Present (800 feet deep tube well water sample)

Table 9. Results of Most Probable Number (MPN) of Coliforms per 100 mL of different samples of three upazilas.

Region	Sample-1	Sample-2	Sample-3	Average
Sadar	26 Number of *Coliforms*/100mL of sample water (1000 feet deep supply water sample)	22 Number of *Coliforms*/100mL of sample water (500 feet deep motor water sample)	26 Number of *Coliforms*/100mL of sample water (450 feet deep tube well water sample)	24.67 Number of *Coliforms*/100mL of water
Kabirhat	17 Number of *Coliforms*/100mL of sample water (60 feet deep tube well water sample)	11 Number of *Coliforms*/100mL of sample water (70 feet deep tube well water)	14 Number of *Coliforms*/100mL of sample water (150 feet deep tube well water)	14 Number of *Coliforms*/100mL of water
Chatkhil	22 Number of *Coliforms*/100mL of sample water (35 feet deep tube well water sample)	17 Number of *Coliforms*/100mL of sample water (256 feet deep tube well water sample)	11 Number of *Coliforms*/100mL of sample water (800 feet deep tube well water sample)	16.67 Number of *Coliforms*/100mL of water

but in other upazillas drinking water were not satisfactory well.

4.1. PH

In this study, upazillas-sadar pH was comparatively higher (7.81) than other upazillas. On the other hand, Chatkhil upazila's drinking water was lower pH (6.18). Ideal pH level of drinking water is 6.5 - 8.5 (by WHO). Chatkhil upazila's drinking water pH was under the acceptable range. In that region drinking water was comparatively acidic. The corrosive nature of acidic water causes metal ion such as iron, manganese, copper, lead and zinc to leach into the water causing elevated levels of toxic metals in the water. It may also cause aesthetic problems such as a metallic or sour taste. In previous studies [14] pH of groundwater was 7.1 to 8.4. Sadar & Kabirhat upazilas drinking water pH was similar to the previous studies but Chatkhil upazila's drinking water pH was comparatively low. The temperature during testing was 26˚C - 28˚C those were similar to the previous studies.

4.2. Electrical Conductivity

The Electrical Conductivity of drinking water sample at upazillas-sadar was 1106

μS/cm which was greater than the acceptable range (Acceptable range 1000 μS/cm by WHO). Kabirhat upazila's drinking water conductivity was also higher (1104.33 μS/cm) than the acceptable range. Comparatively Chatkhil upazila's drinking water was lower (252.1 μS/cm) than others and was in an acceptable range. Conductivity measures the water's ability to conduct electricity. Common ions in water that conduct electrical current include sodium, chloride, calcium and magnesium. Because dissolved salts and other inorganic chemicals conduct electrical current. Conductivity increases as salinity increases. So, upazila-sadar and Kabirhat drinking water samples had higher salinity. In previous studies [14] Electrical Conductivity of groundwater was 1500 μS to 9711 μS. Sadar & Kabirhat upazilas drinking water conductivity was a little-bit lower than the previous studies but Chatkhil upazila's drinking water conductivity was comparatively very much low.

4.3. Salts

Usually, the standard limit of salinity for drinking water is zero (recommended by WHO, 1996). Upazila-sadar water sample had comparatively higher salt (554.33 ppm) than the other two upazillas water samples. Kabirhat upazila's water sample was also higher salt (549 ppm) than Chatkhil upazila's water sample. Chatkhil upazila's drinking water samples were a comparatively lower amount of salt (125.47 ppm).

4.4. TDS

Total dissolved solid below 500 ppm is good for drinking water and the acceptable range is below 1000 ppm by WHO. In this study, upazila-sadar TDS in drinking water were 733 ppm, Kabirhat 725.33 ppm, Chatkhil 165.57 ppm. All three upazillas TDS of drinking water were in acceptable range but not quite good for drinking water. In previous studies [14] TDS of ground water was 128 μS to 1660 μS. Sadar & Kabirhat & Chakhil upazilas drinking water TDS were almost similar to the previous studies.

4.5. Chloride-Ion

Chloride ion in upazillas-sadar and Kabirhat upazilas were very high in amount (Sadar 7326.33 mg/L, Kabirhat 1299.83 mg/L) which were higher than the acceptable range of 250 mg/L by WHO. But in Chatkhil chloride ion in drinking water were in the acceptable range (236.33 mg/L). The high amount of chloride ion in drinking water may wash out beneficiary bacteria from our bodies.

4.6. Iron

Concentrations of iron in drinking water are normally less than 0.3 mg/L by WHO but in this study upazilas-sadar, Kabirhat upazilas, Chatkhil upazila iron content were very much higher than the acceptable range. A high amount of iron may harm our body such as damage healthy skin which can lead to wrin-

kles. Vegetables and other foods cooked in such water will blacken and absorb a bad taste.

4.7. Total Viable Bacterial Count (TVBC)

Total Viable Bacterial Count in Chatkhil upazila drinking water samples bacterial load were comparatively lower (3.26×10^6 CFU/mL) than others and was almost similar with previous study [14]. In Kabirhat upazila drinking water sample bacterial load was comparatively higher (7.13×10^6 CFU/mL) than the other two upazilas. According to WHO guideline value, the values of TVBC should remain within 1.0×10^3 but the results of three upazilas showed the values were excessively above the WHO guideline. There is a common belief in Bangladesh that groundwater is relatively free of microorganisms and, therefore, most of the people in rural areas consume tube-well water without any treatment. However, the results of this study show clearly that all water samples that were examined were contained highly. The previous study [14] TVBC of groundwater was 6.73×10^3 CFU/mL in upazila-sadar. All the results of this study were comparatively higher than previous studies.

4.8. *E. coli* Detection

Without supply drinking water in upazila-sadar more or less almost all upazillas had *E. coli*, *Pseudomonas*, *Klebsiella*, *Enterobacter aerogenes*. These water samples were completely polluted by animal or human waste that may cause serious health hazards like bloody diarrhea, severe anemia and so on. According to WHO guideline value, *E. coli* should be absent in drinking water but the result showed the presence of *E. coli* in every water sample without supply water in upazila-sadar. So, water samples were not suitable for drinking purposes without pretreatment. The previous study [14] *E. coli* was present in upazila-sadar water sample.

4.9. MPN (Most Probable Number) Count

It is a very concern able fact that in upazila-sadar most probable number of *coliforms* was 24.67/100mL which was very much higher than the other two upazilas (Kabirhat 14/100mL, Chatkhil 16.67/100mL). Total *coliforms* include bacteria that are found in water have been influenced by human or animal waste. Fecal *coliforms* are the group of the total *coliforms* that are considered to be present specifically in the gut and feces of warm-blooded animals. By these *coliforms* people may fall into diseases like gastrointestinal illness such as severe diarrhea, nausea and possibly jaundice as well as associated headaches and fatigue.

5. Conclusion

Noakhali district is in the coastal area near the Bay of Bengal. As result, the groundwater quality of Noakhali is not good. Higher iron levels in these areas of water are very common. As far as from sea the groundwater iron level, as well as

microbial load, come low than near areas from sea. The supply water of this district cannot provide to all the people. So, maximum people have to take ground unpurified water for living. For escaping from these problems people should take a suitable water purification method as they can. Otherwise, their health will fall into great difficulties by taking such quality water. Awareness about pure drinking water can make them free from many water-borne diseases.

Conflicts of Interest

The authors declare no conflicts of interest.

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