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Research Article

Physicochemical and Microbiological analysis of tube-well water from Noakhali district, Bangladesh

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Tube-well water is thought to be free of microbial contamination due to the natural filtering ability of the subsurface environment. However the physicochemical and microbiological quality of this water may deteriorate due to the inappropriate installation of tube-wells and improper sanitation condition. The present study was undertaken to investigate the physicochemical and microbiological parameters of tube-well water in the Noakhali district of Bangladesh. 20 tube-well water samples from 10 separate locations were selected for this investigation from Noakhali Sadar Upazila in Noakhali district. In physiochemical analyses, temperature, pH, electrical conductivity (EC), salinity and total dissolved Solids (TDS) was determined by standard methods whereas, microbial analyses was conducted for total viable count (TVC) & for the determination of *E. coli, Vibrio cholera, Vibrio parahaemolyticus, Salmonella spp*. The result of the study revealed that the physicochemical parameters of the tube-well water samples are not satisfactory. All the tube-wells were grossly contaminated with bacteria *E. coli, Vibrio cholerae, Vibrio parahaemolyticus* but no wells are contaminated with *Salmonella* spp. Good and proper environmental and personal hygiene must be maintained especially by the users of those wells to prevent their contamination with bacterial pathogens.

Keywords: Physicochemical, microbiological, tube-well water, bacterial pathogens, contamination.

INTRODUCTION

Water is a crucial resource in the ecosystem since it supports life to survive. Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. In Bangladesh, hand-pumped tube-well water is used primarily as a source of safe drinking water. More than 90% of the households use this technology in this country (Emch *et al*., 2010). A tube-well is a small-diameter cased well fitted with a cast iron suction hand pump(Briscoe J., 1978). Depending on availability and the level of groundwater at different locations, these tube-wells have been set up at various depths. Although the replacement of surface water with tube-well water as the primary source for drinking water is often presumed to have reduced gastrointestinal diseases, contemporary evidence did not establish a reduction of diarrhea in Bangladesh (Levine R., 1976; Briscoe J. , 1978; Khan *et al*., 1978). But still tube-wells are the best option for drinking water sources in Bangladesh. These hand-pump tube-wells have been recommended by public health departments of the government. So a good microbial quality of tube-wells has to be maintained to assure the better health of the rural population.

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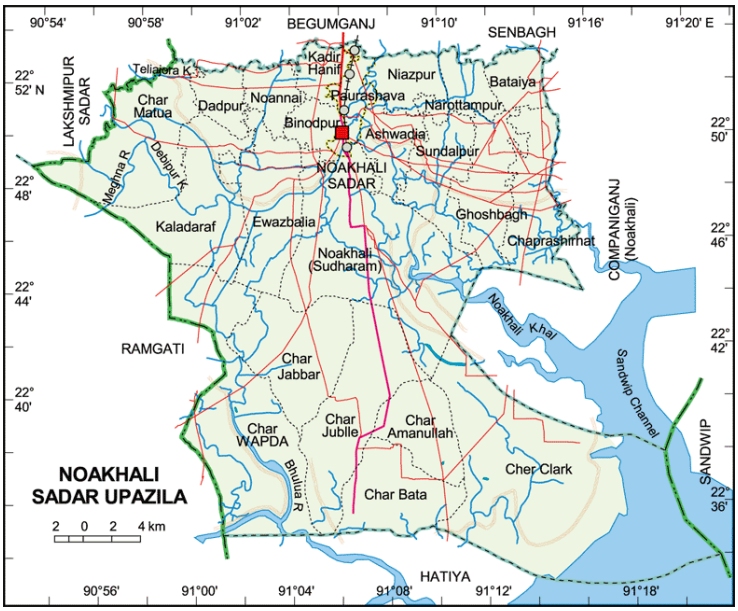

Figure 1. Map of the study location Sadar Upazila, Noakhali, Bangladesh

Availability of safe drinking water has increased over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water (Karavoltsos *et al*., 2008). Recent studies have evidenced that underground water systems in Bangladesh are progressively vulnerable to both microbiological and heavy metal contamination, especially by arsenic (Rahman *et al*., 2015). Chemical and physical pollution of water is not less serious but the life threatening pollutants present in drinking water are of biological origin (Park K., 2007). It is an established fact that polluted drinking water can spread dangerous disease like hepatitis, cholera, dysentery, typhoid and diarrhea. Among these waterborne diseases the most important one is diarrhea. Diarrhea related illness remains a major killer in children and it is estimated that annually 25 million deaths are occurred due to waterborne diseases (Cunningham, W.P., 2005). According to UN estimation; at least 2.5 billion populations of the developing countries have no proper sanitation system and above half of these people have no access to safe drinking water (Cunningham, W.P., 2005). Although Bangladesh has experienced a nearly universal switch of human consumption from surface water to groundwater for safe alternatives, the evidence of high rate of fecal contamination along with the presence of other pathogenic bacteria in this groundwater is alarming (Emch *et al*., 2010, Feighery J., 2010, Datta *et al*., 2014). One study revealed that possible mechanism of tube-well contamination is infiltration into the groundwater aquifers from nearby latrines, septic tanks and ponds, seepage of contaminated surface water through leaky seals of tube well components and harboring of bacteria in hand pumps (Ali *et al*., 2011). The study also showed that tube well water becomes contaminated during collection, handling and storage in households (Lutz *et al*., 2013). These finding together with observations of the sanitation and water infrastructure, raise important questions about the safety and sustainability of shallow groundwater resources, even in an area considered to have improved sanitation. There are limited data available on the microbiological quality of drinking water of tube-well in the coastal region in Bangladesh. Therefore, this study was conducted for physiochemical and bacteriological analysis of drinking water samples in the tube-wells of coastal region in Bangladesh.

MATERIALS AND METHODS

Sampling sites

A total 20 tube-wells from 10 different locations were selected for drinking water samples from Noakhali Sadar Upazila in Noakhali district located at the south eastern coastal region of Bangladesh. The locations are Sonapur, Thakkar, Choumuhoni, Char Jabbar, Ghoshbagh, Somiti Bazar, Banglabazar, Char WAPDA, Niazpur, Binodpur. The study areas lie between the latitudes 22° 54' 0" North and longitudes 91° 8' 0" East. The map of the study location Noakhali Sadar Upazila, Noakhali, Bangladesh is presented in Figure 1.

Sample collection

A total of 20 water samples were collected from 20 tube wells. The tube-well was continuously pumped for one minute to clear the way of opening and the water samples were collected in a sterile container. All the samples were stored in ice box with proper aseptic technique and transported to the laboratory immediately for the experimental analysis.

Table 1. Physicochemical analysis of Tube-well water samples

Sample ID	Sampling Area	Parameters				
		Temperature (°C)	pH	EC (µs/cm)	Salinity (%)	TDS (gm/L)
1B	Sonapur	26.5	7.06	693	15	4.0
2B	Sonapur	27.4	7.32	768	13.1	3.4
3B	Thakkar	24.8	6.98	640	16	4.3
4B	Thakkar	24.2	6.87	621	19.3	4.6
5B	Choumuhoni	26.8	7.10	854	13.4	3.3
6B	Choumuhoni	26.2	6.79	775	19	4.7
7B	Char Jabbar	27.9	6.87	687	10	2.6
8B	Char Jabbar	26.2	7.02	586	12.8	3.3
9B	Ghoshbagh	27.5	7.12	779	5.8	0.014
10B	Ghoshbagh	28.3	7.09	598	15	3.8
11B	Somiti Bazar	25.4	7.23	866	13.1	3.4
12B	Somiti Bazar	23.6	7.42	677	15	4.2
13B	Banglabazar	28.8	6.80	787	15	4.1
14B	Banglabazar	27.1	6.99	776	13	3.3
15B	Char WAPDA	28.6	7.17	657	19	4.7
16B	Char WAPDA	29.1	7.43	768	17	4.6
17B	Niazpur	27.4	6.86	651	12	3.3
18B	Niazpur	28.3	6.72	663	15.8	3.7
19B	Binodpur	25.1	7.17	531	10	3.3
20B	Binodpur	26.7	7.05	743	10.8	2.0

EC= Electrical Conductivity, TDS= Total Dissolved Solid

Measuring physicochemical parameters

Temperature and pH

The temperature and pH of the samples was measured by using digital pH meter (Hanna Instruments, USA).

Electrical conductivity (EC)

Electrical conductivity is the measure of water capacity to conveying electricity. EC was done by conductivity meter (HANNA Instrument HI 9932, USA).

Salinity and Total Dissolved Solid (TDS)

Salinity and total dissolved solids (TDS) were measured using a portable Bench-meter (Multiparameter HI2500, HANNA instruments) following the manufacturer's instructions.

Bacteriological analysis

Total viable bacterial count

For direct counting, spread plate technique was performed as described previously (APHA, 2003). 0.1 ml

of the tube-well water sample is transferred by a micro pipette 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).

Isolation of pathogenic bacteria

To isolate specific pathogenic bacteria, the samples were enriched separately with alkaline peptone water (APW) for plating in thiosulfate citrate bile salts sucrose agar (TCBS) media, with GN (Gram-Negative) Broth for plating in Salmonella Shigella Agar (SS) agar, with Enterobacteria Enrichment Broth- Mossel for plating in MacConkey media. 1 ml of water from each sample was added with 3 ml of respective enrichment media. All the samples were then incubated at 37°c for 24 hours. After overnight enrichment, the samples were plated in MacConkey, TCBS and SS agar plate separately. All the plates were incubated at 37°c for 24 hours. After overnight incubation, the plates were observed for selective pathogens. For the confirmation of *Escherichia coli,* red/pink colonies form MacConkey agar plates were plated in eosin methylene blue agar (EMB) agar plates and for the confirmation of *Vibrio cholerae and Vibrio parahaemolyticus,* standard biochemical tests were performed from the yellow and green colonies in TCBS media respectively.

RESULTS

Physicochemical analysis

Temperature, pH, electrical conductivity (EC), salinity and total dissolved solids (TDS) of tube-well water samples measured in this experiment shown in table 1. Temperature was found maximum in tube well water of Banglabazar (28.8**°C**) and minimum in the water samples of Thakkar (24.2**°C**). All samples showed neutral pH near about 7.0. EC values of samples were recorded range from 531 to 866 µs/cm with a mean EC value of 706 µs/cm. Tube-well water samples from Binodpur was with lowest EC value of 531 µs/cm and Samiti Bazar sample with the highest EC value of 868 µs/cm. The salinity range of the studied tube-well water samples was 10% (Char Jabbar and Binodpur) to 19.3%(Thakkar) and the TDS range of the studied tube-well water was 0.014g/L (Ghoshbagh) to 4.7 g/L (Chaumohoni and Char Wapda) with the average value 3.5 g/L.

Microbiological analysis

The microbiological analysis for the total bacterial count and the presence of *Escherichia coli* as an indicator of coliform, *Vibrio cholerae, Vibrio parahaemolyticus* and *Salmonella* spp**.** were done and results are listed in table 2. Quantitative (total viable count) analysis showed that Too Numerous To Count (TNTC) results for two samples (Thakkar and Char Wapda). Other samples showed countable number of total viable bacteria range from 36 cfu/mL(Hatia) to 3 cfu/mL (Thakkar). 40% of tube-wells in the current study had high level contamination by *E. coli* (8 out of 20), 25% of tube-wells with *Vibrio cholerae* (5 out of 20), 40% with *Vibrio parahaemolyticus* (8 out of 20) and none of the tube-wells are contaminated with *Salmonella* spp.

DISCUSSION

In Bangladesh, the majority of tube-wells are not installed in optimum locations nor maintained optimally, according to sanitary inspection guidelines provided by UNICEF and WHO (WHO, 1996). The population density of Bangladesh at 1000 persons per km^2 is the highest of any country other than urban city states (World Bank, 2006). This population density likely contributes to difficulties in placing tube-wells at the recommended distance away from latrines and other sources of pollution. These factors may contribute in the contamination of most of the tube-well water in this country.

Physicochemical parameters are most significant determinant for evaluating the quality of drinking water. Five types of physicochemical parameters such as temperature, pH, EC, salinity and TDS were considered in this study and their measured values are higher than the recommended values of World Health Organization for safe drinking water (WHO, 1996). So the results generated by this study are the clear indication of poor quality of tube-well water in Bangladesh.

Our data confirm what other studies have noted that tube-wells are commonly contaminated with different types of microorganisms most importantly faecal organisms (Hoque, B. 1999; Islam *et al*. 2001; Luby *et al*., 2006). Most of the contamination detected in these tube-wells was at a low concentration, a concentration that is thought to be associated with a lower risk of diarrhea compared with higher levels of contamination (Moe *et al*., 1991). As we found total viable count in every sample, the present study showed that all samples are contaminated by microorganisms. M.S Islam *et al.* (Islam *et al*., 2001) also reported that there is no contamination free tube-well water in Bangladesh. The health benefit of further improvement in the microbiological water quality of drinking water to this community is an unanswered question that would be appropriate for future research to address. Moe *et al.* reported similar conclusions concerning groundwater contamination in a study carried out in the Philippines (Moe *et al*., 1991).

Table 2. Bacteriological analysis result of Tube-well water samples

Sampling ID	Sampling Area	TVC (cfu/mL)	*Escherichia coli*	*Vibrio cholerae*	*Vibrio parahemolyticus*	*Salmonella spp.*
1B	Sonapur	7	-	-	+	-
2B	Sonapur	11	-	-	-	-
3B	Thakkar	TNTC	+	-	+	-
4B	Thakkar	3	-	-	-	-
5B	Choumuhoni	14	-	-	-	-
6B	Choumuhoni	13	-	-	-	-
7B	Char Jabbar	17	+	+	-	-
8B	Char Jabbar	6	+	-	+	-
9B	Ghoshbagh	14	+	+	-	-
10B	Ghoshbagh	23	-	-	+	-
11B	Somiti Bazar	10	-	+	-	-
12B	Somiti Bazar	19	+	-	+	-
13B	Banglabazar	18	-	-	+	-
14B	Banglabazar	11	-	-	-	-
15B	Char WAPDA	TNTC	+	-	+	-
16B	Char WAPDA	30	-	-	+	-
17B	Niazpur	25	-	-	-	-
18B	Niazpur	36	+	-	-	-
19B	Binodpur	32	+	+	-	-
20B	Binodpur	8	-	+	-	-

TVC= Total viable count, TNTC= Too Numerous To Count

It is a common believe in Bangladesh that groundwater is relatively free of microorganisms and, therefore, most of the people consume tube-well water without treatment. However, the results of this study show clearly that all samples of tube-well water 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*. Faecal contamination(*E. coli*) of tube-well water may results from a complex interactions among faecal pollution on the surface, suboptimal sanitary construction, temperature, moisture, soil type, pore size, pH, salinity, type and size of specific pathogens (Pedley *et al*., 2006). *Vibrio* spp. specially *Vibrio cholerae* and *Vibrio parahemolyticus* are common causative agents for gastrointestinal diseases (Joseph *et al*., 1983). Since gastrointestinal diseases transmitted by unhygienic drinking water are a global threat, low-technology solutions to the problem of providing safe drinking water provide short-term, limited solutions. The key point, however, are those tube-wells by themselves doing not provide a source of microbiologically or chemically safe drinking water.

CONCLUSION

In Bangladesh, it is possible that a more prolonged evaluation of water quality with repeated measurements

would identify a relationship between water quality and physical characteristics of tube-wells that was too subtle to be apparent in a single cross-sectional evaluation. However, the lack of association in a single evaluation suggests that the sanitary risk score does not capture important contributions to contamination.

Conflicts of Interest

We hereby declare that, there is no conflict of interest in whatever form in this work.

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