Open Access Library Journal
2022, Volume 9, e8806
ISSN Online: 2333-9721
ISSN Print: 2333-9705

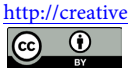
Assessment of Physico-Chemical and Microbiological Quality of Drinking Water in Differet Upazilas of Noakhali District in Bangladesh

Md. Solayman Miah, Md. Ariful Islam*, Md. Tazul Islam, Md. Anwar Ul Alam, Supriya Ghosh, Marium Sultana

Department of Food Technology and Nutrition Science, Noakhali Science and Technology University, Noakhali, Bangladesh
Email: *arifulislam.im@gmail.com

How to cite this paper: Miah, M.S., Islam, M.A., Islam, M.T., Alam, M.A.U., Ghosh, S. and Sultana, M. (2022) Assessment of Physico-Chemical and Microbiological Quality of Drinking Water in Differet Upazilas of Noakhali District in Bangladesh. *Open Access Library Journal*, **9**: e8806.
https://doi.org/10.4236/oalib.1108806

Received: April 29, 2022
Accepted: June 27, 2022
Published: June 30, 2022



Abstract

The name of water is called life. Providing safe drinking water is one of the momentous public health precedencies and the drinking water quality is closely associated with human health. The most important human well-being is affordable, abundant, and clean drinking water. This study has been conducted for assessing the drinking water quality of various locations in Noakhali. Total of nine water samples have been collected from three different locations (Sadar, Begumgonj, and Hatiya). Each sampling location consists of three separate sampling points. The samples have been analysed for their physical-chemical and microbiological quality in order to observe health impact. Physicochemical parameters of the collected samples like Temperature, pH, Electric Conductivity (EC), Total dissolved solid (TDS), and Salinity have measured by Multiparameter meter and Microbial parameters like Total Viable Bacterial Count (TVBC), Total *Coliform* (TC) and the presence of *E. coli* have also examined. All the parameters have analysed and compared with WHO drinking water quality standards to understand the overall water quality status of the study area. The study has shown that the water samples in almost all the locations have been contaminated by microbial contamination and the range of the physicochemical parameters was not suitable for consumption. Preliminary treatment is needed prior to using the water for drinking purposes and necessary steps should be taken for alternative safe sources of drinking water.

Subject Areas

Food Science & Technology

Keywords

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

1. Introduction

In developing countries, the primary concern of people is to obtain clean drinking water. Most of the people in rural areas depend on ground and surface water for sustenance in Africa and Asia. The situation is also different in Bangladesh, particularly in the rural areas.

About 90% of the rural population in Bangladesh uses tube-well water as a primary source of drinking water [1] [2]. A small-diameter cased well fitted with a cast iron suction hand pump is a tube-well [3]. All the tube wells in the coastal areas have been set up at various depths depending on availability and the level of groundwater at different locations. Though the surface water is replaced with tube well water as the main source of drinking water to reduce gastrointestinal disease, there was no coincidental evidence to establish a reduction of diarrhoea in Bangladesh [3] [4].

Water quality encompasses physical (EC, TDS), total suspended solids (TSS), hardness, alkalinity, turbidity, dissolved oxygen (DO), chemical (pH, Cu, Fe, Mn, Zn, P, Cl, etc.), and biological (e.g. *coliform*) characteristics and constituents of both surface and groundwater sources [5]. There are many elements, which are present in drinking water demonstrated as crucial for human health. Nevertheless, elevated concentrations of these elements and their ingestion in excessive amounts may cause severe health problems [5] [6] [7]. Water used for domestic, industrial, or other purposes is mainly infested by the *coliform* group of bacteria [8]. As a consequence, testing for *coliform* bacteria can be a judicious indication of whether other pathogenic bacteria are present. For most water samples analysed in Bangladesh were observed with low metallic content [9].

In groundwater wells, fecal bacteria and viruses have been detected in aquifers of diverse geologic material [10]-[15]. According to World Health Organization (WHO) tube wells are considered as an "improved" drinking water source [16]. In rural Bangladesh millions of inhabitants delivered drinking water from over 10 million of these tube wells. About 11% of all deaths are assessed to be caused by diarrheal disease in this country [17] with the latest studies suggesting that sustained levels of diarrheal disease are caused in part by drinking unprocessed groundwater [18] [19] [20]. Fecal indicator bacteria (FIB) and bacterial and viral pathogens found in tube wells around the world [21] [22] [23] are known to be predictive of diarrheal disease in diverse populations widespread [24].

It is a district in the South-eastern coastal zone of Bangladesh that geographically stands on 22˚50'N 91˚06'E/22.83˚N 91.10˚E coordinates [25]. The average annual temperature varies from district to a maximum of 34.3˚C and a mini-

mum of 14.4˚C, annual rainfall is 3302 mm. The main river is the Meghna and Bamni. The southern coastal belt of the country is facing huge challenges in meeting freshwater demand due to limited water supply, presence of salinity, and other water quality problems [26].

There are limited data available on the microbiological and physic-chemical quality of drinking water from tube-well, groundwater, supply water, and deep tube well in the coastal region of Bangladesh. Therefore, this study was conducted for physiochemical and microbiological analysis of drinking water samples in the tube-wells, groundwater, supply water, and deep tube well water in three upazilas of Noakhali districts for discovering the quality of water (**Figure 1**).

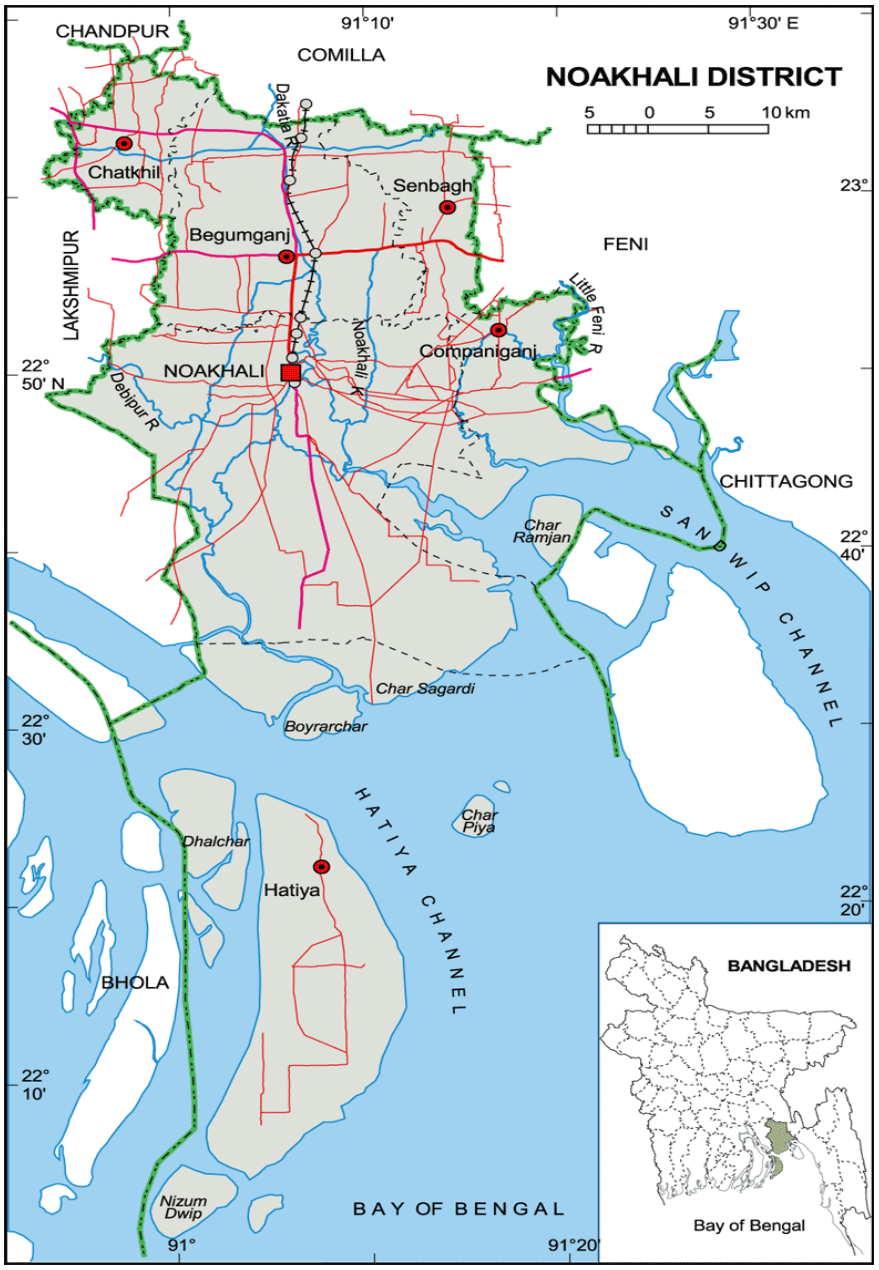


Figure 1. Map shows Noakhali district.

1.1. Study Area

The sampling area of this study is the coastal area of Noakhali which lies between 22˚50' to 22˚83'N latitude and 91˚06' to 91˚10'E longitude with an area of 4203 sq km [26]. Samples were collected from three upazila of Noakhali district of southern Bangladesh. The locations are Noakhali Sadar, Begumgonj and Hatiya presented in Figure 2.

1.2. Study Duration

This study duration was from July to September, 2018.

2. Materials & Methodology

2.1. 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.

2.2. 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.

2.3. Microbiological Test

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

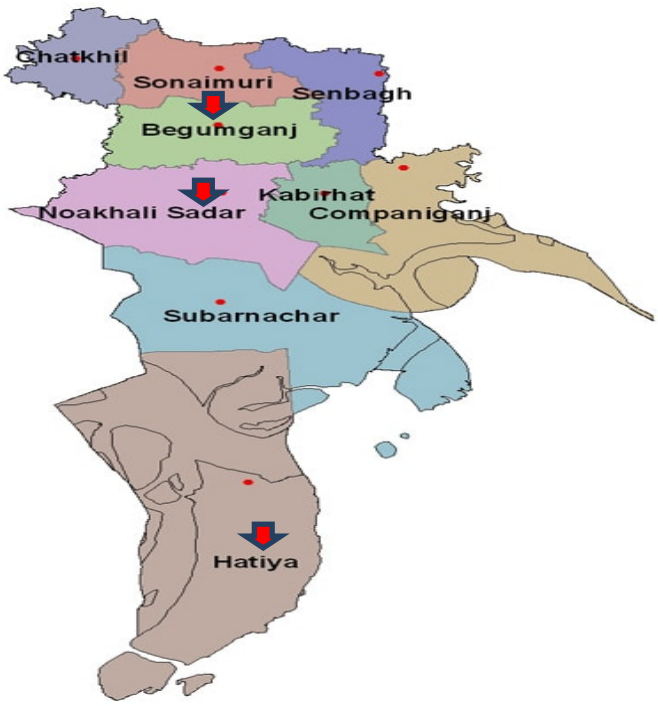


Figure 2. The map shows the sample collection zone by the arrow.

2.4. 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. Most of the people at Hatiya upazila take tube-well water for drinking. From Hatiya upazila three different areas drinking water samples were collected. All most the people at Begumgonj upazila take tube-well water for drinking. From Begumgonj upazila three different areas drinking water samples were collected.

3. Results

Table 1 shows the results of physical parameters of different water samples.

Table 2 shows the averages results of physical parameters of different water samples of three upazila.

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

Summary of the Microbial quality of waters collected from the study areas are given in Table 4.

Table 1. Results of physical parameters of different water samples [27] [28].

Sample No.	pH	Tem. (˚C)	TDS (mg/l)	Salt (mg/l)	EC (us)
S1	7.77	29.7	463	350	675
S2	7.44	29.6	1177	890	1174
S3	8.22	29.4	554	423	849
S4	6.70	30.2	115.2	87	177
S5	6.89	30.8	400	303	607
S6	6.52	30.6	471	358	726
S7	6.77	30.8	798	603	1211
S8	6.70	30.6	34.1	25.3	52.5
S9	6.20	31.0	69.5	52.7	105.4
BD Std.	6.5 - 8.5	-	250	0	600 - 1000
WHO Std.	6.5 - 8.5	-	<1000	0	1000

Table 2. Averages results of physical parameters of different water samples of three upazila.

Sample	P^H	Tem. (˚C)	TDS (mg/l)	Salt (mg/l)	EC (us)
Sadar Noakhali	7.79	29.57	731.33	554.33	899.33
Begumgonj	6.70	30.53	328.73	259.33	503.33
Hatiya	6.56	30.80	300.53	227.00	456.30

Table 3. Chemical analysis of drinking water samples.

Samples No.	Cl^- (mg/l)	Iron (mg/l)
S1	2836	0
S2	6381	1
S3	4963	3
S4	3545	1
S5	354.5	1
S6	354.5	2
S7	2836	<1
S8	3545	0
S9	3545	<1
WHO Guideline	250	0.3

Table 4. Microbiological parameters of different sampling points.

Sample ID	TVBC. (CFU/ml)	TC (CFU/ml)	*E. coli*
S1	1.53×10^5	26	absent
S2	1.98×10^6	22	present
S3	1.77×10^6	26	present
S4	1.12×10^5	24	present
S5	1.77×10^6	26	present
S6	0.97×10^5	24	Present
S7	1.99×10^5	22	Present
S8	2.12×10^6	30	Present
S9	1.34×10^5	24	Present

4. Discussion

4.1. pH

The ideal value of P^H is referred as 7.0 P^H value indicates the strength acidic or alkaline conditions. The P^H of all the samples is underneath WHO acceptable guideline value of 6.5 - 8.5 [29]. This study has observed average higher P^H value in the Sadar Noakhali compared with Begumgonj and Hatiya (Table 3). P^H value of all the drinking water samples is varied from 6.20 to 8.22. The highest P^H value (8.22) observed in tube well on Sonapur and the lowest P^H value in tube well water of Char koilash village. The supply water of Sadar has higher P^H (7.77) than the supply water of Begumgonj (6.70). The tube well water of Sonapur has comparatively higher P^H (8.22) than Eklashpur (6.52) and Char koilash has the lowest value (6.20). There is no harmful effect observed due to low P^H [30].

4.2. Total Dissolved Solids

The TDS values ranged from 34.1 to 1177 mg/l (Table 2) which is measured by

Multiparameter meter Model PL-700ALS. The TDS values have found in this study are within WHO acceptable limit of 1000 mg/l except Dattabari motor water which contain 1177 mg/l. The average TDS of Sadar Noakhali (731.33 mg/l) is comparatively higher than Begumgonj (328.73 mg/l) and Hatiya (300.53 mg/l).

4.3. Electrical Conductivity

Total concentration of charged ions in water is measured through Electrical Conductivity (EC). EC of the collected water samples have ranged from 52.5 µS to 1211 µS which is measured by Multiparameter meter Model PL-700ALS. The average conductivity varied significantly in all the collected drinking water samples. The average EC of Sadar Noakhali (899.33 µS) which is higher than Begumgonj (503.33 µS) and Hatiya (456.30 µS). The pond water of Sonadia (Hatiya) recorded relatively low conductivity (52.5 µS/cm) which is within the WHO guideline value of 1000 µS/cm. Shallow tube well water (Char Changa, Hatiya) have recorded higher conductivity values (1211 µS/cm) which is above WHO guideline value. This might be occurred due to high level of soluble salts such as carbonates, chlorides, sulphate and nitrates and cations such as potassium, magnesium, calcium and sodium in the sediment and soil in the coastal region.

4.4. Salt

All the salts dissolve in water is represented by salinity. Though the standard value salinity is zero, the salt of all collected samples recorded value varies significantly which is measured by Multiparameter meter Model PL-700ALS. The lowest salt (25.3 mg/l) has recorded at Sonadia in Hatiya upazila which is also above the WHO guideline value. The highest value of salt has been measured in motor water (890 mg/l) of Dattabari water samples. The average salt of Sadar Noakhali (554.33 mg/l) drinking water is comparatively higher than the others two regions (**Table 3**).

4.5. Chloride Ions, Cl^-

The chloride anions are found in all the water sources. Potassium chromate has been used as an indicator for the titration with silver nitrate solution and NaCl. The Cl^- concentration in all the nine sources of drinking water tested are above the WHO standard limit of 250 mg/l. The concentration of Cl^- in all samples has tested varied significantly from each other. The highest level measured in motor water (6381 mg/l) of Dattabari samples and lowest value recorded in motor water of Begumgonj (354.5 mg/l) and tube well water (354.5 mg/l) of Eklashpur which is comparatively much lower than all other water samples. In case of tube well water, Sonapur tube well water have highest Cl^- (4963 mg/l) and Eklashpur have lowest value (354.5 mg/l) but Cl^- ions in Char koilash tube well water have comparatively higher value (3545 mg/l) than Eklashpur. The Sadar Noakhali has found the higher average value compared with Begumgonj and Hatiya (**Table 3**)

4.6. Total Iron Ions

The level of total iron concentration in all the nine sampling points ranged from 0 to 3 mg/l (Table 3). Iron reagent kit is used to determine the color then this color is matched with color comparator cube. Only the supply water of Jahurul haque mia garaz and the pond water of Sonadia founds 0 mg/l of iron which were within the WHO guideline level of 0.3 mg/l. Shallow tube well water samples of Char Changa and tube well water of Char Koilash contain less than 1 mg/l of iron. Tube well water of Sonapur recorded highest level of iron (3 mg/l) which were much higher than WHO acceptable limit.

4.7. Total Viable Bacterial Count (TVBC)

This study found TVBC for all the samples has ranged from 0.98×10^5 cfu/ml to 2.12×10^6 cfu/ml which is measured by pour plate technique. TBVC for all the 9 samples varied significantly. The pond water of Sonadia recorded highest level as 2.12×10^6 cfu/ml and the tube well water of Eklashpur recorded lowest value as 0.97×10^5 cfu/ml. This study also found that tube well water contains lower amount of TVBC compared with other source of water sample. The drinking water of Sadar has recorded an average of 1301,000 cfu/ml which is comparatively higher than the average value of Begumgonj 659666.667 cfu/ml and Hatiya 1219666.67 cfu/ml (Table 4). According to WHO guideline value, the values of TVBC should remain within 1.0×10^3 cfu/ml but the result showed the values are excessively above than the WHO guideline.

4.8. *Escherichia coli* (*E. coli*)

E. coli is present in drinking water designates that the water is contaminated by fecal bacteria of humans or other warm-blooded animals and gives a green metallic sheen color in selective EMB agar media. This study has found that only the supply water of Sadar Noakhali free of *E. coli*. There is positive result (*E. coli* present) for all the water samples except Jahurul haque mia garaz's supply water.

4.9. Total *Coliform* (TC)

The indicator for pathogenic organisms is total *coliform* and *Fecal coliform*. EPA [30] demonstrates that every water sample that has *coliform* must be analysed for either fecal *coliforms* or *E. coli*. This study uses presumptive test from MPN for calculating total *coliform*. This study founds different level of total *coliform* ranges from 24 cfu/ml to 30 cfu/ml. All the supply water of the three study region recorded 26 cfu/ml of total *coliform*. The motor water of Dattabari and shallow tube well water of Char Changa also found same (22 cfu/ml) result. The highest value of TC has found in the pond water of Sonadia which is comparatively higher than others. The average value of TC has recorded same in Begumgonj and Hatiya (24.67 cfu/ml) water samples and comparatively lower in Sadar (16.642 cfu/ml).

5. Conclusions

This study aims to assess the drinking water samples for determining the physicochemical parameters and microbiological quality analysis of different drinking water samples of three upazila of Noakhali. Results are then compared with each other and drinking water standards have been given by World Health Organization (WHO). From the result, it has been assessed that only the P^H of all the sample water is within the acceptable limit, and all the other parameter are not within the acceptable limit. The bacteriological parameter is also higher than the consulting level. The present study has found that the result from the study has indicated that almost all the samples from different sources are not suitable for drinking purposes or consumption without any primary treatment like adding bleaching powder in water, boiling, filtering, etc.

The present study is shown that the chloride anions and iron content are also above the acceptable limit except for supply water of Jahurul haque mia garaz and the pond water of Sonadia which is within the WHO acceptable limit. All the water samples tested for *E. coli* have shown a positive result except for supply water of Jahurul haque mia garaz. The TC and TVBC have varied significantly in each simple which is not suitable for consumption. Still, now the overall drinking water quality of the greater Noakhali region is poorly understood. Due to time constrain, our study does not cover all the sources of water quality status in the study area. Intensive research and continuous monitoring are required to know the overall water quality of the greater Noakhali region.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Nahar, N. (1997) Arsenic: Silent Catastrophe. *Bull. Environ. Health*, **1**, 1-4.

[2] Emch, M., Yunus, M., Escamilla, V., Feldacker, C. and Ali, M. (2010) Local Population and Regional Environmental Drivers of Cholera in Bangladesh. *Environmental Health*, **9**, Article No. 2. https://doi.org/10.1186/1476-069X-9-2

[3] Briscoe, J. (1978) The Role of Water Supply in Improving Health in Poor Countries. *The American Journal of Clinical Nutrition*, **31**, 2100-2113. https://doi.org/10.1093/ajcn/31.11.2100

[4] Levine, R., D'Souza, S., Khan, M. and Nalin, D. (1976) Failure of Sanitary Wells to Protect Against Cholera and Other Diarrhoeas in Bangladesh. *The Lancet*, **308**, 86-89. https://doi.org/10.1016/S0140-6736(76)92299-6

[5] World Health Organization (2004) Guidelines for Drinking-Water Quality. World Health Organization.

[6] Goldhaber, S.B. (2003) Trace Element Risk Assessment: Essentiality vs. Toxicity. *Regulatory Toxicology and Pharmacology*, **38**, 232-242. https://doi.org/10.1016/S0273-2300(02)00020-X

[7] Mastoi, G.M., Shah, S.G. and Khuhawar, M.Y. (2008) Assessment of Water Quality of Manchar Lake in Sindh (Pakistan). *Environmental Monitoring and Assessment*,

141, 287-296. https://doi.org/10.1007/s10661-007-9895-8

[8] Zamxaka, M., Pironcheva, G. and Muyima, N. (2004) Microbiological and Physico-Chemical Assessment of the Quality of Domestic Water Sources in Selected Rural Communities of the Eastern Cape Province, South Africa. *Water SA*, **30**, 333-340. https://doi.org/10.4314/wsa.v30i3.5081

[9] Rahman, I.M., Islam, M.M., Hossain, M.M., Hossain, M.S., Begum, Z.A,, Chowdhury, D.A., Chakraborty, M.K., Rahman, M.A., Nazimuddin, M. and Hasegawa, H. (2011) Stagnant Surface Water Bodies (SSWBs) as an Alternative Water Resource for the Chittagong Metropolitan Area of Bangladesh: Physicochemical Characterization in Terms of Water Quality Indices. *Environmental Monitoring and Assessment*, **173**, 669-684. https://doi.org/10.1007/s10661-010-1414-7

[10] Goss, M.J., Barry, D.A. and Rudolph, D.L. (1998) Contamination in Ontario Farmstead Domestic Wells and its Association with Agriculture: 1. Results from Drinking Water Wells. *Journal of Contaminant Hydrology*, **32**, 267-293. https://doi.org/10.1016/S0169-7722(98)00054-0

[11] Abbaszadegan, M., Lechevallier, M. and Gerba, C. (2003) Occurrence of Viruses in US Groundwaters. *Journal-American Water Works Association*, **95**, 107-120. https://doi.org/10.1002/j.1551-8833.2003.tb10458.x

[12] Embrey, S.S. and Runkle, D.L. (2006) Microbial Quality of the Nation's Ground-Water Resources, 1993-2004. Scientific Investigations Report 2006-5290, US Department of the Interior, US Geological Survey, Reston, VA. https://doi.org/10.3133/sir20065290

[13] Borchardt, M.A., Bradbury, K.R., Alexander Jr. E.C., Kolberg, R.J., Alexander, S.C., Archer, J.R., Braatz, L.A., Forest, B.M., Green, J.A. and Spencer, S.K. (2010) Norovirus Outbreak Caused by a New Septic System in a Dolomite Aquifer. *Groundwater*, **49**, 85-97. https://doi.org/10.1111/j.1745-6584.2010.00686.x

[14] Johnson, T.B., McKay, L.D., Layton, A.C., Jones, S.W., Johnson, G.C., Cashdollar, J.L., Dahling, D.R., Villegas, L.F., Fout, G.S., Williams, D.E. and Sayler, G. (2010) Viruses and Bacteria in Karst and Fractured Rock Aquifers in East Tennessee, USA. *Groundwater*, **49**, 98-110. https://doi.org/10.1111/j.1745-6584.2010.00698.x

[15] Kozuskanich, J., Novakowski, K.S. and Anderson, B.C. (2010) Fecal Indicator Bacteria Variability in Samples Pumped from Monitoring Wells. *Groundwater*, **49**, 43-52. https://doi.org/10.1111/j.1745-6584.2010.00713.x

[16] WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (Eds.) (2000) Global Water Supply and Sanitation Assessment 2000 Report. https://www.who.int/publications/i/item/9241562021

[17] Streatfield, K., Persson, L.A., Chowdhury, H.R. and Saha, K.K. (2001) Disease Patterns in Bangladesh: Present and Future Needs. International Centre for Diarrhoeal Disease Research, Dhaka.

[18] Escamilla, V., Wagner, B., Yunus, M., Streatfield, P.K., van Geen, A. and Emch, M. (2011) Effect of Deep Tube Well Use on Childhood Diarrhoea in Bangladesh. *Bulletin of the World Health Organization*, **89**, 521-527.

[19] Escamilla, V., Knappett, P.S., Yunus, M., Streatfield, P.K. and Emch, M. (2013) Influence of Latrine Proximity and Type on Tubewell Water Quality and Diarrheal Disease in Bangladesh. *Annals of the Association of American Geographers*, **103**, 299-308. https://doi.org/10.1080/00045608.2013.756257

[20] van Geen, A., Ahmed, K.M., Akita, Y., Alam, M.J., Culligan, P.J., Emch, M., Escamilla, V., Feighery, J., Ferguson, A.S., Knappett, P. and Layton, A.C. (2011) Fecal Contamination of Shallow Tubewells in Bangladesh Inversely Related to Arsenic.

Environmental Science & Technology, **45**, 1199-1205. https://doi.org/10.1021/es103192b

[21] Luby, S.P., Gupta, S.K., Sheikh, M.A., Johnston, R.B., Ram, P.K. and Islam, M.S. (2008) Tubewell Water Quality and Predictors of Contamination in Three Flood-Prone Areas in Bangladesh. *Journal of Applied Microbiology*, **105**, 1002-1008. https://doi.org/10.1111/j.1365-2672.2008.03826.x

[22] Leber, J., Rahman, M.M., Ahmed, K.M., Mailloux, B. and van Geen, A. (2011) Contrasting Influence of Geology on *E. coli* and Arsenic in Aquifers of Bangladesh. *Groundwater*, **49**, 111-123. https://doi.org/10.1111/j.1745-6584.2010.00689.x

[23] Ferguson, A.S., Layton, A.C., Mailloux, B.J., Culligan, P.J., Williams, D.E., Smartt, A.E., Sayler, G.S., Feighery, J., McKay, L.D., Knappett, P.S. and Alexandrova, E. (2012) Comparison of Fecal Indicators with Pathogenic Bacteria and Rotavirus in Groundwater. *Science of the Total Environment*, **431**, 314-322. https://doi.org/10.1016/j.scitotenv.2012.05.060

[24] Gundry, S., Wright, J. and Conroy, R. (2004) A Systematic Review of the Health Outcomes Related to Household Water Quality in Developing Countries. *Journal of Water and Health*, **2**, 1-13. https://doi.org/10.2166/wh.2004.0001

[25] Karmakar, P., Islam, M.M., Kibria, M.G., Hossain, M.S. and Sattar, M.M. (2012) Prevalence, Belief and Awareness of Preferring Traditional Healthcare System in Urban and Rural People of Noakhali District, Bangladesh. *International Current Pharmaceutical Journal*, **1**, 229-234. https://doi.org/10.3329/icpj.v1i9.11611

[26] Adhikary, S.K., Elahi, M.M. and Hossain, A.I. (2012) Assessment of Shallow Groundwater Quality from Six Wards of Khulna City Corporation, Bangladesh. *International Journal of Applied Sciences and Engineering Research*, **1**, 488-498. https://doi.org/10.6088/ijaser.0020101050

[27] World Health Organization (2003) Atrazine in Drinking-Water: Background Document for Development of WHO Guidelines for Drinking-Water Quality. World Health Organization, Geneva.

[28] Jamal, A.H., Ahsan, A., Ahmed, S., Akter, S., Sultana, R., Nahar, A. and Uddin, R. (2020) Physicochemical and Microbiological Quality of Potable Water Supplied by DWASA in Dhaka City of Bangladesh. *American Journal of Biological and Environmental Statistics*, **6**, 1-6. https://doi.org/10.11648/j.ajbes.20200601.11

[29] Islam, M.A., Ghosh, S., Alam, A.U., Islam, M.T., Kabir, M.R. and Sultana, M. (2021) Assessment of Physico-Chemical and Microbiological Quality of Drinking Water in Three Upazilas of Noakhali District in Bangladesh. *Open Access Library Journal*, **8**, e7941. https://doi.org/10.4236/oalib.1107941

[30] Gofti, L., Zmirou, D., Hartemann, P. and Potelon, J.L. (1999) Waterborne Microbiological Risk Assessment: A State of the Art and Perspectives. *Revue D'epidemiologie et de Sante Publique*, **47**, 61-73.