Supply Water Quality Assessment in the Sirajganj Municipality, Sirajganj, Bangladesh

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Abstract

In many developing countries, such as Bangladesh, water quality and the risk of water-related diseases are serious public health concerns. The present study's goal was to ascertain the water supply quality and to characterize and analyze its suitability for drinking purposes in the municipal area of Sirajganj Town, Bangladesh. Fifteen water samples were randomly collected from different municipal wards and analyzed for various physicochemical properties, including hydrogen ion concentration (pH), electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), acidity, total alkalinity (TA), total hardness (TH), arsenic (As), and iron (Fe) concentrations. The results were compared with the Environmental Conservation Rules (ECR) and World Health Organization (WHO) recommended standards. All the physicochemical parameters were found to be within the prescribed permissible limits. The pH values, which ranged from 6.61 to 7.73, were neutral to slightly alkaline. The TH value varied from 204 to 284 mg/L, indicating that the supply water type was hard. Hence, it was suggested that the local water treatment plant should soften the water supply before consumption. In the case of DO and Fe, the DO values varied from 2.0 to 3.9 mg/L, which were far below the levels prescribed by the ECR recommended standards. Fe concentration in some areas exceeded the WHO recommended standards, probably due to the corrosion of old metal pipelines and improper treatment of groundwater before distribution in the supply network. The existing water supply in Sirajganj Municipality was at a satisfactory level, but weaknesses in the current water supply management system were identified, and there was a continuous lack of service provisions. Suggested measures include consistently monitoring water distribution networks, promptly repairing and maintaining overhead and service tanks, establishing database management systems, regulating private investment, adopting advanced technology, ensuring provisions for staff training, and implementing a rights-based approach in water supply.

Keywords: *Municipality; Supply Water; Drinking water; Assessment; Physicochemical Characteristics.*

1. **Introduction**

Water is essential to all life forms and makes up 50–97% of the weight of all plants

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and animals and about 70% of the human body (Buchholz, 1998). Water covers 71% of the Earth's surface and is vital for all known forms of life. On Earth, 96.5% of the planet's water is found in oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor, clouds, and precipitation (Gleick, 1993; UN, 2005). The water supply in Bangladesh relies mainly on groundwater. Although Bangladesh has been considered rich in groundwater resources, total groundwater storage data are absent. The National Water Plan Phase-II estimated average groundwater as 21 km^3 in 1991 (FAO, 2010). In Bangladesh, the water supply coverage has been increasing both in urban and rural areas since the 1980s. More than 31 million people in Bangladesh collect drinking water from unsafe sources (UNICEF-WHO, 2008). Exposure to arsenic through drinking water sourced from groundwater is a global public health problem that is particularly devastating in Bangladesh. It has been estimated that about 29 million people in Bangladesh are exposed to drinking water with arsenic exceeding Bangladesh standards of 50 µg/L and 49 million people exceeding the provisional WHO guideline value of 10 µg/L (GoB, 2002). Mitigating the problem of water containing high levels of arsenic requires a sizeable investment in the water supply infrastructure (Sara *et al.*, 2012). Diarrhea is recognized as a major health problem in children throughout developing countries like Bangladesh. As much as 80% of the diseases in Bangladesh are related to unclean water (Sharifa *et al.*, 2011). Bangladesh transmission of cholera/diarrhea is believed to be associated with poor quality of water for drinking, bathing, washing utensils, etc., with fecal pollution of water sources and the quality of the home environment identified as the key source of pathogens causing diarrhea (Islam *et al.*, 2013; Sarker *et al.*, 2012 and Spira *et al.*, 1980). Hence, for diarrheal disease control, the improvement of water supply and excreta disposal facilities has attracted much interest, and the governments of poor countries have undertaken water and sanitation improvement programs with the confidence that such physical investments in water/sanitation areas will surely result in substantial improvements in the diarrheal incidence. The improvements in water/sanitation environments, together with the rise in living standards, have played a major role in reducing diarrhea rates and controlling the epidemic of typhoid and cholera (Mengstie *et al.*, 2023; Shamimuzzaman *et al.*, 2019; Khayum *et al.*, 2011 and Sharifa *et al.*, 2011). In developing countries like Bangladesh, people are constantly battling with different diseases, most of which are due to a lack of clean drinking water and sanitation. Children and women bear the greatest health burden associated with poor water and sanitation. Better hygiene and access to safe drinking water and sanitation will accelerate progress and reduce the mortality rate.

The population of Sirajganj town is about 0.22 million (SFD, 2020). It is situated on the bank of the Jamuna River. Sirajganj town is one of the most vulnerable areas to floodplains. During floods, the people of Sirajganj district suffer from inadequate, safe drinking water, resulting in negative consequences for human health. They are affected by different waterborne diseases like diarrhea, dysentery, typhoid, skin diseases, chlorella diseases, etc. Therefore, tap water supply can play a vital role in the health management of this area. Still, insignificant has been done on the water quality assessment at Sirajganj Municipality. From assesing the need of study, this attempt has been made to assess the quality of the supplied water in the Municipal Area at Sirajganj Town and develop a strategy to improve the water supply distribution system and management practices in this area to achieve supply water quality standards.

1.1 The objectives of this study:

- To assess physicochemical parameters, including Hydrogen Ion Concentration (pH), Electrical Conductivity (EC), Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Acidity, Total Alkalinity (TA), Total Hardness (TH), Arsenic (As), and Iron (Fe) in the supplied water at Sirajganj Municipality.
- To compare the experimented water parameters with the drinking water standards provided by Environmental Conservation Rules (ECR) and the World Health Organization (WHO) recommended standards.
- To suggest steps to improve service delivery by increasing efficiency in the management system.

2. Materials and Methods

2.1 Study Area

The research work was conducted in the municipal areas of Sirajganj Sadar Upazila of Sirajganj district (24º47' N and 89º59' E)

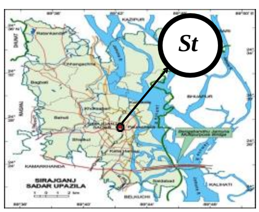

Figure 1: Map of the Study area (Banglapedia, 2022)

2.2 Sample Collection, Preparation and Analysis

The experiment was conducted from March to May 2019 at the Water Quality Laboratory of the Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University, Tangail, Bangladesh, to assess the supplied water quality in the municipal area at Sirajganj Town. To assess the physicochemical parameters of the supplied water, fifteen samples were randomly collected from different wards in Sirajganj Municipality: SS Road, Mujib Sarak, Datta Bari, Goila, Amlapara, Dhanbandhi, Hoshenpur, Goshala, and Kalibari. 500 ml plastic bottles were used for water sample collection. Before sample collection, all bottles were washed with dilute acid, followed by distilled water, and dried in the oven. The bottles were rinsed with water three times before being collected. After the collection of water samples, the sample bottles were labeled with the sampling location. The samples were kept at a low temperature in the dark for chemical analysis. To assess the pH of the collected samples, a digital pH meter (ADWA) was used. Electrical Conductivity (EC) was measured by a digital EC meter (HM DIGITAL), Dissolved Oxygen (DO) was measured by a digital DO meter (DO-5509), and a digital TDS meter (HM DIGITAL) was used to determine Total Dissolved Solids (TDS). The titration method was applied to assess acidity, hardness, and alkalinity. Arsenic (AS) and iron (Fe) were tested in the Department of Public Health and Engineering, Tangail.

3. Results and Discussion

3.1 Analysis of Physicochemical Properties

The measured values of different physicochemical properties of the collected water samples have been summarized in Table 1. The findings of the research have been assessed according to WHO drinking water quality guidelines and Bangladesh standards as well.

Table 1. Summary of measured water quality parameters at Sirajganj Municipality

Sample No.	pH	EC (µS)	DO (mg/L)	TDS (µS)	Acidity (mg/L)	TA (mg/L)	TH (mg/L)	As (ppb)	Fe (mg/L)
S-01	7.35	68	3.3	420	65	200	212	ND	0.9
S-02	7.27	69	3.2	423	65	240	236	ND	0.8
S-03	6.93	66	2.2	407	75	200	244	ND	0.8
S-04	7.32	59	3.2	346	60	260	284	ND	0.9
S-05	7.73	59	3.1	349	50	290	266	ND	0.8

S-06	7.32	71	3.4	349	55	270	280	ND	0.7
S-07	6.83	77	2.2	367	70	280	240	ND	0.5
S-08	7.26	65	3.9	402	75	260	224	ND	0.7
S-09	7.01	53	3.8	436	55	250	236	ND	0.3
S-10	6.61	66	2.0	374	75	270	214	ND	0.3
S-11	7.45	68	2.8	321	65	220	204	ND	0.4
S-12	7.18	57	2.1	354	55	270	247	ND	0.4
S-13	6.78	67	2.0	368	60	210	281	ND	0.3
S-14	7.57	55	3.7	442	55	280	240	ND	0.4
S-15	6.99	75	2.8	326	75	250	244	ND	0.3
Min	6.61	53	2.0	321	50	200	204	-	0.3
Max	7.73	77	3.9	442	75	290	284	-	0.9

pH = Hydrogen Ion Concentration; EC = Electrical Conductivity; DO = Dissolved Oxygen; TDS = Total Dissolve Solid; TA = Total Alkalinity; TH = Total Hardness; µS = microsiemens; mg/L = milligrams per liter; ppb = parts per billion; ND = Not Detectable; Max = Maximum and Min = Minimum

3.2 Comparison between experimented Supply Water Parameters with ECR and WHO Standards

The mean values with a standard deviation of physicochemical parameters of supplied water were compared with the standard guideline values recommended by the Bangladesh Drinking Water Standard (BDWS) and the World Health Organization (WHO) for drinking purposes (Table 2). The table shows the most desirable limits and maximum allowable limits of various parameters.

Table 2: Comparison of water samples with its recommended standard quality

Parameters	Unit	Mean±Standard Deviation	Water Quality Standards	
			BDWS	WHO
pH	-	7.17±0.31	6.5-8.5	6.5-8.5
EC	µS	65±7.07	1000	250
DO	mg/L	2.91±0.67	6	-
TDS	µS	378.93±39.75	1000	1000
Acidity	mg/L	63.67±8.76	-	-
TA	mg/L	250.00±29.76	500	250
TH	mg/L	243.47±25.13	200-500	500
As	ppb	ND	0.05	0.01
Fe	mg/L	0.57±0.24	0.3-1.0	0.3

Source: Water Quality Standards (ECR, 2023 and WHO, 2006)

3.3 Discussion on the Physicochemical Properties

3.3.1 Hydrogen Ion Concentration (pH)

Figure 2 shows that the concentration of pH values of sample water in different wards of Sirajganj Municipality, which was almost neutral, ranged from 6.61 to 7.73. Whereas, the lowest value of 6.61 was found in Dhanbandhi (Sample no. S-10) and the highest value of 7.73 was found in Datta Bari (Sample no. S-05) (Table 1).

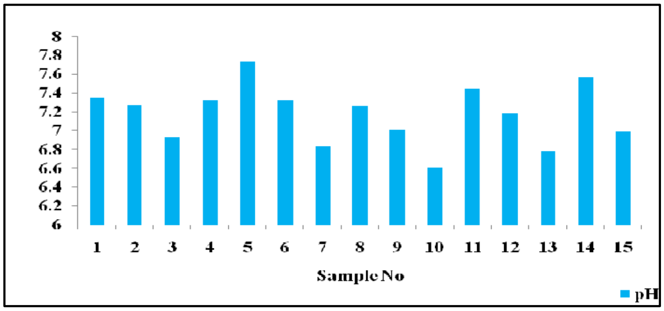

Figure 2: Variation of pH in different samples

The average value of pH in the sample water was found 7.17, where the standard deviation was 0.31. The pH values of all water samples from different wards were found in the permissible range according to the WHO and BDWS recommended standards concerning pH values. Therefore, the water was suitable for drinking purposes (Table 2).

3.3.2 Electrical Conductivity (EC)

The concentration of EC values in different wards of Sirajganj Municipality is indicated in Figure 3. In general, the EC values of all water samples ranged from 53 to 77 µS. Out of 15 samples, the minimum value of 53 µS was found at Hosenpur (Sample no. 09), and the maximum value of 77 µS was recorded at Goila (Sample no. S-07) (Table 1).

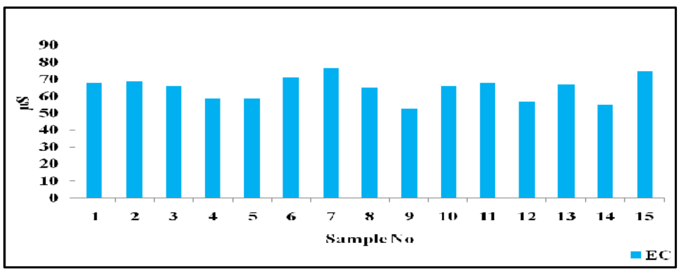

Figure 3: Variation of EC in different samples

According to the Water Quality Classification, EC values of water were classified as excellent (up to 250 µS), good (250-750 µS), fair (750-2,250 µS), and poor (>2,250 µS) (US Salinity Laboratory, 1954). The average EC value in the sample water was 65 µS, with a standard deviation of 7.07. Based on this classification, the mean EC value was categorized as excellent, falling below the permissible limit of BDWS and WHO-recommended standards. This classification indicates that the supplied water in Sirajganj Municipality is suitable for drinking purposes (Table 2).

3.3.3 Dissolve Oxygen (DO)

Figure 4 shows that the minimum concentration of DO value of 2.0 mg/L was found in the two water samples collected from Dhanbandhi (Sample No. S-10) and Hoshenpur (Sample No. S-13), whereas the maximum value was found at 3.9 mg/L in the water sample collected from Amlapara (Sample No. S-08) (Table 1).

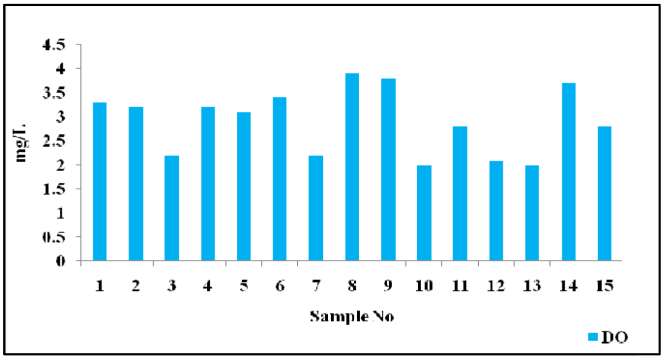

Figure 4: Variation of DO in different samples

In the case of DO value, the mean value of DO for different wards was found to be 2.91 mg/L with a standard deviation of 0.67, which was far below the BDWS recommended standards (Table 3). In this study, water directly comes from the overhead tank in the distribution pipes, and this distributed water cannot react with air. Probably due to this reason, DO levels were found in lower ranges.

3.3.4 Total Dissolve Solid (TDS)

The concentration of TDS values in different wards of Sirajganj Municipality is shown in Figure 5. The TDS values of supplied water ranged from 321-442 µS. The minimum concentration was found at 321 µS at Hosenpur (Sample No. S-11), and the maximum was at 442 µS at Goshala (Sample No. S-14) (Table 1). However, in our country, the standard acceptable value of TDS for drinking water was 1000 mg/L, according to the BDWS, 1997, and WHO, 2006 (1 µS = 1 mg/L).

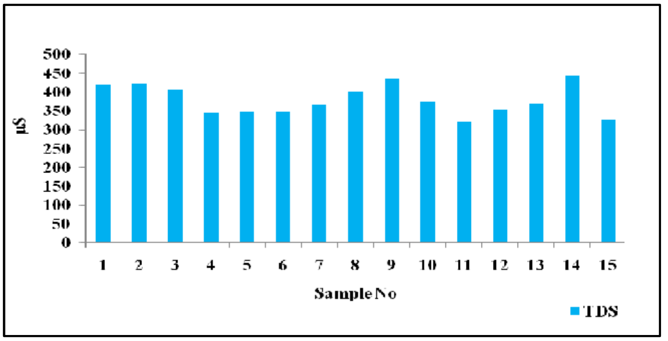

Figure 5: Variation of TDS in different samples

Depending on the TDS values, water could be grouped as excellent (<300 mg/L), good (300–600 mg/L), fair (600–900 mg/L), poor (900–1200 mg/L), and unacceptable (>1200 mg/L) (WHO, 1996a, b). The average TDS value of different wards in Sirajganj Municipality was found to be 378.93 µS with a standard deviation of 39.75. The present results indicate that all water samples were within the safe limit of WHO and BDWS recommended standards, which indicated that the supplied water in Sirajganj Municipality was suitable for drinking purposes (Table 2).

3.3.5 Acidity

Figure 6 indicates that the value of acidity ranges between 50 and 75 mg/L in the different wards of Sirajganj Municipality. The lowest value of acidity (50 mg/L) (as $CaCO_3$) was found in Datta Bari (Sample No. S-05), and the highest values of acidity (75 mg/L) were found in Mujib Sarak (Sample No. S-03), Amlapara (Sample No. S-08), Dhanbandhi (Sample No. S-10), and Kalibari (Sample No. S-15) (Table 2).

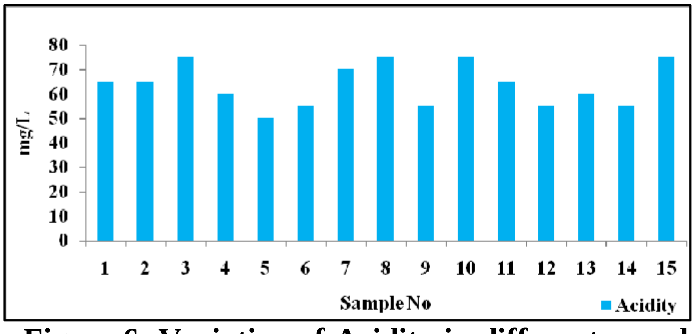

Figure 6: Variation of Acidity in different samples

3.3.6 Total Alkalinity (TA)

The test results of TA in all water samples ranged from 200 to 290 mg/L, as shown in Figure 7, whereas the minimum concentration was found at 200 mg/L in the water sample collected from SS Road (Sample No. S-01), Mujib Sarak (Sample No. S-03), and the maximum concentration was found at 290 mg/L in the water sample collected from Datta Bari (Sample No. S-05) (Table 1).

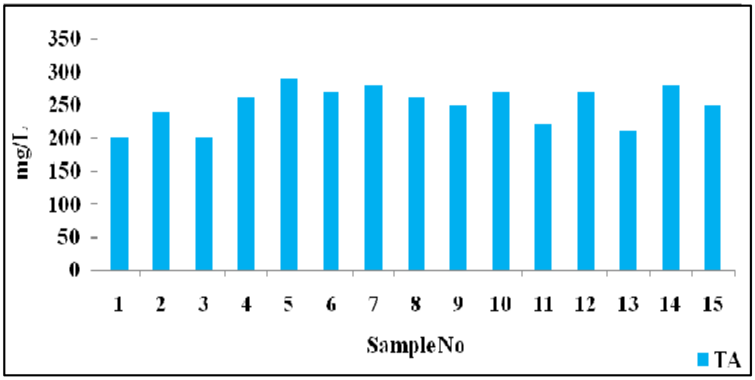

Figure 7: Variation of TA in different samples

The mean value of TA in sample water was 250 mg/L, and the standard deviation was 29.76, which was suitable for drinking purposes according to the BDWS and WHO recommended standards (Table 2).

3.3.7 Total Hardness (TH)

TH value in all supplied water samples in different wards at Sirajganj Municipality is presented in Figure 8, where the minimum TH value was found at 204 mg/L at Hoshenpur (Sample No. 11), and the maximum was found at 284 mg/L in the water sample collected from Mujib Sarak (Sample No. S-04) (Table 2).

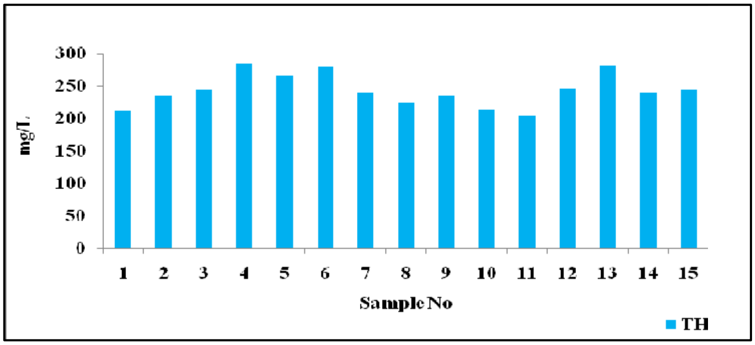

Figure 8: Variation of TH in different samples

Based on the TH value, water could be classified as soft (<75 mg/L), moderately soft

(75–150 mg/L), hard (150–300 mg/L), or very hard (>300 mg/L) (Sawyer and McCartly, 1967). Table 3 records a mean value of TH of 243.47 mg/L, where the standard deviation was 25.13. The results indicate that all of the water samples in the study period fall in the hard water category and below the MPLs according to the BDWS and WHO recommended standards (Table 3).

3.3.8 Arsenic (As)

The arsenic concentration of all selected supplied water samples could not probably be detected because of its absence (Table 1).

3.3.9 Iron (Fe)

The level of Fe concentration in all water samples is indicated in Figure 9. The minimum value was found to be 0.3 mg/L at Hosenpur (Sample No. S-09 and S-13), Dhanbandhi (Sample no. S-10) and Kalibari (Sample no. S-15) and the maximum value was found to be 0.9 mg/L at SS Road (Sample No. S-01) and Mujib Sarak (Sample No. S-04) (Table 1).

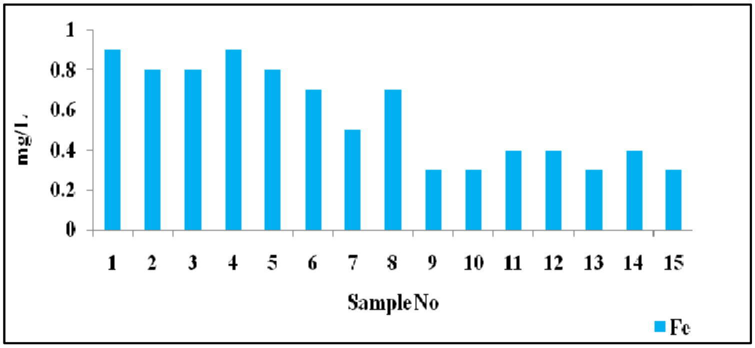

Figure 9: Variation of Fe in different samples

The concentration of Fe in the sample water was found to be 0.57 mg/L, with a standard deviation of 0.24. All water samples complied with the BDWS recommended standards (Table 2). However, the maximum concentration of Fe was observed in wards 03, 08, and 09, surpassing the WHO permissible limits (Table 2). The elevated levels of Fe in the sample water may result from the corrosion of old metal pipelines and inadequate treatment of groundwater before distribution in the supply network. I recommend that the municipal authority take immediate steps to address this issue in the mentioned wards.

4. Conclusion

This study aimed to characterize the physicochemical parameters of the supplied water from different wards in the Sirajganj Municipal area. The quality of the supply water was assessed by comparing parameters with the standard desirable limits prescribed by BDWS and WHO.

From the study, it can be concluded that the supplied water was deemed safe for drinking purposes based on the analysis of pH, EC, TDS, DO, acidity, TA, TH, Arsenic, and Fe. The values of pH, EC, TDS, and TA ranged between 6.61–7.73, 53–77 µS, 321-442 µS, and 200–290 mg/L, respectively, meeting the suitability criteria outlined in both BDWS and WHO guidelines. Arsenic was not detectable in the study area, and acidity values ranged between 50 and 75 mg/L. However, the TH varied from 204 to 284 mg/L, indicating hard water based on the water classification group of hardness (Sawyer and McCarthy, 1967). Despite this, the mean value of TH did not exceed the standard levels prescribed by BDWS and WHO guidelines. Therefore, it is suggested that the local water treatment plant should consider softening the supply of water before consumption.

In the case of DO and Fe, DO values varied from 2.0 to 3.9 mg/L, falling below BDWS recommended standards. However, Fe concentrations in some areas exceeded the WHO recommended standards, possibly due to the corrosion of old metal pipelines and inadequate treatment of groundwater before distribution in the supply network. The provision of pure water is crucial, and laboratory tests play a significant role in ensuring water quality. Considering population growth and estimated future water demand, the planning, design, construction, supervision, and maintenance of water supply systems for providing safe drinking water to local communities are essential. Improving the efficiency of the management system and ensuring a pure water supply system would greatly benefit the people in the future.

5. Recommendation

The current study affirms the suitability of water supplied in Sirajganj Municipality for drinking and cooking purposes. Furthermore, the following recommendations are proposed to enhance the water supply system in Sirajganj Municipality:

- Improve the provision for treating Fe concentrations in areas that exceed WHO standards. This involves enhancing the existing plant technology and replacing old pipelines.
- Address the hard water categorization indicated by the TH value by

recommending the local water treatment plant to soften the supply water before consumption.

- Implement regular monitoring of water quality across distribution networks and maintain overhead and service tanks to ensure the consistent supply of clean potable water.
- Organize training camps and workshops at various levels for employees, including lab assistants, scientific officers, engineering and field personnel. Training should cover ensuring acceptable water quality, mechanical expertise (engineering) for site selection, pipe selection (metal or plastic), GIS map division, and field personnel training for proper service connection, rehabilitation of old pipes, installation of new pipes, maintenance of sluice valves and chambers, and immediate identification and repair of leaks or faults.

References

Banglapedia. (2022). Sirajganj Sadar Upazila, Sirajganj district. *National Encyclopedia of Bangladesh, Asiatic Society of Bangladesh, Dhaka, Bangladesh.*

Buchholz, R.A. (1998). Principles of environmental management. *The Greening of Business, 2nd. Prentice-Hall, London, UK.*

ECR (Environmental Conservation Rules). (2023). *Ministry of Environment, Forest and Climate Change*, *Bangladesh*. *https://faolex.fao.org/docs/pdf/BGD219240.pdf.*

FAO (Food and Agricultural Organization). (2010).

Gleick, P.H. (1993). Water in Crisis: A Guide to the World's Freshwater Resources. *Oxford University Press., p. 13, Table 2.1-Water reserves on the earth.*

GoB (Government of Bangladesh). (2002). Arsenic Mitigation in Bangladesh. *Local Government Division, Ministry of LGRD and Co-operatives, Government of Bangladesh.*

Islam, M. S., Sarker, B. C., Mahmud, N. A., & Saifullah, A. S. M. (2013). Water quality and Sanitation status: A study on Char land of Bhuapur upazila under Tangail district. *Journal of the Bangladesh Agricultural University, 11(452-2016-35612), 209-214.*

Khayum, A., Nandini, N., Chandrashekar, J. S., & Durgesh, R. (2011). Assessment of drinking water quality of Bangalore west zone, India–a case study. *Environ. We. Int. J. Sci. Tech*, 6, 113-122.

Mengstie, Y. A., Desta, W. M., & Alemayehu, E. (2023). Assessment of Drinking Water Quality in Urban Water Supply Systems: The Case of Hawassa City, Ethiopia. *International Journal of Analytical Chemistry, 2023.*

Sara, V. Flanagan, Richard, B. Johnston and Yan Z., (2012). Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation. *Publication: Bulletin of the World Health Organization; Type: Policy and practice, Article ID: BLT.11.101253.*

Sarker, B. C., Sarker, S. K., Islam, M. S., & Sharmin, S. (2012). Public awareness about disposal of solid waste and its impact: a study in Tangail Pourashava, Tangail. *Journal of Environmental Science and Natural Resources*, 5(2), 239-244.

Sawyer, C.N., & McCartly, P.L. (1967). *Chemistry for Sanitary Engineers. 2nd edition, McGraw Hill, New York, pp: 518.*

SFD-Sustainable Sanitation Alliance. (2020). Sirajganj Municipality, Bangladesh. https://sfd.susana.org/about/worldwide-projects/city/277-sirajganj-municipality

Shamimuzzaman, M., Nayeem, R. H., Ara, N., Rahman, M. M., Jahid, M. I. K., & Hasan, M. N. (2019). Physico-chemical and microbiological quality assessment of supply water around Dhaka city, Bangladesh. Journal *of Water Resource and Protection, 11(03), 280.*

Sharifa Begum, Mansur Ahmed and Binayak Sen (2011). Do Water and Sanitation Interventions Reduce Childhood Diarrhea? New Evidence from Bangladesh. *Bangladesh Development Studies, Vol. XXXIV, No. 3.*

Spira, W. M. Y. A., Sayeed, M. U. Khan. & M. A. Sattar. (1980). Microbiological Surveillance of Intra-Neighbourhood El Tor Cholera Transmission in Rural Bangladesh. *Scientific Report 35. ICDDR'B, Dhaka, Bangladesh.*

United Nations. (2005). Un.org. 2005-03-22. Retrieved 2010-07-25.

US Salinity Laboratory. (1954). Diagnosis and Improvement of Saline and Alkali Soils.

WHO (World Health Organization). (1996a). Guidelines for Drinking-Water Quality. 2nd Edition, *Health Criteria and Other Supporting Information, WHO, Geneva, Switzerland.*

WHO (World Health Organization). (1996b). Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programs. *E and FN Spon, London, UK.*

WHO (World Health Organization). (2006). *Guidelines for drinking water quality, World Health Organization, Geneva, Switzerland.*

WHO-UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation. (2003- 2010).