Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 22 | No. 1 | pp. 245-252 | 2023

Original Research Paper

https://doi.org/10.46488/NEPT.2023.v22i01.023

Open Access Journal

Analysis of Water Quality of Hatirjheel Lake, Dhaka, Bangladesh

A. B. M. Kamal Pasha, Syed Omayer Mustafa, S. M. Mahmudur Rahman†, Muhammad Abdullah, Md. Azharul Haque Chowdhury and Mahfuza Parveen

Department of Environmental Science and Disaster Management (ESDM), Daffodil International University (DIU), Daffodil Smart City, Birulia, Savar, Dhaka, 1216, Bangladesh

†Corresponding author: S. M. Mahmudur Rahman; mahmudur.esdm0017.r@diu.edu.bd

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 09-04-2022
Revised: 28-05-2022
Accepted: 29-05-2022

Key Words:
Hatirjheel lake
Water quality parameters
Dissolved oxygen
Aquatic ecosystem

ABSTRACT

The study assessed the status of water quality parameters for an urban water body (Hatirjheel Lake) in Dhaka, the Capital city of Bangladesh. Nine different water samples were collected from nine points of the lake during the dry season in January 2021. Water quality parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), total alkalinity, total acidity, total hardness, Ca^{2+} hardness, free CO_2, and dissolved oxygen (DO) were determined for the samples. The status of the parameters is pH (6.51-7.05), EC (510-600 $\mu S.cm^{-1}$), TDS (450-590 ppm), TSS (0.0-0.034 $mg.L^{-1}$), total alkalinity (80-392 $mg.L^{-1}$), total acidity (224-500 $mg.L^{-1}$), total hardness (348-452 $mg.L^{-1}$), Ca^{2+} hardness (74-162 $mg.L^{-1}$), free CO_2 (730-1170 $mg.L^{-1}$), DO (2.7-5.5 $mg.L^{-1}$). However, the DO value at some points of the lake is too less (2.7 $mg.L^{-1}$ and 3.7 $mg.L^{-1}$) than the standard value (> 5-6 $mg.L^{-1}$) of ECR, DoE, which might not be healthy for any water body and aquatic ecosystem. Other water quality parameters are within the permissible limit of WHO and ECR, DoE.

INTRODUCTION

Water is the most essential aspect of all-natural resources and is necessary for all living organisms to keep functioning. The regional and seasonal availability of water, as well as the quality of surface and groundwater, have a major impact on Bangladesh's environment, economic growth, and development. Water bodies are an essential component of a smart city. As Dhaka has grown into a megacity over the last few decades, the importance of green areas, wetlands, different water bodies, and uncluttered spaces is clearly understood. The city's waterbody is approximately 10-15% of its total terrestrial area (Miah et al. 2017). In the center of Dhaka, Hatirjheel lake plays a significant role in the city's drainage system. It was previously linked to the Banani, Dhanmondi, and Gulshan Lakes, as well as the Begun Bari Khal at the Rampura Bridge (Tariquzzaman et al. 2016). The lake, which covers 302 acres in the Tejgaon, Moghbazar, and Rampura regions, has played an important role as the area's only drainage system (Miah et al. 2017). It performs critical hydrologic functions such as source and sinks for the storm of the wide area of Dhaka. The storm sewers that discharge into Hatirjheel are built to carry stormwater. As a result, the Hatirjheel-Begunbari Khal system is the largest and most significant drainage system in Dhaka (Hossain et al. 2020) where approximately one-third of the city's stormwater is drained through this lake (Tehsin 2020).

Within the Dhaka Metropolitan Area (DMP), Haitrjheel is a prominent depression and the lake has long been in demand by city dwellers seeking physical and spiritual sustenance. Intense urban growth, combined with human intervention, has resulted in water quality depletion (bad odor, turbid water, inappropriate for use), as well as siltation and contamination from residential, industrial, and agricultural waste (Chowdhury & Chowdhury 2018). Different forms of urban waste are trapped and excessive waste water is deteriorating the quality of the lake ecosystem. As a result, it creates a great impact on biodiversity. Habitats for the species are deteriorating as well at the lake. Birds, fishes, aquatic plants, and other species have disappeared from the

ORCID details of the authors:

A. B. M. Kamal Pasha
https://orcid.org/0000-0002-6144-2537
S. M. Mahmudur Rahman
https://orcid.org/0000-0003-1992-8864
Muhammad Abdullah
https://orcid.org/0000-0001-6129-9622
Md. Azharul Haque Chowdhury
https://orcid.org/0000-0002-6383-4964
Mahfuza Parveen
https://orcid.org/0000-0002-1491-0481

lake where solid wastes are creating a problematic situation. In the lake bed, a dense layer of solid waste sediments is forming. As a result, plants that grow in a lake's bed that provide food for fish and other living organisms are no longer viable. The reverse scenario, on the other hand, is still being pursued. Excess nitrogen and phosphorous from waste will accumulate in lake water, and consequently, rooted aquatic plants and algae can invade quickly. Further, the algal bloom can cause navigation problems in lake water, as well as other environmental issues (Tariquzzaman et al. 2016).

Bangladesh, luckily, has sufficient freshwater reserves due to its geographic location. However, in Dhaka city, due to overcrowding, ignorance, and a lack of legal compliance, the overall quality of almost all of the waterbodies deteriorated (Parvin et al. 2019). The Hatirjheel Lake has been reduced to a drain and it is no longer pleasing to the eye. In contrast to the surrounding landscapes and the environment, this lake often spread excessive bad odor, and form a type of color that is not pleasant to the eyes. In this consequence, finding the present condition of water pollution and evaluating the water quality of this lake is very necessary. Thus, the present study was conducted to evaluate the water quality of Hatirjheel Lake by using the physicochemical properties of water.

MATERIALS AND METHODS

Study Area

Hatirjheel Lake (23°44′58.47″ N and 90°23′48.35″ W) is an urban recreational zone with a combination of integrated transportation facilities in the center of Dhaka city, with a length of 4.1 km and a surface area of 0.79 km^2 (Google earth). It is 2.6 meters deep on average. The lake is 460 meters wide at its widest point (Tariquzzaman et al. 2016). The lake is surrounded by the north, south, east and west by Gulshan-Banani, Maghbazar-

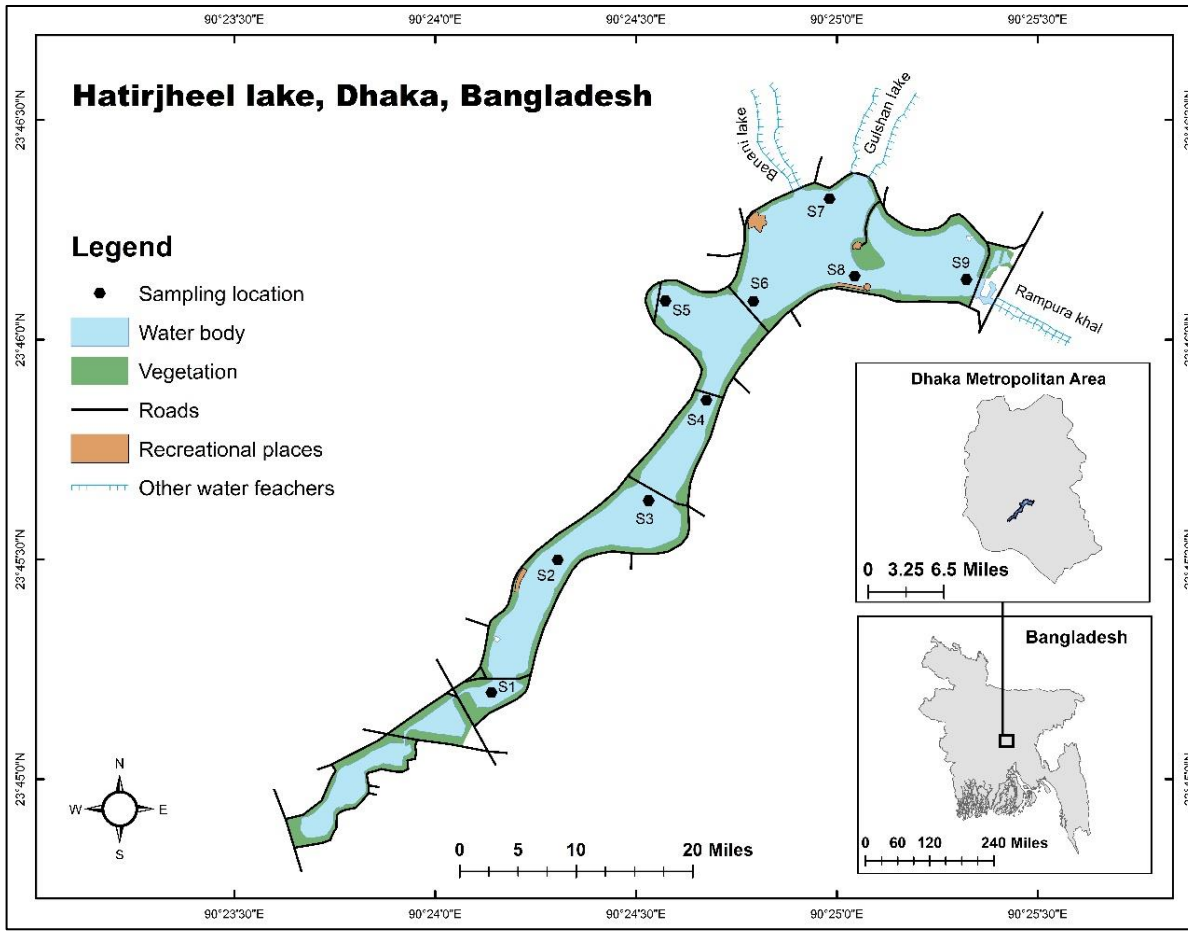


Fig. 1: Study area and the sampling locations.

Banglamotor, Rampura-Badda, and Tejgaon industrial areas respectively.

Sampling and Sampling Locations

Nine (09) different water samples (surface water) were collected into 250 ml sample collection bottles (HDPE) from nine (09) different locations of this lake during the dry season on 16th January 2021 (Fig. 1). Before the collection of water samples, the bottles were cleaned and washed with detergent solution, and then rinsed with deionized water and dried. After completion of the sample collection, bottles were closed instantly and labeled distinctly (Rezwan et al. 2022). Finally, the samples were immediately transported to the laboratory for water quality parameter measurements and analysis.

Sample Analysis and Instrumental Techniques

This study was carried out to explore the state of water and its quality throughout Hatirjheel Lake, after bringing the samples to the laboratory. To do that, the physical and chemical properties of the lake water were analyzed. The pH and Total Dissolved Solids (TDS) were determined by the *HANNA* pH/EC/TDS/Temperature Meter (HI9814), whereas. The electrical conductivity (EC) and temperature were measured by *HANNA* Pocket Conductivity Meter (HI-98303), DiST®4 EC Tester, and Dissolved Oxygen (DO) by Lutron 5509 Dissolved Oxygen Meter. The samples were diluted every time before each lab test to get the value within the existing range of the equipment. Acidity was analyzed through the titrimetric method using a standard solution of 0.02N NaOH solution, whereas, the alkalinity was measured through the same titrimetric method by titrating water samples against 0.02N HCl solution. Total Hardness and Calcium hardness were analyzed through a titration process by using a standard solution of 0.01N EDTA. The concentration of Free CO_2 was determined by the titrimetric method using 0.05N NaOH standard solution.

Statistical Analysis

All experimental results are presented as the mean ± S.D. (n = 3). The mean difference was evaluated at the significant level of 0.01 and 0.05. Pearson's correlation was calculated among the water quality parameters. IBM SPSS (Version 23) and Microsoft Excel (Version 2016) were used to analyze the collected data. Bar charts and tabular forms were used to present the findings of this study.

RESULTS AND DISCUSSION

The status of the physio-chemical properties of nine water samples in this study are given in Fig. 2. Among the water quality parameters, pH is a significant one (Hasan et al. 2009). The pH status of the samples ranges from 6.51-7.05 (Table 1). The study identified the highest pH value in sample 1 (S1) whereas the lowest pH value was in sample 7 (S7) (Fig. 2 A), which demonstrates that the water quality of S7 was quite acidic. The study found the presence of battery industries effluent and effluent from the restaurants around the area of S7 that indicated a lower pH value at the site compared to all other samples. A smiler study reported that Hatirjheel Lake water poses a mean value of pH 7.18 (Islam et al. 2015).

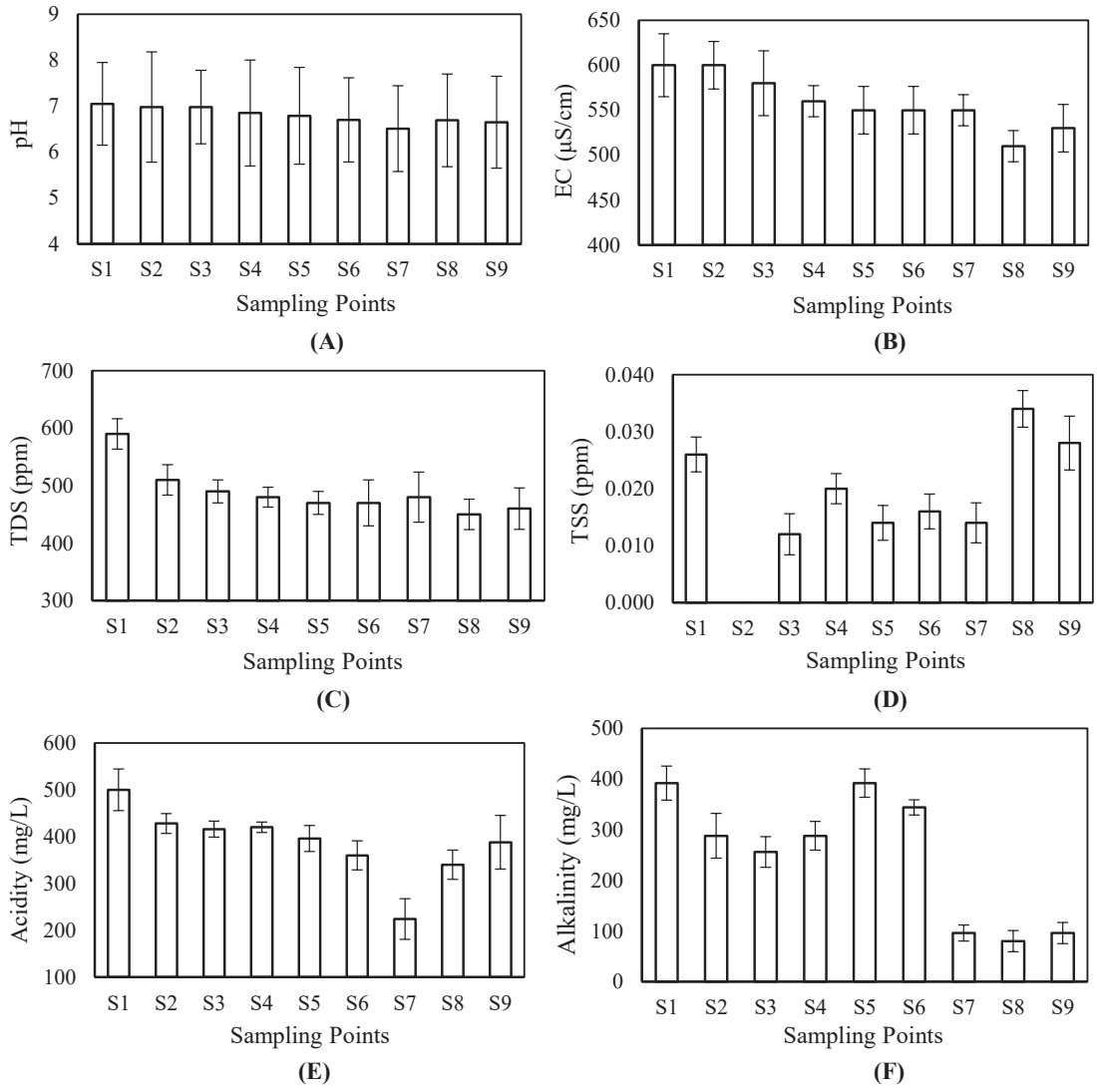
Electrical conductivity (EC) is an essential water quality parameter that indicates the water capacity for conducting the electrical current (Pasha et al. 2022). The status of EC throughout the lake ranges between 510-600 $\mu S.cm^{-1}$ (Table 1). The study recorded the highest EC value in samples 1 and 2 (S1 and S2) respectively, and the lowest in sample 8 (S8) (Fig. 2 B). The concentration of EC has exceeded the permissible limits in the lake (WHO 2003). Another study shows that the EC value of the same season was found about 709.3 $\mu S.cm^{-1}$ (Islam et al. 2015). They have also found that, during the post-monsoon season, the EC was lower, than that of the pre-monsoon season. Total dissolved solids (TDS) are the number of solids that exists in a water sample (Uddin et al. 2016). The concentration of TDS in the lake ranges between 450-590 ppm (Table 1). The study found the highest TDS value in sample 1 (S1) and the lowest in sample 8 (S8) (Fig. 2 C). The study identified the dumping of household wastes and discharge of household effluents in the area that indicated a higher TDS value at the sampling site among all other sampling sites. The standard limit of TDS is 1000 ppm (ECR 1997, Gorchev & Ozolins 2004). The concentration of TSS in the lake ranges between 0-0.034 $mg.L^{-1}$ (Table 1) whereas the standard value of TSS is 10 $mg.L^{-1}$ (ECR 1997) and 150 $mg.L^{-1}$ (Gorchev & Ozolins 2004). The study found the highest TSS value in sample 8 (S8) and the lowest in sample 2 (S2) (Fig. 2 D). The filtration process has been used through the Buchner Funnel in the TSS determination.

The titrimetric method has been used in the acidity, alkalinity, hardness, and free carbon dioxide determination (Pasha et al. 2022, Rezwan et al. 2022). Water has the capability to neutralize bases, which is considered acidity (Pasha et al. 2022). The concentration of Total acidity of the lake ranges between 224-500 $mg.L^{-1}$ (Table 1). The analysis shows that the highest value of acidity was found in sample 1 (S1) and the lowest in sample 7 (S7) (Fig. 2 E). Due to the existence of weak acid and a higher amount of base water can be highly alkaline, generally (Islam & Majumder 2020). The concentration of Total Alkalinity of the lake ranges between

Table 1: Level of different water quality parameters of Hatirjheel lake.

Parameters	Minimum	Maximum	Mean	SD	ECR 1997	WHO 1984
pH	6.51	7.05	6.80	0.18	6.5-8.5	6.5-8.5
EC (µS/cm)	510	600	558.89	30.18	500-700	150
TDS (ppm)	450	590	488.89	41.67	1000	1000
TSS (ppm)	0.00	0.04	0.02	0.01	10	150
Acidity (mg/L)	224	500	385.78	75.79	-	-
Alkalinity (mg/L)	80	392	248	126.68	200-500	200
Total hardness (mg/L)	348	452	392	35.72	200-500	500
Ca^{2+} hardness (mg/L)	74	162	122.44	25.59	-	500
Free CO_2 (mg/L)	730.40	1170.40	906.36	162.34	-	-
DO (mg/L)	2.70	5.50	4.42	0.94	> 5-6	-

* SD = Standard deviation



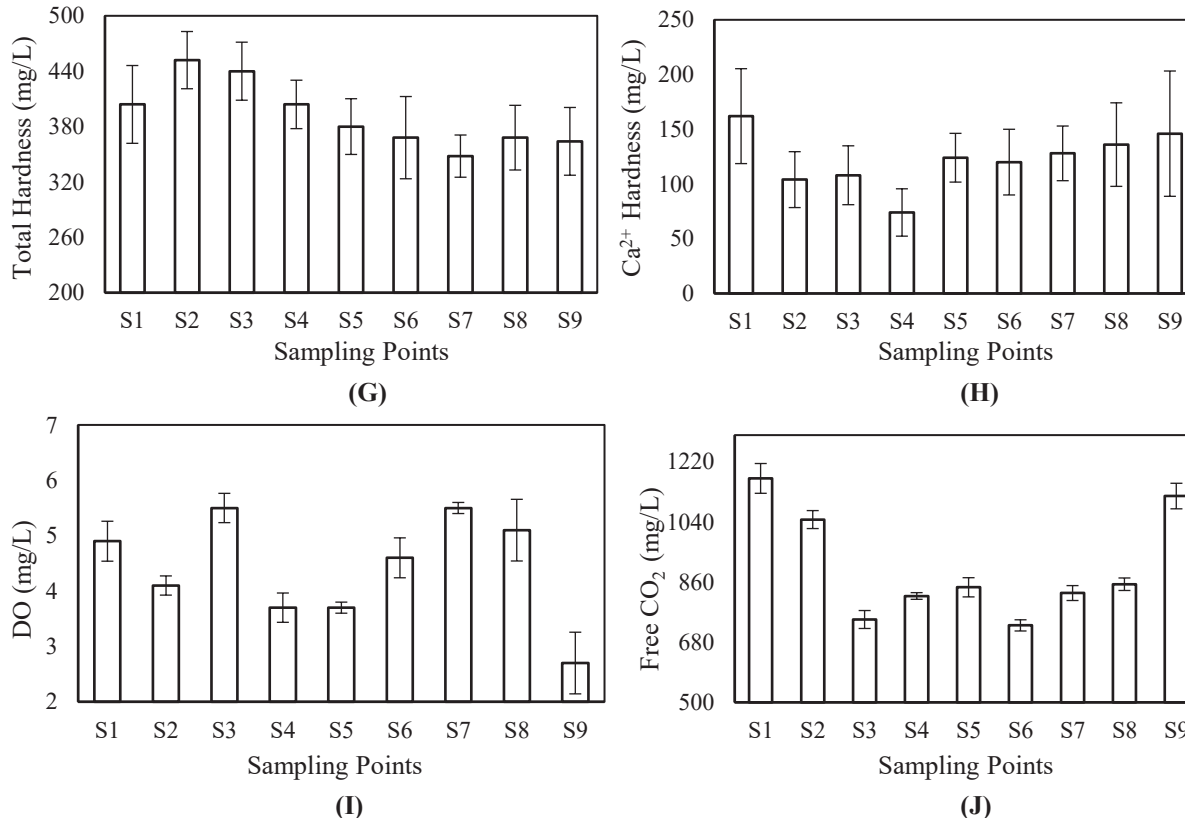


Fig. 2: Status of water quality in the Hatirjheel lake, (A) pH; (B) Electrical conductivity (EC); (C) Total dissolved solids (TDS); (D) Total suspended solids (TSS); (E) Total acidity; (F) Total alkalinity; (G) Total hardness; (H) Ca^{2+} Hardness; (I) Dissolved oxygen (DO); (J) Free carbon dioxide.

Table 2: Cross-correlation matrix between the water quality parameters.

WQP	pH	EC	TDS	TSS	Acidity	Alkalinity	TH	Ca^{2+} H	Free CO_2	DO
pH	1									
EC	**0.802	1								
TDS	*0.702	**0.814	1							
TSS	-0.280	-0.621	-0.106	1						
Acidity	**0.893	0.593	0.618	-0.002	1					
Alkalinity	0.664	0.641	0.539	-0.381	0.659	1				
TH	**0.879	*0.774	0.440	-0.567	0.665	0.440	1			
Ca^{2+} H	-0.132	-0.142	0.326	0.515	0.017	-0.147	-0.423	1		
Free CO_2	0.316	0.319	0.581	0.193	0.487	0.011	0.146	0.558	1	
DO	0.059	0.176	0.232	-0.084	-0.301	-0.070	0.068	0.089	-0.405	1

Legend: ** = Significant at 0.01 level; * = Significant at 0.05 level

WQP = Water Quality Parameters; TH = Total Hardness; Ca^{2+} H = Ca^{2+} Hardness;

80-392 $mg.L^{-1}$ (Table 1), where the standard value is 200-500 $mg.L^{-1}$ (ECR 1997, WHO 2003). The highest alkalinity was found in samples 1 and 5 (S1 and S5) and the lowest in sample 8 (S8) (Fig. 2 F). The study observed the mixing of sewage effluents with the water body around the sampling site of S1 and S5. The effluents from the households contained several chemical compounds that contributed to the higher alkalinity in the S1 and S5 sampling area compared to all other samples.

Hardness in water is the presence of minerals (calcium and magnesium) in the water. Hard water contains dissolved minerals in a significant amount, and soft water contains minerals dissolved in fewer amounts (Takahashi & Imaizumi

1988). The value of the total hardness of the lake is found between 348-452 mg.L^{-1} (Table 1). The highest total hardness was found in sample 2 (S2) and the lowest in sample 7 (S7) (Fig. 2 G). The standard concentration of Total Hardness is 200-500 mg.L^{-1} (ECR 1997, WHO 2003). All nine (09) water samples were evaluated to detect the Ca^{2+} hardness. The value of Ca^{2+} Hardness of the lake is ranged between 74-162 mg.L^{-1} (Table 1) and the standard limit of Ca^{2+} Hardness is 500 mg.L^{-1} (Gorchev & Ozolins 2004, WHO 2003)a basic human right and a com- ponent of effective

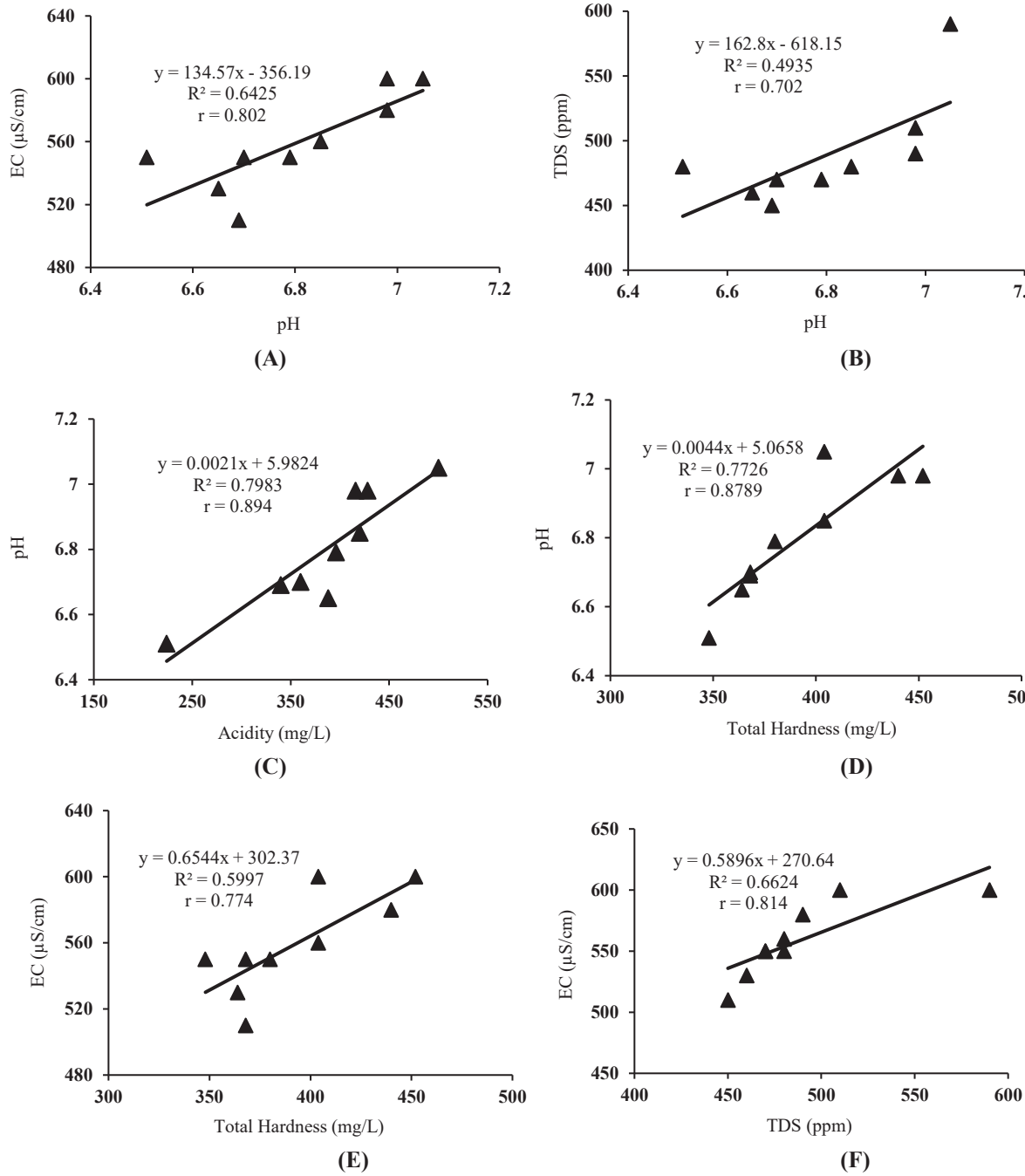


Fig. 3: Correlation between, (A) pH and EC; (B) pH and TDS; (C) pH and Acidity; (D) pH and Total Hardness; (E) EC and Total Hardness; (F) EC and TDS.

policy for health protection. The importance of water, sanitation and hygiene for health and development has been reflected in the outcomes of a series of international policy forums. These have included health-oriented conferences such as the International Conference on Primary Health Care, held in Alma-Ata, Kazakhstan (former Soviet Union. The highest total hardness was found in sample 1 (S1) and the lowest in sample 4 (S4) (Fig. 2 G). Fig. 2 (J) shows that the concentration of Free CO_2 in the lake is found between 730-1170 $mg.L^{-1}$. The highest free CO_2 was found in sample 1 (S1) and the lowest in sample 6 (S6) (Fig. 2 J). As an indicator of the appropriate water quality, dissolved oxygen (DO) is a vital parameter (Pasha et al. 2022). The concentration of DO in the water of Hatirjheel Lake is ranged between 2.7-5.5 $mg.L^{-1}$. In the present study, the highest DO was found in samples 3 and 7 (S3 and S7), and the lowest in sample 9 (S9) (Fig. 2 I). According to the Environmental Conservation Rules by the Department of Environment, Government of Bangladesh, the DO value should have to be 5 $mg.L^{-1}$ for a healthy aquatic ecosystem and the survival of the aquatic species (Uddin et al. 2016, ECR 1997). The study found that the value of dissolved oxygen was significantly lower in all other samples except samples 3, 7, and 8. It indicates that the concentration of DO is not sufficient in the lake water.

The cross-correlation matrix here is showing the correlation between the water quality parameters in Table 2. The relationship between pH and EC represents that the value of pH is increasing with the increase of EC. It is a positive relationship, where r = 0.802 (strong positive relationship) (Fig. 3 A). The relationship between pH and TDS of the sample waters represented that the value of pH is increasing with the increase of TDS. It is also a positive relationship, where the r = 0.702 (moderate positive relationship) (Fig. 3 B). The relationship between pH and Acidity represents that the value of pH is increasing with the increase in total hardness. It is a positive relationship, where r = 0.894 (strong positive relationship) (Fig. 3 C). The relationship between pH and Total Hardness of the sample waters represented that the value of pH is increasing with the increase of Total Hardness. It is also a positive relationship, where the r = 0.879 (strong positive relationship) (Fig. 3 D). The relationship between EC and Total Hardness represents that the value of EC is increasing with the increase in total hardness. It is a positive relationship as well, where r = 0.774 (moderate positive relationship) (Fig. 3 E). The relationship between EC and TDS of the sample waters represented that the value of EC is increasing with the increase of TDS. It is also a positive relationship, where the r = 0.814 (strong positive relationship) (Fig. 3 F).

CONCLUSIONS

The status of the determined water quality parameters (pH, EC, TDS, TSS, alkalinity, acidity, hardness, Ca^{2+} hardness, Free CO_2) of the Hatirjheel Lake is quite good in terms of the surrounding environment, as the responsible authorities working continuously to improve the water quality of the lake from 2014. However, the water quality is not good enough for the purpose of human use. Though, the DO value at some point of the lake is too less (2.7 $mg.L^{-1}$ at S9, 3.7 $mg.L^{-1}$ at S4 and S5) than the standard value (>5-6 $mg.L^{-1}$), and the mean DO value of the lake is only 4.4 $mg.L^{-1}$. So, still, there is scope to work on the biological water quality, turbidity of the water body, etc. to ensure the healthy ecosystem of the lake.

ACKNOWLEDGMENTS

The authors are grateful and give thanks for this work being supported by the faculty and officials of the Department of Environmental Science and Disaster Management (ESDM), Daffodil International University (DIU).

REFERENCES

Chowdhury, S. and Chowdhury, R. 2018. Assessment of water quality of Hatirjheel and Gulshan lakes. International Journal of Innovative Research in Science, Engineering, and Technology, 7(7): 8374-81.

ECR 1997. The Environment Conservation Rules. Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, pp. 179-227.

Gorchev, H.G. and Ozolins, G. (ed.) 2004. Guidelines for Drinking-Water Quality, 3rd Edition. WHO 1:564.

Hasan, I. Rajia, S. Kabir, K.A. and Latifa, G.A. 2009. Comparative study on the water quality parameters in two rural and urban rivers emphasizing on the pollution level. Glob. J. Environ. Res., 3(3): 218-222.

Hossain, M.I. Ansari, M.N.A. and Saika, U. 2020. Lake base urban recreation in Dhaka metropolitan area: Hatirjheel lake as a potential case. International Journal of Research Granthalaya, 5(12): 266-74.

Islam, M.S. and Majumder, S.M.M.H. 2020. Alkalinity and hardness of natural waters in Chittagong City of Bangladesh. Int. J. Sci. Bus., 4(1): 137-150.

Islam, M.S. Rehnuma, M. Tithi, S.S. Kabir, M.H. and Sarkar, L. 2015. Investigation of water quality parameters from Ramna, Crescent and Hatirjheel lakes in Dhaka city. Journal of Environmental Science and Natural Resources, 8(1): 1-5.

Miah, M.B. Majumder, A.K. and Latifa, G.A. 2017. Evaluation of microbial quality of the surface water of Hatirjheel in Dhaka city. Stamford Journal of Microbiology, 6(1): 30-33.

Parvin, M. Muzahed, M. and Majumder, A.K. 2019. A comparative study on the selected parameters of water quality of Dhanmondi, Ramna and Hatirjheel lakes in Dhaka city. Journal of the Asiatic Society of Bangladesh, Science, 45(2): 261-65.

Pasha, A.B.M.K. Abdillahi, M. M. Rahman, S.M.M. Mozumder, S. Chowdhury, A.H. Fuente, J.A.D. and Parveen, M. 2022. Studies on physicochemical properties of Buriganga river water and the vegetation coverage of surrounding area, Dhaka, Bangladesh. Sci. Int. (Lahore), 34(2): 73-78.

Rezwan, S.M. Chowdhury, M.A.H. and Rahman, S.M.M. 2022. Assessment of ecosystem services, plant diversity pattern, and water quality of an urban water body in Dhaka, Bangladesh. In: Abdalla, H. Rodrigues, H. Gahlot, V. Salah Uddin, M. and Fukuda, T. (eds) Resilient and Responsible Smart Cities. Advances in Science, Technology & Innovation. Springer, Cham.

Tariquzzaman, S.M. Nishu, S. Saeed, T.F. and Reday, R.A. 2016. Water quality and EIA of simple Hatirjheel lake. In: Proceedings of the 3rd International Conference on Civil Engineering for Sustainable Development, (February), pp. 978–84.

Takahashi, Y. and Imaizumi, Y. 1988. Hardness in drinking water. Eisei Kagaku, 34(5): 475-579.

Tehsin, S. 2020. Ecosystem Services of Hatirjheel Lake of Dhaka, Bangladesh. (Unpublished).

Uddin, M.G. Moniruzzaman, M. Hoque, M.A.A. Hasan, M.A. and Khan, M. 2016. Seasonal variation of physicochemical properties of water in the Buriganga River, Bangladesh. World Appl. Sci. J., 34(1): 24-34.

WHO 2003. Guidelines for the Safe Recreational Water Environment. Vol. 1, Coastal and Fresh Waters. World Health Organization.