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Water Quality Assessment and Trophic State Evaluation of Foy's Lake, Bangladesh

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Abstract: In recent years, human activities have significantly altered Foy's Lake, shifting it from a clear, pristine state to a turbid, eutrophic condition. Thus, this study analyzed seasonal variations of physicochemical parameters, chlorophyll-*a* levels, and the trophic state index (TSI) to assess water quality and trophic state fluctuations in Foy's Lake, Chittagong. Sampling was conducted in September 2023 (as wet season) and January 2024 (as dry season) to assess the key water quality parameters including transparency, temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), total alkalinity (TA), and chlorophyll-*a* (Chl-*a*). Secchi depth (SD) and Chl-*a* concentration were used to determine trophic conditions based on the Carlson Trophic State Index (CTSI). Results showed that in wet season, temperature, pH, DO, EC, TDS, transparency, TA, TH, and Chl-*a* ranged from 30.25–30.9°C, 5.4–5.5, 7.21–7.55 mg/L, 123.6–136.3 µS/cm, 51.5–78.48 mg/L, 109.06–126.94 cm, 49.6–68.4 mg/L, 36.09–41.75 mg/L, and 0.824–1.072 µg/L, respectively. In dry season, these values ranged from 28.45–29.02°C, 5.11–5.37, 6.36–6.92 mg/L, 143.7–156.3 µS/cm, 43.24–83.12 mg/L, 183.82–218.98 cm, 95.95–130.71 mg/L, 39.03–43.35 mg/L, and 0.885–0.933 µg/L, respectively. The mean TSI values based on SD and Chl-*a* were 59.58–48.54 and 31.23–28.75, respectively. Overall, most parameters decreased in the dry season except for transparency, EC, total alkalinity, and total hardness. While temperature, EC, DO, TH, TA, and Chl-*a* remained within standard limits, transparency exceeded the standard for aquaculture in both seasons. TSI values classified the lake as oligotrophic (Chl-*a*) and eutrophic (SD) in both seasons. Pearson's correlation analysis showed strong positive relationships among most parameters. To preserve the ecological integrity and aesthetic value of Foy's Lake, the study recommends the necessity to develop guidelines for the trophic status monitoring of Foy's Lake since results suggest the deteriorating lake condition.

Keywords: Water quality; Chlorophyll-*a*; TSI; Eutrophication; Foy's Lake.

INTRODUCTION

Water, often referred to as the molecule of life, is fundamental to the survival of all living organisms and plays an indispensable role in sustaining ecological balance and economic development (Kabir *et al*., 2020). Covering approximately 71% of the Earth's surface, water is not only a vital resource for hydration and sanitation but also supports a wide range of activities across the agricultural, industrial, fisheries, and hydropower sectors (Shammi *et al*., 2022). Aquatic ecosystems, which are inherently dynamic, serve as critical habitats for numerous species, enabling movement, reproduction, oxygen exchange, and other life-supporting processes (Islam *et al*., 2015) Wetlands and inland water bodies-such as rivers, lakes, canals, haors, baors, and beels-are integral components of the global freshwater network and are particularly prominent in Bangladesh (Islam *et al*., 2022). These resources serve as repositories of biodiversity and offer various ecosystem services that support the livelihoods of

local communities (Nion *et al*., 2020). Among these, lakes hold a special ecological and socio-economic significance. Defined as inland water bodies disconnected from ocean systems, lakes are complex ecosystems that integrate biological, chemical, and physical characteristics (Bhateria & Jain, 2016). Despite accounting for just 0.3% of the global surface water resources, lakes provide essential services including drinking water supply, fisheries, recreation, and aesthetic value (Vasistha & Ganguly, 2020). However, the ecological integrity and water quality of lakes are increasingly threatened by a multitude of anthropogenic pressures. Recreational activities, urban runoff, agricultural discharges, and industrial effluents often introduce pollutants such as nutrients, pesticides, and heavy metals into lake systems (Islam *et al*., 2021). These pollutants can lead to eutrophication-a process characterized by excessive algal growth, reduced transparency, and oxygen depletion-which significantly degrades water quality and aquatic life health (Shammi *et al*., 2022). Consequently, understanding and monitoring the water quality of lakes are critical for ensuring their sustainable use and ecological preservation.

Water quality is typically assessed using a suite of physical, chemical, and biological parameters. These include physical aspects such as temperature and turbidity; chemical parameters such as pH, conductivity, dissolved oxygen (DO), total dissolved solids (TDS), and nutrient concentrations; and biological indicators like plankton diversity and chlorophyll-*a* levels (Delincé, 2013). Among these, chlorophyll-*a* serves as a direct proxy for algal biomass and primary productivity, makes it a key indicator in eutrophication studies (Islam *et al*., 2021). The Trophic State Index (TSI), developed to categorize lakes based on nutrient enrichment and productivity levels, uses variables such as chlorophyll-*a* concentration, Secchi disk transparency, and total phosphorus to classify lakes into oligotrophic, mesotrophic, or eutrophic states (Islam *et al*., 2022; Nion *et al*., 2020). The relevance of water quality monitoring becomes even more pronounced in the context of recreational lakes, which often serve dual ecological and societal functions. These lakes contribute to urban groundwater recharge, flood management, and microclimatic regulation, while simultaneously offering spaces for leisure, tourism, and cultural engagement (Sultana & Islam, 2016), making it imperative that their water quality is suitable and regularly monitored to safeguard public health and ecological stability.

Foy's Lake, located in the Pahartali area of Chittagong, Bangladesh, is a notable example of a multi-functional urban lake. Originally constructed to serve the water needs of the railway colony, it has since evolved into a significant recreational hub for the region (Bhouyain & Sen, 1991; Hossain *et al*., 2021). Despite its ecological and recreational importance, systematic scientific studies on the water quality and trophic status of Foy's Lake remain scarce. In particular, the Trophic State Index (TSI) and its components: chlorophyll-*a* TSI and Secchi depth TSI-has not been previously evaluated in this context. Given the increasing pressures from tourism, urban development, and potential pollution sources, there is an urgent need to assess the lake's current ecological health and productivity status. Therefore, this study was undertaken with the following objectives: (i) to assess the quality of water in Foy's Lake by measuring key physicochemical parameters, and (ii) to determine the Trophic State Index (TSI) of Foy's Lake using Chlorophyll-*a* TSI and Secchi Disk Depth TSI. By addressing these objectives, the study aims to contribute to the scientific understanding and sustainable management of urban recreational lakes, with particular emphasis on ecosystem health, water quality, and eutrophication dynamics.

MATERIALS AND METHODS

Study Area

Foy's Lake is an artificial freshwater lake located in Chittagong, Bangladesh, geographically positioned at approximately 22.22°N latitude and 91.48°E longitude (Fig. 1). Constructed during the British colonial period, with the primary objective of ensuring a reliable water supply for the Chittagong Railway Department. The lake was created by damming a natural depression, and it originally provided an estimated water supply of approximately 800,000 gallons (Bhouyain & Sen, 1991). It is surrounded by hills on all sides, which not only contribute to its scenic landscape but also influence its hydrological dynamics. The catchment area of the lake covers approximately 320 acres. Unlike many natural lakes, Foy's Lake has no defined outflow, making it a closed-basin water body. Its primary water sources include natural springs, along with additional inputs from surface runoff, seepage, and direct precipitation. Hydrologically, the lake exhibits significant spatial variability in both depth and length, with a maximum depth of around 6 meters recorded during the dry season (Hossain *et al*., 2021). Although the lake has not been formally developed for aquaculture, subsistence fishing by local communities has historically been a common practice.

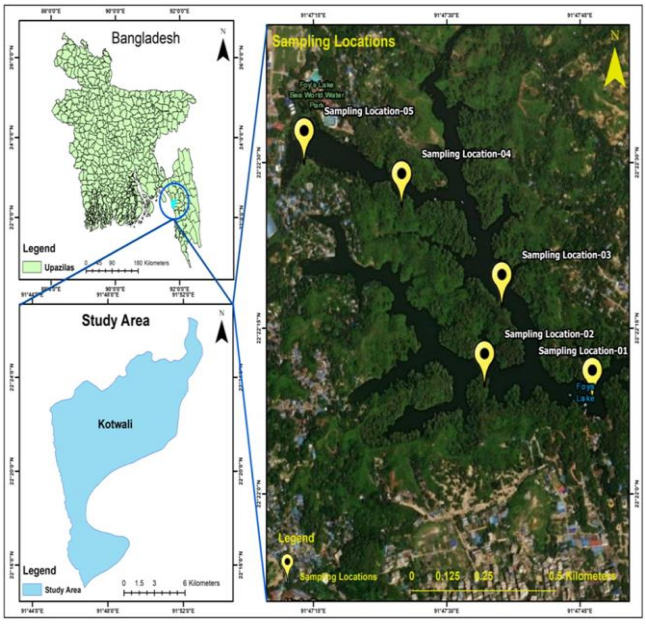

Figure 1. Map showing the study area in Foy's Lake.

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Sample Collection

During the wet season in September 2023 and the dry season in January 2024, water samples were collected from five stations in Foy's Lake. A total of 30 samples, three from each station, were collected during these two seasons. The 500 ml of water collected from each sampling station was stored in double-stoppered plastic bottles after they had been cleaned, rinsed with a detergent solution, and left overnight to treat with 5% HNO_3. The bottles were then allowed to dry after being rinsed with deionized water. The bottles were labeled with their individual identification numbers, safely sealed, and sent to the lab for examination after the collection procedure. The samples were kept at 4°C in the lab until they were processed further.

Sample Analysis

Collected samples were analyzed at the Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University Tangail-1902, Bangladesh. A portable pH meter (Model: pH Scan WP 1) was calibrated with a pH 7.0 buffer solution prior to use. EC and TDS were recorded using HM Digital meters. Dissolved oxygen (DO) was determined using a digital DO meter (Model: D.46974, Taiwan), with sodium thiosulfate (0.025N) as a titrant where necessary. Total alkalinity was assessed by titration with 0.1N HCl using methyl orange as an indicator. Total hardness was measured via EDTA titration, employing Eriochrome Black T as the indicator. Chlorophyll-*a* concentration was analyzed using a UV-Vis spectrophotometer (Model: T-60). A 100 mL water sample was filtered through a cellulose nitrate membrane, and the filter was soaked in 10 mL of 90% acetone for 18–24 hours. The extract was centrifuged, and absorbance was recorded at 630, 645, and 665 nm to calculate chlorophyll-*a* levels. All analyses followed standard protocols, and data were used to compute the Trophic State Index (TSI) to assess the lake's ecological status.

Determination of Trophic Status

The trophic status of Banani Lake was assessed using Carlson's Trophic State Index (TSI), which provides a numerical estimate of nutrient enrichment and algal productivity. TSI values were derived from chlorophyll-*a* concentrations and Secchi disk transparency using the following equations (Carlson, 1977): TSI (Chlorophyll-*a*) = 9.81 × ln(Chlorophyll-*a* [µg/L]) + 30.6; TSI (Secchi Depth) = 60 – 14.41 × ln(Secchi Depth [m]). These calculations yield TSI values on a scale from 0 to 100, reflecting different trophic conditions. According to Carlson's classification (Carlson, 1977): Oligotrophic: TSI ≤ 30; Oligo-mesotrophic: 30 < TSI ≤ 40; Mesotrophic: 40 < TSI ≤ 50; Lightly eutrophic: 50 < TSI ≤ 60; Moderately eutrophic: 60 < TSI ≤ 70; Hypereutrophic: TSI > 70.

Statistical Analysis

Collected data were organized and analyzed using Microsoft Excel and SPSS software. Results were presented through tables and charts to facilitate clear interpretation. Pearson's correlation analysis was employed to assess the relationships between different water quality parameters.

RESULTS AND DISCUSSION

Physicochemical water quality parameters

Temperature: During the wet season, the maximum recorded temperature was 30.9°C at St-1, while the lowest recorded temperature was 29.9°C at St-5. Again, during the dry season, St-3 recorded the highest temperature of 29.9°C, while St-1 and St-4 recorded the lowest temperature of 28.5°C (Table 1). The mean temperatures throughout both the dry and wet seasons were, respectively, 30.62°C and 29.02°C. The water temperature of Foy's Lake was optimal for aquatic life because it was between 20 and 30°C, which is the standard value (EQS, 1997). According to Rubel *et al*. (2019), Foy's Lake had an average temperature of 29.86 ºC, which is similar to Foy's Lake. Sayeed *et al*. (2015) found that the average water temperature at Chalan Beel was 27.68°C. According to Islam *et al*. (2010), the water temperature in the Ashulia Beel ranged from 28.7 to 35.7°C during the wet season and from 22.4 to 25.6°C during the dry season. In the Kaptai Lake water, the monsoon season observed the highest average temperature of 31.1°C, while the post-monsoon period had the lowest average temperature of 21.12°C (Islam *et al*.. 2021). Seasonal considerations and different collection times may be responsible for this observation (Kabir *et al*., 2020).

Transparency: Throughout the wet season, St-3 had the highest Secchi depth (130 cm), while St-1 had the lowest (103 cm). During the dry season, the lowest Secchi depth of 175 cm was found at St-5, and the highest Secchi depth of 225 cm was found at St-1 (Table 1). The wet and dry seasons typically had mean Secchi depths of 118.54 cm and 201.4 cm, respectively. According to Rahman (1992), productive water bodies should have a maximum transparency of 40 cm. The outcome demonstrates that Foy's Lake is beyond of the optimal range for fish and other aquatic life. In the Ashulia Beel, the transparency varied from 6.85 to 21.50 cm during the wet season and from 5.25 to 13.75 cm during the dry season (Islam *et al*., 2010). The water in Kaptai Lake had the highest transparency of 303 cm during the post-monsoon season and the lowest transparency of 17 cm during the monsoon season (Islam *et al*., 2021). The mean highest transparency of 54.30 cm was found in post-monsoon and the lowest transparency of 22.12 cm was found in monsoon season was found in Chalan Beel (Islam *et al*., 2022).

pH: According to Islam *et al*. (2015), the pH can have an impact on the toxicity and solubility of substances in water. St-3 had the highest pH (5.7) during the wet season, whereas St-4 had the lowest pH (5.4). During the dry season, St-1 had the highest pH (5.4), whereas St-3 had the lowest (5.1) (Table 1). In general, the wet and dry seasons had mean pH values of 5.54 and 5.24, respectively. The study found that all sampling stations had mildly acidic pH values, which is within the acceptable range of 6.5 to 8.5

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for inland surface water (EQS, 1997). The pH of Foy's Lake has been found to be in the alkaline range (7.5-8.0) by Rubel *et al*. (2019). Furthermore, studies conducted Islam *et al*. (2010), confirmed the slightly alkaline nature of Ashulia Beel water by showing pH levels ranging from 7.1 to 7.8 during the wet season and 7.1 to 8.4 during the dry season. According to Islam *et al*. (2015), a study carried out in Dhaka City in the Ramna, Crescent, and Hatirjheel Lakes revealed pH values ranging from 7.67 to 7.85. Kaptai Lake's average pH was 7.28, falling within the acceptable limit as per EPA water quality guidelines (EPA, 2017; Islam *et al*., 2021). Islam *et al*. (2022) found that the water's mean pH in Chalan Beel was 6.79.

Table 1. Water quality parameters of the Foy's Lake with the given standards.

Parameter	Sampling Stations	Wet season		Dry season		Standard
		Avg. (3)	Range	Avg. (3)	Range	
Temperature (ºC)	1	30.9		28.5		
	2	30.8	30.25	28.7	28.45 - 29.02	25-30 (EQS, 1997)
	3	30.8	-	29.9		
	4	30.7	30.90	28.5		
	5	29.9		29.5		
	Mean±SD	**30.62±0.365**		**29.02±0.57**		
Transparency (cm)	1	103.0		225.0	218.98 - 183.82	40 (Rahman, 1992)
	2	117.6	126.94	190.0		
	3	130.0	-	214.0		
	4	123.6	109.06	203.0		
	5	118.5		175.0		
	Mean±SD	**118.54± 8.94**		**201.4±17.58**		
pH	1	5.6		5.5		
	2	5.5	5.4	5.2	5.11 - 5.37	6.5-8.5 (EQS, 1997)
	3	5.7	-	5.1		
	4	5.4	5.5	5.2		
	5	5.5		5.2		
	Mean±SD	**5.54±0.101**		**5.24±0.13**		
DO (mg/l)	1	7.1		6.5		
	2	7.5	7.21	6.9	6.36 - 6.92	5.0 (EQS, 1997)
	3	7.4	-	6.6		
	4	7.6	7.55	7.0		
	5	7.3		6.2		
	Mean±SD	**7.38±0.17**		**6.64±0.28**		
EC (µS/cm)	1	130		150	143.7 - 156.3	800-1000 (EQS, 1997)
	2	130	123.6	150		
	3	140	-	140		
	4	120	136.3	150		
	5	130		160		
	Mean±SD	**130±6.32**		**150±6.32**		
TDS (mg/L)	1	63.67		65.00	83.12 - 43.24	165 (Huq &Alam, 2005)
	2	63.66	78.48	60.66		
	3	65.33	-	63.00		
	4	65.00	51.50	61.67		
	5	67.33		66.00		
	Mean±SD	**64.99 ±13.49**		**63.18 ±19.94**		
Total Alkalinity (mg/L)	1	65.00		141.67	95.95 - 130.71	>100 (Rahman, 1992)
	2	46.67	49.60	98.33		
	3	58.35	-	105.00		
	4	51.67	68.40	96.67		
	5	73.33		125.00		
	Mean±SD	**59±9.4**		**113.33±17.38**		
Total Hardness (mg/L)	1	43.30		40.00	39.03 - 43.35	123 (Huq & Alam, 2005)
	2	38.67	36.09	41.33		
	3	35.33	-	40.00		
	4	36.67	41.75	45.33		
	5	40.67		39.33		
	Mean±SD	**38.92±2.83**		**41.19±2.16**		
Chlorophyll-*a* (µg/L)	1	43.3		0.923	0.933 - 0.885	≥5 (Carlson, 1977)
	2	38.67	1.072	0.909		
	3	35.33	-	0.926		
	4	36.67	0.824	0.929		
	5	40.67		0.8628		
	Mean±SD	**0.948±0.124**		**0.909 ±0.024**		

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Dissolve Oxygen (DO): During the wet season, St-1 had the lowest DO (7.1 mg/L) while St-4 had the highest DO (7.6 mg/L). Again, St-4 had the highest DO (7.0 mg/L) during the dry season, whereas St-5 had the lowest DO (6.2 mg/L) (Table 1). The mean DO for the wet and dry seasons was typically 7.38 mg/L and 6.64 mg/L, respectively. Most aquatic species will die below the optimal DO values for fisheries, which were found to be between 4 and 6 mg/L (Boyd, 1997). According to the study, Foy's Lake's DO is nearly within the suitable range of values. However, according to the results of this experiment, the DO readings were within the (EQS, 1997) allowed limit of 5.0 mg/L for aquatic environments. Rubel *et al*. (2019), observed the average DO of Foy's lake was 7.94mg/L which aligns with our observation. During the wet season, the recorded dissolved oxygen (DO) levels at Ashulia beel ranged from 1.1 to 2.1 mg/L, while during the dry season, the range was 0.5 to 2.0 mg/L. The Ashulia Beel water quality was unsuitable for aquatic species and fisheries (Islam *et al*., 2010). The average DO of the several stations over the seasons throughout the study period varied between 6.35 and 7.21 mg/L in the water of Kaptai Lake (Islam *et al*., 2021). Khondker *et al*. (2010), reported that Lake Bogakain's DO range from 0.61 to 11.39 mg/l. In Chalan Beel, Islam *et al*. (2022), found mean water DO of 6.34 mg/L.

Electrical Conductivity (EC): During the wet season, St-3 had the highest EC of 140 µS/cm, while St-4 had the lowest EC of 120 µS/cm. Again, during the dry season, St-5 had the maximum EC of 160 µS/cm, whereas St-3 had the lowest EC of 140 µS/cm (Table 1). The wet and dry seasons typically had mean ECs of 130 µS/cm and 150 µS/cm, respectively. Inland surface water with an EC value of 800 to 1000 µS/cm is appropriate for aquatic environment (EQS, 1997), whereas Foy's Lake had EC contents that were far below the standard. Rubel *et al*. (2019) found that the mean water EC value in Foy's Lake was 68.96 µScm-1, which is lower than what has been observed. In Kaptai Lake water, the monsoon season had the lowest EC at 82.50 µS/cm, while the post-monsoon season usually had the highest EC at 141.24 µS/cm (*Islam et al*., 2021). Khondker *et al*. (2010), reported that Lake Bogakain's EC ranged from 75 to 80 µS/cm. Islam *et al*. (2022), found that the water EC in Chalan Beel was 134.80 µS/cm on average.

Total Dissolved Solid (TDS): During the wet season, St-5 had the highest TDS (67.33 mg/L), while St-1 had the lowest TDS (63.6 mg/L). Again, during the dry season, St-5 had the highest TDS (66 mg/L) and St-2 had the lowest TDS (60.6 mg/L) (Table 1). The dry and wet seasons typically had mean TDS levels of 64.994 mg/L and 63.18 mg/L, respectively. Foy's Lake had a mean water TDS value of 34.48 mg/L (Rubel *et al*., 2019), which is less than what has been observed. In the Kaptai Lake water, the post-monsoon season had the highest mean TDS of 80.5 mg/L, while the monsoon season had the lowest TDS of 44.5 mg/L (Islam *et al*., 2021). According to Islam *et al*. (2010), the TDS value in the Ashulia Beel during the dry season varied from 207 to 276 mg/L, which was higher than during the wet period. Khondker *et al*. (2010) stated that Lake Bogakain's TDS ranged between 39 and 42 mg/l.

Total alkalinity: During the wet season, St-5 had the highest total alkalinity (73.33 mg/L), whereas St-2 had the lowest (46.67 mg/L). Again, during the dry season, St-1 had the highest total alkalinity (141.67 mg/L) and St-4 had the lowest (96.67 mg/L) (Table 1). The wet and dry seasons typically had mean total alkalinities of 59 mg/L and 113.33 mg/L, respectively. Rahman (1992), states that for fresh water, the standard value of total alkalinity is greater than 100 mg/L. In Kaptai Lake, the total alkalinity peaked in December 2013 at 90.68 mg/L (Bashar *et al*., 2015). The finest fish-producing lakes are often those with a total alkalinity value of over 80 mg/L, which indicates a nutrient-rich, hard-water lake. The Ashulia Beel water's total alkalinity value ranged from 30 to 63 mg/L during the wet season and from 90 to 115 mg/L during the dry season (Islam *et al*., 2010).

Total Hardness: During the wet season, St-1 had the highest total hardness (43.3 mg/L) while St-3 had the lowest total hardness (35.33 mg/L). Again, during the dry season, St-4 had the highest overall hardness (45.33), whereas St-5 had the lowest (39.33) (Table 1). The wet and dry seasons typically had mean total hardness values of 38.92 mg/L and 41.19 mg/L, respectively. A study conducted by Rubel *et al*. (2019), claimed that the total hardness of Foy's Lake was between 30.00 and 32.50 mg/L. According to Huq & Alam (2005), aquatic organisms require a total hardness of 123 mg/L. According to this study, total hardness contents were less appropriate for use in fisheries. A soft water body has 0–60 mg/L of calcium carbonate (Brown *et al*., 1970). As a result, Foy's Lake water could be considered soft. The Ashulia Beel water's total hardness value ranged from 30.0 to 91.3 mg/L during the wet season and from 115 to 127 mg/L during the dry season (Islam *et al*., 2010). The water in Kaptai Lake had the lowest total hardness of 43 mg/L during the monsoon season and the highest average total hardness of 71.25 mg/L during the pre-monsoon (Islam *et al*., 2021).

Chlorophyll-*a*: Chlorophyll-*a* is a reliable measure of a lake's overall algal population. According to Pavluk & Vaate (2017), there was a favorable correlation between phytoplankton biomass as chlorophyll-*a* and both phytoplankton density and water depth. The highest chlorophyll-*a* 1.159 µg/L was found at St-4 and the lowest chlorophyll-*a* 0.832 µg/L has been measured at St-3 during the wet season. Again, during the dry season, St-1 had the highest alkalinity (0.929 µg/L) and St-4 had the lowest chlorophyll-*a* (0.8628 µg/L) (Table 1). The wet and dry seasons typically have mean chlorophyll-*a* values of 0.9476 µg/L and 0.9099 µg/L, respectively. The Kaptai Lake water's mean levels of chlorophyll-*a* were highest during the monsoon season (1.60 µg/L) and lowest during the post-monsoon season (0.98 µg/L) (Islam *et al*., 2021). In Chalan

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Beel, the monsoon season had the mean highest chl-*a* levels of 1.63 µg/L, while the post-monsoon season had the lowest level of 0.99 µg/L (Islam *et al*., 2022).

Estimation of Trophic State Index (TSI)

Chlorophyll-*a* TSI: During the wet season, St-4 had the highest TSI (Chl-*a*) of 32.04, while St-3 had the lowest TSI (Chl-*a*) of 28.79. During the dry season, St-4 had the highest TSI (Chl-*a*) of 29.9 and St-5 had the lowest TSI (Chl-*a*) of 29.4 (Fig. 2). The wet and dry seasons typically had mean TSI (Chl-*a*) values of 29.98 and 29.67, respectively. The Lake is oligotrophic according to Carlson's trophic state classification criteria, which are based on the Chl-*a* TSI. Chl-*a* TSI 41.24 was measured by Khondker *et al*. (2010), in Bogakain Lake in Bandarban, Bangladesh. In Kaptai Lake water, the pre-monsoon season had the highest Chl-*a* TSI (34.56), while the post-monsoon season had the lowest (29.71) (Islam *et al*., 2021). In Chalan Beel, the pre-monsoon season had the highest Chl-*a* TSI of 33.40, while the post-monsoon season had the lowest at 30.35 (Islam *et al*., 2022).

Secchi Disk [TSI (SD)]: During the wet season, St-4 had the highest secchi disc TSI (59.7), while St-5 had the lowest [TSI (SD)] of 57.01. Again, during the dry season, St-5 had the highest [TSI (SD)] of 51.93, whereas St-1 had the lowest [TSI (SD)] of 48.31 (Fig. 3). The wet and dry seasons typically had mean [TSI (SD)] values of 58.03 and 49.962, respectively. According to the study's findings, the lake is eutrophic (50<TSI ≤70) as defined by Carlson's trophic state classification standards (Carlson, 1977), which are based on Secchi disc TSI. According to Rahman *et al.* (2014), Kaptai Lake's [TSI (SD)] was 48.19 before the monsoon season and 53.00 after. In Chalan Beel, the monsoon season had the highest [TSI (SD)] (86.60), while the post-monsoon season had the lowest (73.09) (Islam *et al*., 2022).

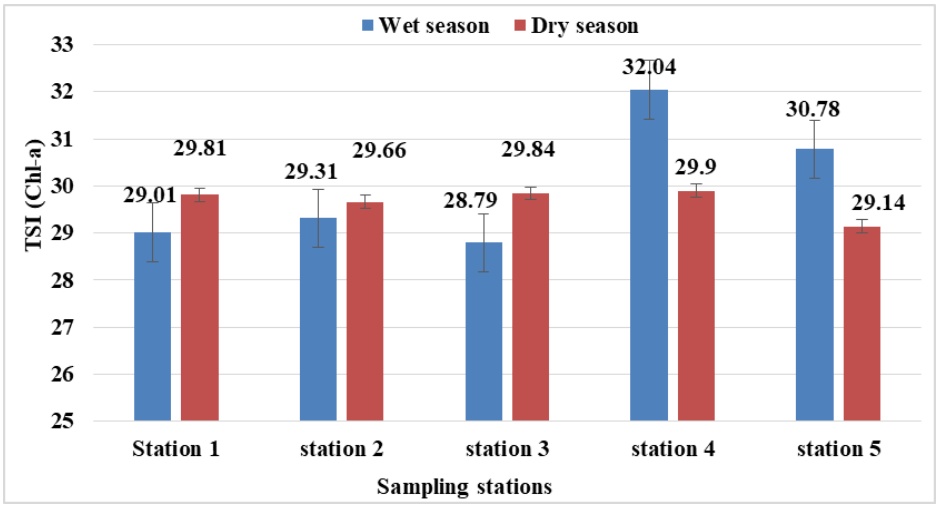

Figure 2. The status of chlorophyll-*a* [TSI (Chl-*a*)] in different seasons of the Foy's Lake.

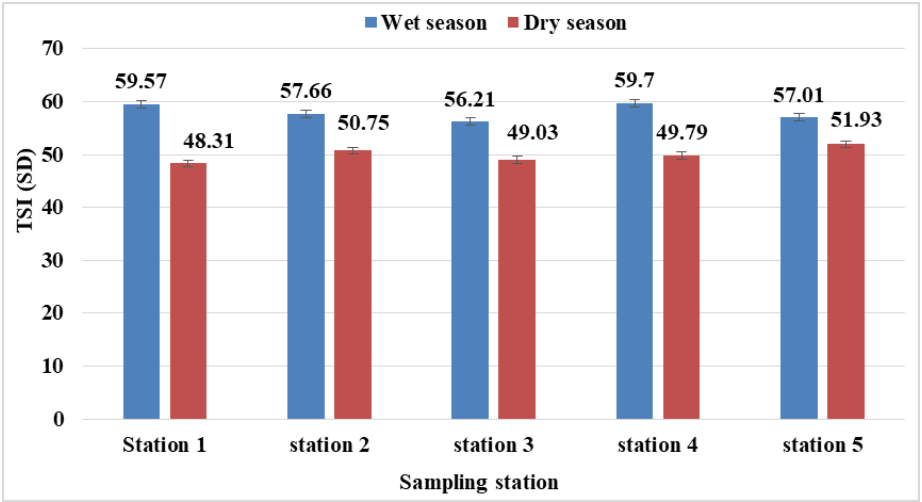

Figure 3. The status of [TSI (SD)] in different seasons of the Foy's Lake.

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Table 2. Pearson correlation coefficients (r) among water quality parameters of the Foy's Lake.

Parameters	Temp.	Trans.	DO	pH	EC	TDS	TA	TH	Chl-*a*	TSI (SD)	TSI (Chl-*a*)
Wet Season											
Temp.	1										
Trans.	-0.124	1									
DO	0.070	0.726*	1								
pH	0.300	0.051	-0.524	1							
EC	0.087	0.226	-0.368	0.930*	1						
TDS	-0.905*	0.425	0.027	-0.097	0.077	1					
TA	-0.669	-0.300	-0.729	0.249	0.223	0.654*	1				
TH	-0.174	-0.950*	-0.804	-0.039	-0.149	-0.136	0.546*	1			
Chl-*a*	-0.418	0.235	0.533*	-0.850	-0.831	0.418	-0.027	-0.193	1		
TSI (SD)	0.356	-0.579	-0.053	-0.532	-0.794	-0.483	-0.181	0.397	0.426	1	
TSI (Chl-*a*)	-0.449	0.225	0.522*	-0.857	-0.829	0.437	-0.007	-0.173	0.999**	0.411	1
Dry Season											
Temp.	1										
Trans.	-0.219	1									
DO	-0.539	0.215	1								
pH	-0.627	0.488	-0.195	1							
EC	-0.220	-0.702	-0.441	0.233	1						
TDS	0.321	-0.043	-0.939*	0.404	0.476	1					
TA	-0.060	0.262	-0.748	0.792*	0.364	0.859**	1				
TH	-0.566	0.058	0.823**	-0.163	-0.098	-0.639	-0.619	1			
Chl-*a*	-0.354	0.832**	0.707**	0.139	-0.814	-0.567	-0.290	0.495	1		
TSI (SD)	0.224	-0.999**	-0.248	-0.466	0.720**	0.077	-0.226	-0.086	-0.852	1	
TSI (Chl-*a*)	-0.370	0.819**	0.723**	0.133	-0.800	-0.577	-0.304	0.524*	0.999**	-0.840	1

** Correlation is significant at the 0.01 level (two-tailed).
* Correlation is significant at the 0.05 level (two-tailed).

Interrelationship between water quality parameters and Chlorophyll-a

The degree of interdependence among physicochemical and biological parameters can be effectively assessed using Pearson's correlation coefficient, a widely accepted statistical tool (Kabir *et al*., 2020). In this study, key water quality indicators-such as temperature, transparency, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), Chlorophyll-*a* (Chl-*a*), trophic state index based on chlorophyll-a [TSI (Chl-*a*)], and Secchi depth-based trophic state index [TSI (SD)]-were subjected to correlation analysis using their observed values (Table 2).

During the wet season, moderate positive correlations were observed between TA and TDS, TH and TA, DO and Chl-*a*, as well as between TSI (Chl-*a*) and DO. Moreover, statistically significant positive correlations were identified between transparency and DO, EC and pH, and between TSI (Chl-*a*) and Chl-*a*, indicating coherent relationships among these parameters during periods of increased water input and dilution. In the dry season, the correlation patterns shifted slightly, reflecting seasonal influences. Moderate positive associations emerged between TSI (Chl-*a*) and DO, Chl-*a* and DO, pH and TDS, EC and TSI (SD), and between TSI (Chl-*a*) and TH. Additionally, strong positive correlations were found between TSI (Chl-*a*) and Chl-*a,* TA and TDS, DO and TH, transparency and Chl-*a*, and transparency and TSI (Chl-*a*). These results suggest that increases in nutrient-related and optical parameters are directly related and possibly driven by anthropogenic pressures such as nutrient loading and reduced water flow.

Overall, the correlation analysis indicates a direct and proportional relationship between several key variables, underscoring their interlinked behavior under different seasonal regimes. Such interdependencies not only reflect the dynamic nature of lake ecosystems but also highlight the importance of integrated monitoring approaches in assessing the health and trophic evolution of aquatic systems like Foy's Lake.

CONCLUSION

The current study is a baseline investigation of the seasonal change of physicochemical characteristics in Foy's Lake, which will provide useful information about Lake Ecosystem management and conservation. The analysis showed that the temperature, transparency, EC, TDS, and total hardness were within the given standard for both seasons; but EC and total alkalinity was within the limit only in the dry season. Moreover, pH, TDS, and total hardness were lower than the standard limit for both seasons. The mean trophic state index (TSI) values based on SD values both in the wet season and dry season indicates a eutrophic and mesotrophic state, respectively. Since lakes are crucial bodies of water that provide surface water, maintaining, conserving, and preserving them is of the highest priority. The government and stakeholders working together can preserve the natural resources, scenic beauty, and water quality of this lake.

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Author's contributions

MHK, AA, MRM, RSS and AH: methodology and investigation and sample analysis; MHK, AA, MRM, MSK and PS writing-original draft preparation; MHK, RSS and MSI: funding acquisition. All authors read, revised, and improved the manuscript and attested to the validity and legitimacy of the data and its interpretation, and agreed to its submission.

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Conflict of Interest

There is no conflict of interest to declare.

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