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RESEARCH ARTICLE

Physiochemical Profile of Tilyar Lake – Essential Parameters for Sustainable Biodiversity

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Abstract

Objectives: To investigate the seasonal fluctuations in water quality of Tilyar Lake, Rohtak by analyzing physicochemical parameters in summer, monsoon and winter seasons during 2023-2024. **Methods:** Water samples were collected from three different sites, chosen on the basis of anthropogenic interference, in three seasons namely summer, monsoon and winter. Bureau of Indian Standards (BIS) approved methods were used to analyze different parameters as temperature, pH, TDS, TSS, EC, TH and Nitrate. Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) was used to assess the heavy metals. **Findings:** Parameters like temperature (ranging between 24.36 $\pm$ 0.12 to 27.63 $\pm$ 0.66), pH (8.23 $\pm$ 0.02 to 9.55$\pm$ 0.01), TDS (143.67 $\pm$ 1.52 to 174.67 $\pm$ 2.08), TSS (148.00 $\pm$ 2.00 to 201.67 $\pm$ 1.52), EC (215.67 $\pm$ 3.51 to 285.33 $\pm$ 2.51), TH (75.33 $\pm$ 1.52to 108.00 $\pm$ 01) and Nitrate etc. showed statistically significant difference between the three seasons. However, among the sites there was no significant difference observed in the three seasons. All the parameters except pH were found to fall within the permissible limits of BIS. Heavy metals such as Arsenic and Nickel were also detected in the water samples. **Novelty:** The surface water quality is affected continuously by various factors. Periodic assessment of water quality is hence very important. This study provides supportive evidences for season based special management to maintain the lake health for the development of sustainable biodiversity.

Keywords: Biodiversity; Heavy Metals; Physicochemical; Water quality; Tilyar Lake

1 Introduction

The International Glossary of Hydrology defines a lake as an inland water body of considerable size[(1)]. A lake is a dynamic and complex structure and a significant natural resource on the Earth, contributing 50.01% of water present on Earth[(2)]. Broadly, lakes play an important role in different geological region's hydrological cycles, ecological dynamics, socio-economic activities, recharging groundwater, working as sponge to handle flooding, and impact microclimate and cultural heritage[(3)]. Additionally, it

provides many goods and services to humans through potable water, water for domestic use, irrigation and industries. Lakes also encourage humans for reformation and fisheries as well as providing habitat to flora and fauna [4]. In India, the majority of the lakes and wetlands are famous especially for tourism purposes, fishing, etc. [3]

Briefly, since long the lakes are an integral part of the community that consistently triggers the development of the society, city and associated regions. Unfortunately, lakes are facing immense loads of pollution due to industrialization, urbanization, disposal of domestic effluents, surface runoff from agricultural fields [5], religious activities such as immersion of idols, etc. resulting in varying degrees of degradation of water quality, enhanced nutrition, changes in chemical and biological parameters leading to the problem of eutrophication and threats of extinction [5].

Despite the significant role in the environment, city developers have consciously ignored and damaged these lakes. Additionally, unplanned urbanization is leading to the exposure of the lake's landscape covered by impermeable surfaces responsible for sewage and effluent water collection in lakes instead of rainwater. Moreover, freshwater bodies are facing the critical problem of deterioration consequently posing the problems of eutrophication, vanishing or extinction [6]. The balance and functions of an aquatic ecosystem critically depend on the physicochemical characteristics of water, which undergoes spatial and temporal variations due to both natural like temperature and mainly anthropogenic activities [7]. Therefore, periodic assessment of water bodies is important so that necessary and effective laws can be formulated for improving the water quality and saving these limited number of water bodies. Heavy metals and metalloids from their constituent organic and inorganic complexes, having a high rate of toxicity and persistent nature [8], affect the aquatic biota as well as the human population dependent on water resources [9]. Heavy metal contamination of water effects human health and other life form deleteriously. According to an estimate, unhealthy aspects of water contribute 80% of all diseases in man.

A large number of studies have been done on the glacial lakes of India although, few studies with inconclusive findings have been undertaken on the lakes situated in North India, especially of Haryana. Rohtak is one of the major districts of Haryana and Tilyar Lake the major water body present in the district, supporting large biodiversity and serving tourism purposes. The lake is facing a pollution load because of solid waste disposal in the lake by visitors, siltation and aquatic weeds. Of the very few studies already done on the lake, most studies focussed only on the avifaunal or planktonic diversity of the lake, however physicochemical parameters provide insight into lake health and decide the biological composition of the lake at various sites and in different seasons were not analyzed extensively. The present study was conducted to fill this research gap by seasonal assessment of the water quality of Tilyar Lake, which is obligatory in terms of public health and biodiversity and ecosystem well-being by assessing various physicochemical parameters during the different seasons at selected sites. However, additional collaborative work on high-quality studies is desirable to establish policy for monitoring and updating the existing management policies.

2 Methodology

2.1 Study Location

Haryana state in North India is geographically positioned between 27°39'N to 30°35'N and 74°28'E to 77°36'E with an area of 44,212 sq. km. Haryana was formed on 1st November 1966, sharing the capital Chandigarh with Punjab. Haryana is surrounded in the North by Himachal Pradesh, in the South by Rajasthan, in the North-East by Uttarakhand, in the East by Uttar Pradesh and Delhi, and from the North-West by Punjab. Rohtak, one of the 22 districts of the state Haryana, is located at the latitude of 28°23'N to 29°06'N and longitude of 76°13'E to 76°58'E, covering 1,745 sq. Km area. Rohtak is a dry district with extremely hot summers and cold winters. Tilyar Lake is an artificial lake and situated 5 km far from Rohtak city bus stand, on Rohtak- Delhi Road with a covering area of 22.1 acres and mean depth of 3.01 meters. Rainfall and Jawahar Lal Nehru Canal (JLN canal) are the main sources of water inflow and the lake rarely dry out completely through the year. Figure 1 displays the geographical location of Tilyar Lake and sites of water sampling.

2.2 Water Sampling

The three sampling sites were selected on the basis of the degree of human interference and anthropogenic load on the lake. The details of selected sites are, Site S1- water inlet of lake; Site S2- entry point to the lake (most disturbed area of lake); Site S3- middle of lake (least disturbed area of the lake) [Figure 1]. Water samples were collected during early morning between 8:00 to 10:00 am in sampling bottles from three selected sites in three different seasons in the year (2023-24) four months comprising one season i.e. February 2023 to May 2023 (Summer), June 2023 to September 2023 (Monsoon), October 2023 to January 2024 (Winter). The samples were collected in triplicates in 1L polyethylene bottles, all the bottles were precleaned and rinsed with distilled water as per standard methods. For determining DO the water samples were collected in BOD bottle. For determining

heavy metals, the samples were collected in 100ml polyethylene bottles pretreated with 10% 1M nitric acid for 30 minutes and then rinsed with distilled water or deionized water. The samples were analyzed in the laboratory as per the standard methods. The samples were stored in refrigerator at 4°C to prevent extraneous activities [10].

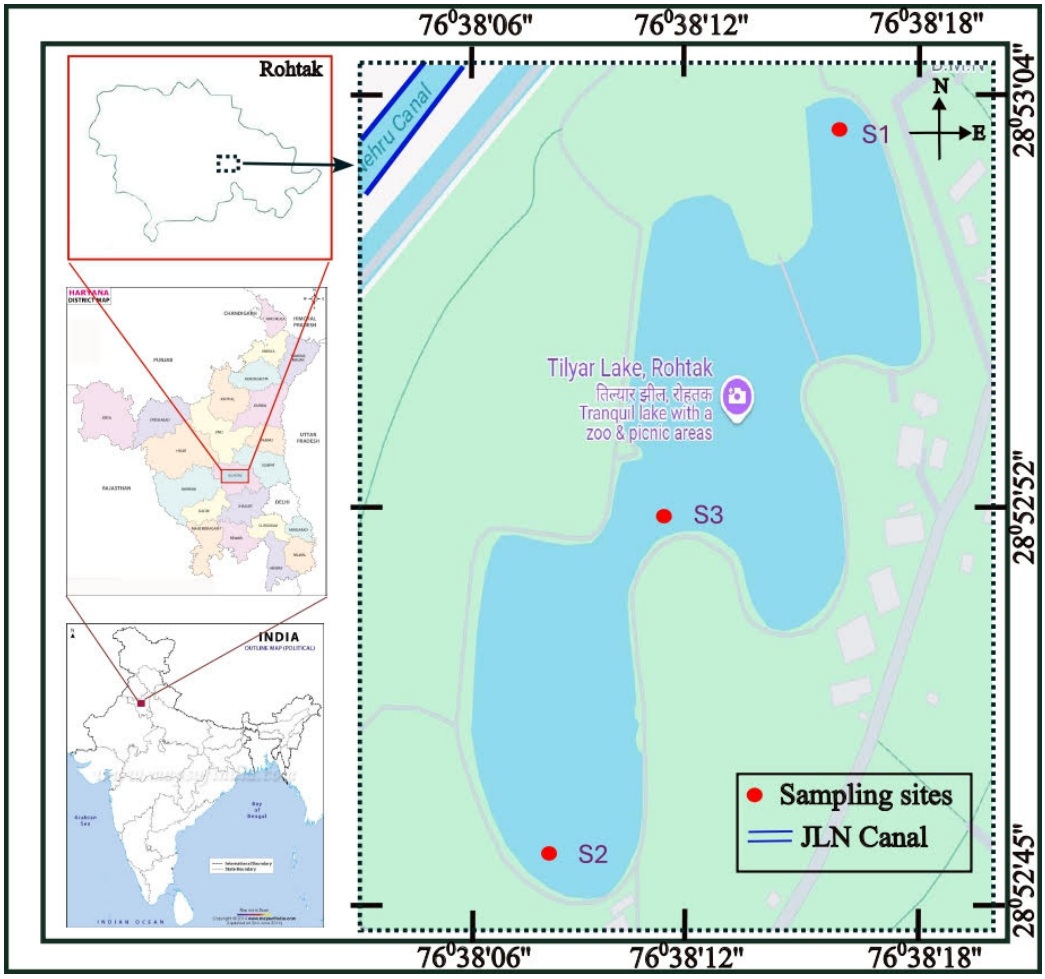

Fig 1. Geographical location of Tilyar lake and the sampling points (S1: water inlet to lake, S2: entry point to the lake, S3: Middle/ least disturbed area of lake). (Map not to scale)

2.2.1 Physiochemical profile analysis of collected water samples

Water samples were processed and evaluated adopting standard methods of water analysis [10] [11]. The physiochemical parameter investigated general parameters including hydrogen ion concentration (pH) (Electrometric method, using digital pH meter), electrical conductivity (EC) (Conductivity meter), Turbidity (Nephelometric method, using turbidity meter), total dissolved solids (TDS) and total suspended solids (TSS) (Gravimetric method), total hardness (TH) (Titrimetric method), dissolved oxygen (DO) (Winkler-Azide method). The Nitrate level was measured by the Chromotropic acid method and heavy metals were detected by inductively coupled plasma mass spectrometry (ICP-MS) [10] [Table 1].

Table 1. Physicochemical parameters investigated for the Lake Tilyar

Parameters	Units	Test Method	BIS Standards
pH	pH Unit	Electrometric method (System-361)	6.5-8.5
Electrical Conductivity (EC)	μS/cm	Conductivity meter (HPG System G-3001)	250 μS/cm
Dissolved Oxygen (DO)	mg/l	Winkler-Azide method	5 mg/l

Continued on next page

Table 1 continued

Total Dissolved Solids (TDS)	mg/l	Gravimetric method	1000 mg/l
Total Suspended Solids (TSS)	mg/l	Gravimetric method	-
Nitrate (NO_3)	mg/l	Chromotropic acid method	50 mg/l
Total Hardness (TH)	mg/l	Titrimetric method	100 mg/l
Turbidity	NTU	Nephelometric method (Systronics-135)	5 NTU
Heavy Metals	mg/l	ICP-MS (Nexion-1000)	Varied

2.2.2 Statistical Analysis

Comparison of different physicochemical parameters between the sites and seasons, mean ± standard deviation has been calculated on the basis of seasonal data collected from the three different sites in replicates. The spatial and temporal variations in physicochemical parameters were tested by using one-way ANOVA at the level of significance $P \leq 0.05$ using SPSS (Software IBM SPSS, Version 29.0.2.0 (20).

3 Results and Discussion

The samples collected in different seasons and from chosen sites were processed for selected parameters and the findings are shown in Table 2, Table 3 and Table 4. From the statistical analysis of data, no significant difference was observed between the three different sites (S1, S2 and S3) in all the corresponding seasons. In the present study, the analyzed and observed parameters were within the standards values defined by the Bureau of Indian Standards (BIS) [Table 1] except for the pH and turbidity. However, statistically significant difference for different parameters was found between the summer, winter and monsoon seasons at all sites [Table 2, Table 3,Table 4].

Table 2. Multiple comparison of parameters at Site 1 (Lake Inlet) in different seasons in Tilyar Lake (Each value represents the Mean ± SD)

Parameter	Summer	Monsoon	Winter
Temperature (°C)	27.6 ± 0.66^{a}	25.26 ± 0.21^{a}	24.36 ± 0.12^{bd}
pH	$9.55 \pm 0.01^{\mathbf{a}}$	$8.48 \pm 0.02^{\mathbf{b}}$	$8.29 \pm 0.04^{\mathbf{cb}}$
Turbidity (NTU)	1^{cd}	15^{a}	6.1 ± 1^{b}
TDS (mg/l)	$172.67 \pm 1.15^{\mathbf{a}}$	$146.00 \pm 2.00^{\mathbf{bc}}$	$171.67 \pm 1.52^{\mathbf{a}}$
TSS (mg/l)	$173.67 \pm 2.89^{\mathbf{b}}$	$158.00 \pm 1.00^{\mathbf{cd}}$	$201.67 \pm 1.52^{\mathbf{a}}$
EC (μS/cm)	$217.67 \pm 1.52^{\mathbf{cd}}$	$228.67 \pm 0.58^{\mathbf{b}}$	$285.33 \pm 2.51^{\mathbf{a}}$
TH (mg/l)	$76.67 \pm 0.58^{\mathbf{bc}}$	$103.00 \pm 1.73^{\mathbf{a}}$	$103.33 \pm 1.52^{\mathbf{a}}$
Nitrate (mg/l)	$2.40 \pm 0.10^{\mathbf{b}}$	$1.63 \pm 0.20^{\mathbf{cd}}$	$5.23 \pm 0.05^{\mathbf{a}}$
DO (mg/l)	$7.33 \pm 0.15^{\mathbf{a}}$	$7.27 \pm 0.25^{\mathbf{a}}$	$7.43 \pm 0.11^{\mathbf{a}}$

Figures in each column followed by different letters are significantly different (p<0.05), One-Way ANOVA followed by Tukey's all pair wise Multiple Comparison

Table 3. Multiple comparison of parameters at Site 2 (Entry point to the lake) in Tilyar Lake (Each value represents the Mean ± SD)

Parameter	Summer	Monsoon	Winter
Temperature (°C)	27.5 ± 0.26^{a}	25.06 ± 0.06^{bd}	25.36 ± 0.23^{cd}
pH	$9.54 \pm 0.02^{\mathbf{a}}$	$8.36 \pm 0.02^{\mathbf{bd}}$	$8.23 \pm 0.02^{\mathbf{cd}}$
Turbidity (NTU)	1^{cd}	12^{a}	6.23 ± 0.21^{b}
TDS (mg/l)	$173.67 \pm 2.88^{\mathbf{a}}$	$147.33 \pm 1.52^{\mathbf{bc}}$	$175.00 \pm 2.64^{\mathbf{a}}$
TSS (mg/l)	$173.66 \pm 2.89^{\mathbf{b}}$	$149.00 \pm 5.57^{\mathbf{cd}}$	$191.67 \pm 1.52^{\mathbf{a}}$
EC (μS/cm)	$219.33 \pm 1.52^{\mathbf{cd}}$	$243.67 \pm 2.08^{\mathbf{b}}$	$283.67 \pm 1.15^{\mathbf{a}}$
TH (mg/l)	$75.33 \pm 1.52^{\mathbf{cd}}$	$104.67 \pm 1.52^{\mathbf{a}}$	$99.00 \pm 1.00^{\mathbf{b}}$
Nitrate (mg/l)	$2.50 \pm 0.20^{\mathbf{a}}$	$1.80 \pm 0.10^{\mathbf{bc}}$	$2.87 \pm 0.05^{\mathbf{a}}$
DO (mg/l)	$7.50 \pm 0.17^{\mathbf{a}}$	$7.23 \pm 0.11^{\mathbf{a}}$	$7.57 \pm 0.05^{\mathbf{a}}$

Figures in each column followed by different letters are significantly different (p<0.05), One-Way ANOVA followed by Tukey's all pair wise Multiple Comparison

Table 4. Multiple comparison of parameters at Site 3 (Least disturbed area of lake) in different seasons in Tilyar Lake (Each value represents the Mean ± SD)

Parameter	Summer	Monsoon	Winter
Temperature (°C)	27.63 ± 0.59^{a}	26 ± 0.5^{a}	24.46 ± 0.12^{bc}
pH	$9.52 \pm 0.07^{\mathbf{a}}$	$8.41 \pm 0.10^{\mathbf{cd}}$	$8.47 \pm 0.02^{\mathbf{bd}}$
Turbidity (NTU)	1^{cd}	14^{a}	6.03 ± 0.06^{b}
TDS (mg/l)	$174.67 \pm 2.08^{\mathbf{a}}$	$143.67 \pm 1.52^{\mathbf{bc}}$	$166.33 \pm 1.52^{\mathbf{a}}$
TSS (mg/l)	$174.66 \pm 1.52^{\mathbf{b}}$	$148.00 \pm 2.00^{\mathbf{cd}}$	$192.67 \pm 1.52^{\mathbf{a}}$
EC (μS/cm)	$215.67 \pm 3.51^{\mathbf{cd}}$	$242.67 \pm 2.51^{\mathbf{b}}$	$281.67 \pm 1.52^{\mathbf{a}}$
TH (mg/l)	$77.33 \pm 1.52^{\mathbf{bc}}$	$108.00 \pm 1.00^{\mathbf{a}}$	$106.33 \pm 0.58^{\mathbf{a}}$
Nitrate (mg/l)	$2.57 \pm 0.23^{\mathbf{b}}$	$1.53 \pm 0.15^{\mathbf{cd}}$	$3.70 \pm 0.17^{\mathbf{a}}$
DO (mg/l)	$7.37 \pm 0.20^{\mathbf{a}}$	$7.17 \pm 0.20^{\mathbf{a}}$	$7.60 \pm 0.10^{\mathbf{a}}$

Figures in each column followed by different letters are significantly different ($p<0.05$), One-Way ANOVA followed by Tukey's all pairwise Multiple Comparison

The temperature of water ranged from a minimum of 24.36 ± 0.12 in winter to a maximum of 27.63 ± 0.66 in the summer season. At site-1 and site-3, results significantly differed in winter as compared to other seasons, however, in site-2 monsoon and winter temperature were significantly lower than summer. The temperature of water influences various abiotic properties and biotic activities for instance the growth of the aquatic organism. In the present study, in all the sites, temperature significantly differed among the different seasons, indicating a seasonal cycle of temperature within the lake ecosystem, closely following the air temperature changes during the seasons and thereby, it may influence the biodiversity of the lake and landscape around the lake. During summer the temperature was cooler than the environmental temperature which may be due to the small and shallow structure of the lake. All three sites showed the lowest temperature during the winter season due to the short photo period which increased from January to the maximum in summer and then declined during the monsoon season. A similar finding was observed in the Ramadugu Lake, Telangana [3,12].

The pH of the Tilyar Lake ranged between 8.23 ± 0.02 in the winter season to 9.55± 0.01 in the summer season. pH of site-1, 2 and-3 was found significantly different in monsoon and winter as compared to the summer season. Alkaline pH during the summer season could be attributed to increased photosynthetic and decomposition activity resulting in high CO_2 and bicarbonate ion production, shifting the pH towards the alkaline side. Ecosystem with pH > 8.5 is highly productive, therefore, Tilyar Lake can be considered a highly productive lake. Investigations by Gautam et al., 2022 recorded similar, minimum pH during monsoon season and maximum during summer [13].

The turbidity of the lake water ranged between a minimum of 1 NTU in summers to a maximum of 15 NTU in monsoon season. The turbidity of the lake can be attributed to the presence of a wide range of dissolved and suspended solids present in the water. The turbidity of the lake water increased significantly in the monsoon season because of surface runoff during monsoon and the larger amount of water being discharged into the lake by the feeder canal i.e. JLN canal. Consequently, turbidity of summer season was significantly differed from the other two seasons. Contradictory results were observed by Dey et al., 2021 [14].

The Electrical conductivity (EC) of water was recorded to be minimum 215.67 ± 3.51 in the summer season to a maximum of 285.33 ± 2.51 in the winter and the EC levels during the summer season was significantly differed from winter and monsoon seasons. The movement and accumulation of ions and nutrients after the monsoon runoff may lead to this relationship. Higher EC during pre-monsoon period was observed in Loktak Lake [15].

TSS were recorded to range between 148.00 ± 2.00 in monsoon season to 201.67 ± 1.52 in winter season. Significantly varied TSS was recorded during the winter season compared by summer and monsoon. TDS was recorded to range between 143.67 ± 1.52 in monsoon season to 174.67 ± 2.08 in summer season. Statistical results were similar to TSS. TSS and TDS showed similar results in the present study, the results of monsoon in all three sites statistically differed from the summer and winter seasons. Dilution of water during monsoon season may have led to these observations of TSS and TDS. Furthermore, the surface runoff during monsoon leads to transportation of silt and colloids to the lake and may lead to increased TSS noted during winter, and settling of particles till summer season could be the reason for decrease in TSS from winter to summer season. Similar results were obtained in Dara Dam, Maharastra [13].

TH of the lake due to calcium and magnesium salts varied between in 75.33 ± 1.52in summer season to 108.00 ± 01 in winter season. TH during summer in all the sites was comparatively different from the other two seasons. Contradictory, results were found in small lakes of Maharastra, where higher TH was observed during summer month [16]. However similar results were

observed in Sukhna lake, Chandigarh [17].

DO content of water was found minimum 7.17 ± 0.20 during monsoon and maximum 7.60 ± 0.10 during the winter season. DO content which is an important parameter, reflecting various physical and biological processes taking place in water, for example, photosynthesis by aquatic plants and atmospheric oxygen diffusion. Providentially, DO did not significantly differ among the various seasons and the findings were within the acceptable limits recommended by BIS, similar results were observed in small lakes in Ahmednagar district, Maharastra [16].

The Nitrate content of water ranged between 1.53 ± 0.15 in monsoon to 5.23 ± 0.05 during winter season. Nitrate levels during monsoon significantly differed from the summer and winter values. Oxidation of organic nitrogenous substances, runoff from the agricultural fields and atmospheric nitrogen fixation by nitrogen fixing organisms contributes to the nitrate content of water. The productivity of the lake and the growth of macrophytes and algae are dependent on nitrate, making it an important nutrient. A low level of nitrate in the wet season compared to dry season was found by Isiuku et al., 2020 in the water bodies of Nigeria [18].

Heavy metals as Arsenic (As), Iron (Fe) and Nickel (Ni) were present in the concentration range of 0.004 mg/l. Tilyar Lake is an important reservoir for the collection of water from JLN canal and additionally, surface runoff during monsoon and may influence the levels of heavy metal in different seasons. The present study observations have shown that heavy metals including Cadmium (Cd), Lead (Pb), Mercury (Hg), Chromium (Cr) were found below the level of quantification (BLQ), however, Arsenic (As), Iron (Fe) and Nickel (Ni) were present and the concentration is within the acceptable limits recommended by BIS and ICMR. However relatively higher concentrations of heavy metals were found in eight lakes of Kenya [19].

4 Conclusion

At present, the published data available for the physical and chemical properties for the Tilyar lake is scanty and inconclusive. In this study, the water samples of the Tilyar Lake were collected and analyzed for the physicochemical parameters in different seasons and different sites subsequently the findings were cautiously recorded. Variations of various physico-chemical parameters were observed between the sampling sites and in between the different seasons. The results obtained in the present study points out that all the parameters except the pH and turbidity were found to be within the standard permissible limits prescribed by BIS and WHO (World Health Organization). High pH can adversely affect the biological processes in the lake ecosystem which can lead to the deterioration of the water chemistry of the lake. The lake is found to be highly productive during the period of study. Anthropogenic disturbances because of the lake being used for boating and as a picnic spot leading to large numbers of tourists visiting the lake is detrimental for the lake. The lake water is sometimes changed completely, leading to the destruction of the complete biodiversity. This should be avoided rather strict management strategies should be employed to prevent the lake ecosystem from degradation.

Implementation of NLCP Methods: for the conservation, restoration and management of the lakes and wetlands to maintain the environmental sustainability that comprises Goal 3 – Good health and well-being; Goal 6 – Clean water and sanitation; Goal 11 – Sustainable cities and communities; Goal 13 – Climate Action and Goal 14 – Life below the water of the Sustainable Development Goals (SDGs) [20]. Additionally, further investigations comprising the various parameters of the concerned lake including the biodiversity should be undertaken in collaboration with the government and NLCP.

The present study provides supportive evidence for season based special management to maintain the lake health for the development of sustainable biodiversity. However, there exists a scope for additional collaborative work on high-quality studies to establish policy for monitoring and modifying the existing management policies. Further, specific studies on the effects of spatial and temporal variations in changes in land use patterns of catchment areas, hydrology, climate, and morphology of lake on the biodiversity of lake should be undertaken.

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