

ORIGINAL ARTICLE

Water quality characteristics and its influence on seasonal distribution and diversity indices of macrophytes in Tavarekere Lake, Shimoga taluk, Central Western Ghats region, Karnataka, India

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ABSTRACT

*Aquatic macrophytes play a crucial role in maintaining the ecological balance of freshwater ecosystems, serving as primary producers, habitat providers and biofilters for nutrients and pollutants. The study was carried out to know the diversity and distribution of aquatic macrophytes and water quality variations affecting their growth and composition. Field study was conducted in different seasons to record the macrophyte species associated in the lake, the study results revealed that water quality in seasonal changes significantly influence the macrophyte distribution. During the monsoon season, increasing the nutrient levels, lower pH and higher total dissolved solids (TDS) supported the abundance of macrophytes, diversity indices results shows that highest species richness (13 species) and diversity (Shannon-H=2.342). In contrast, winter exhibits the lowest diversity (8 species) and highest species dominance ($D = 0.2108$), reflecting less favorable environmental conditions. Summer season maintains moderate diversity, with some species experiencing stress due to increased water temperature and higher TDS. Notably, species like *Eichhornia crassipes* and *Salvinia molesta* dominated throughout the year, while others such as *Azolla pinnata* and *Lemna minor* are observed during the monsoon season. These seasonal patterns underscore the importance of environmental factors in shaping macrophyte communities with the monsoon being a critical period for maintaining biodiversity.*

Keywords: Water quality, macrophytes, diversity, physico-chemical parameters

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INTRODUCTION

Plants that grow in or close to water are known as aquatic macrophytes and are essential to the health of aquatic ecosystems. These plants can be found in brackish, freshwater and saltwater habitats, varying in size and form. Three forms of macrophytes exist: floating (either wholly free-floating or rooted with floating leaves), emergent (rooted in sediments and extending above the water surface) and submerged (growing entirely below the water surface). By promoting biodiversity, enhancing water clarity and stabilizing sediments they benefit the aquatic ecosystem.

Many species thrive along water margins, appear during monsoon seasons or flourish in dry conditions. These plants use light energy, water and carbon dioxide for photosynthesis producing carbohydrates and releasing oxygen into the water, which supports aquatic life. Moreover, these plants can alter water temperatures and oxygen levels, indirectly affecting fish growth and survival. In addition to providing food and habitat for fish, wildlife and other aquatic organisms, macrophytes stabilize sediments, improve water clarity and enhance diversity in shallow lake areas. Macrophytes are primary exploiters of nutrients from sediments, preventing these nutrients from being temporarily lost from the water. These nutrients are released back into the ecosystem only after the macrophytes die, decay and undergo

mineralization. Consequently, macrophytes play a crucial role in nutrient dynamics and primary productivity in shallow aquatic ecosystems (1,2).

Macrophytes form the foundation of aquatic food chains and actively support in maintain food webs and ecosystem services in the freshwater ecosystem. Macrophyte abundance depends on various environmental factors such as light, water temperature, substrate composition, disturbances, competitive interactions, herbivory, epiphyte loading, water levels and the quality of lake water and sediment nutrients. Numerous local factors including the water's physicochemical state, substrate type, pond profile and pond size influence macrophytes diversity. Among these, the physicochemical state of the water is significantly impacts macrophyte diversity and is affected by the land uses surrounding the water bodies (3, 4, 5).

Macrophytes are essential to the upkeep of wetland habitats, which means that the health of the environment depends on the presence of aquatic plants. The functioning of an ecosystem can be severely disrupted by the disappearance of macrophytes. In addition to being important biological indicators for identifying pollution, the diversity and abundance of macrophytes are crucial for evaluating the ecology of wetlands. Therefore, documenting the current status of macrophytes is essential for effective conservation measures (6).

Human activities impact biological diversity by not only changing the habitat but also modifying the landscape structure surrounding it. Generally, freshwater ecosystems are among the most endangered worldwide, facing threats from climate change, direct human destruction or natural changes in succession. As freshwater habitats decline, aquatic macrophytes are also disappearing (7). Therefore, understanding the mechanisms that maintain macrophyte diversity in lake is crucial. By using macrophyte diversity as an indicator, it may be possible to conserve the biodiversity of the entire lake.

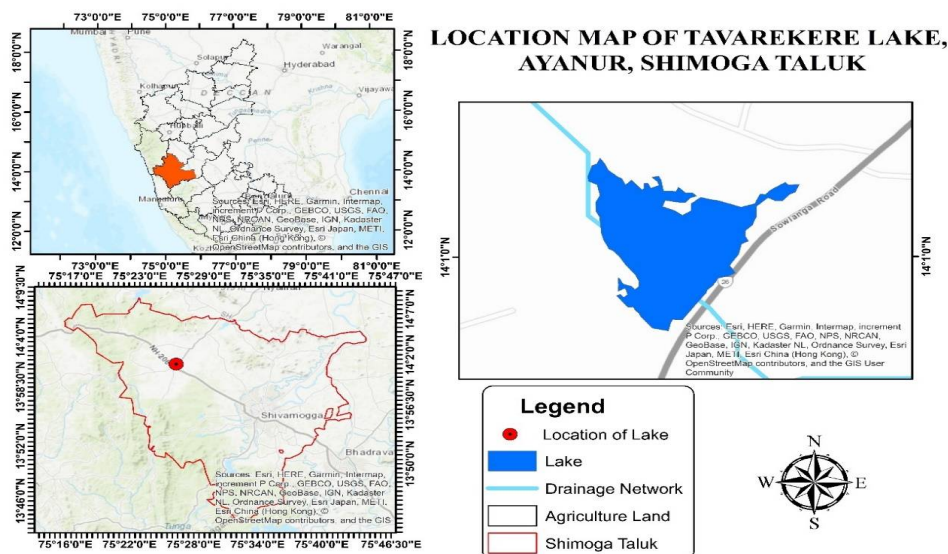
Thus, this study aims to examine Tavarekere Lake's aquatic macrophyte richness, distribution patterns and seasonal variations. Its specific goals are to advance the knowledge of Tavarekere Lake's biological dynamics and offer insightful information on management and conservation efforts.

MATERIAL AND METHODS

Study area

Tavarekere Lake is located very close to Ayanur village in the Shimoga District of Karnataka. The lake is situated at GPS coordinates 14° 1' 0.1092" N and 75° 26' 25.2024" E. The nearest town is Shimoga, approximately 18 km from Ayanur village. The village covers a total geographical area of 813.8 hectares. The lake's catchment area is about 36 acres, with a depth ranging from 7 to 8 meters. Lake primarily receives water from rainfall and agricultural runoff from the surrounding fields. This region receives rainfall about 940-950mm per year and temperature ranged from 23°C to 37°C. The water colour shows slightly greenish, three villages depended on the lake to cultivate crops and the total irrigated area is around 600 to 700 acres. Major crops grown adjacent to the lake include paddy, areca, maize and coconut. Tavarekere Lake also supports rich biodiversity and contributes significantly to local livelihoods (Map 1).

Map 1: Tavarekere Lake



Water sample collection method

Water samples were collected in polyethylene cans for a period of one year during three different seasons (from November 2022 to October 2023). Temperature was measured on-site using a centigrade thermometer, pH was recorded with a portable pH pen and pH paper. Total dissolved solids (TDS) and Electrical Conductivity (EC) were analyzed using a portable EC & TDS meter. Other physicochemical properties of the water including nitrates, sulfates, total alkalinity, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), total hardness, calcium, magnesium, chlorides and dissolved oxygen were analyzed according to standard methods outlined by APHA (8).

Aquatic macrophytes collection

Macrophyte samples were collected during rainy, winter and summer seasons from (November 2022 to October 2023) further, the samples were preserved using 5% formaldehyde and maintained in the laboratory. Aquatic plants were identified using books and monographs (9).

The quadrat method was used to study the community structure of macrophytes, determining their frequency, density and abundance as well as their importance value index (10).

RESULTS AND DISCUSSION

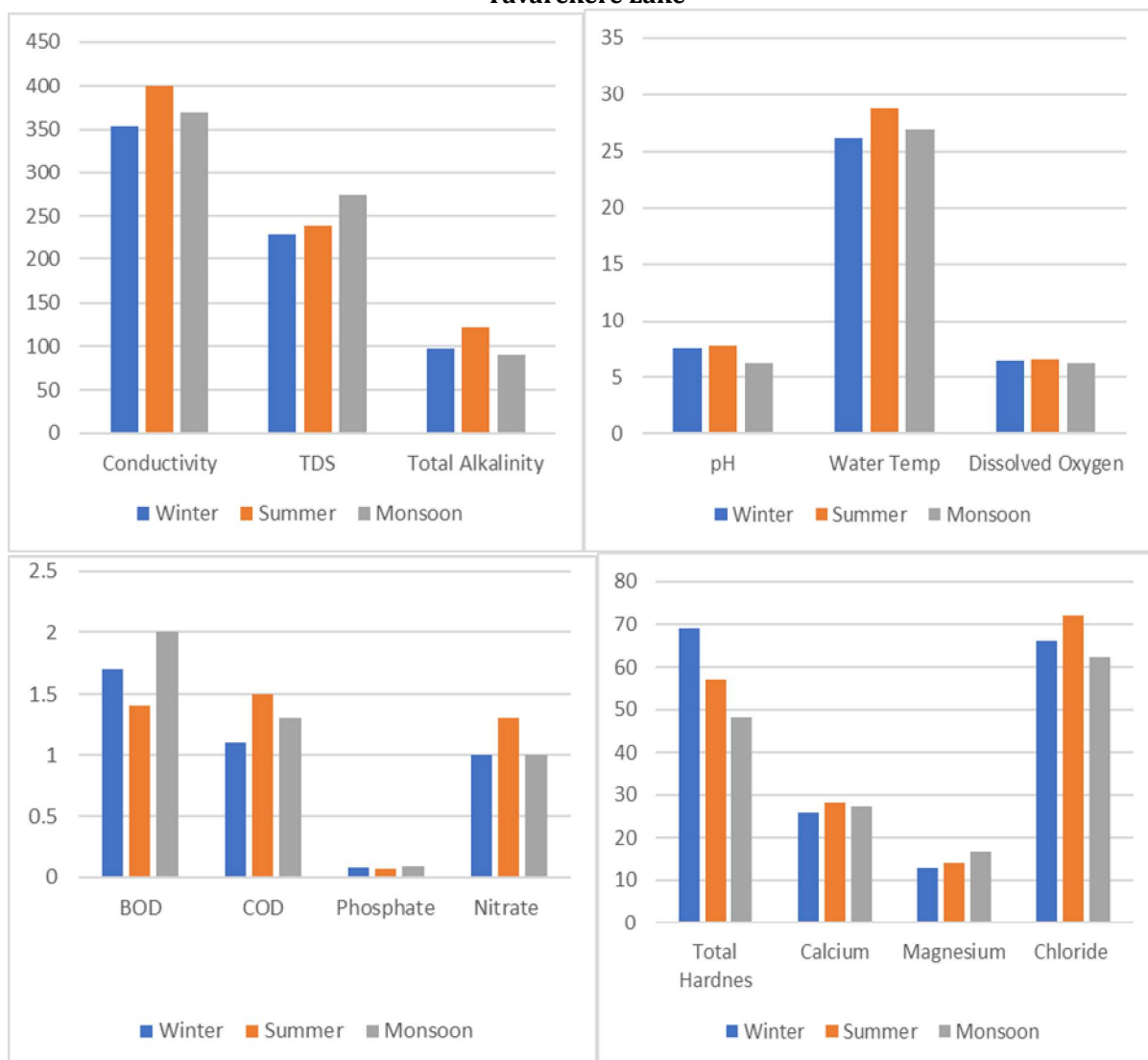
Physico-chemical characteristics

The seasonal variation of physico-chemical properties of water was observed in Tavarekere Lake. The seasonal variation of water samples are significantly influences on the diversity and distribution of aquatic macrophytes. During the monsoon season, the lake exhibits a lower pH (6.3), indicating increased acidity, while pH remains neutral in winter season and summer season (7.8 and 7.6) respectively. This is in reference to a study that stated the pH values ranged between 6-7. The pH of water in monsoon season recorded close to neutral condition but less than 7.0 (11). Water temperature peaks in summer (28.8°C), potentially enhancing macrophyte growth, while conductivity and total dissolved solids (TDS) are also highest during summer and monsoon, reflecting the concentration of ions and dissolved matter. This is about increasing temperatures within an optimal range can usually enhance the activity of enzymes and therefore, promote photosynthesis in submerged macrophytes (12,13). Alkalinity and hardness decrease in the monsoon due to rainwater dilution, affecting nutrient availability for macrophytes. Increased biochemical oxygen demand and chemical oxygen demand during the monsoon shows higher organic matter decomposition, which can stress aquatic life. Nutrient levels such as phosphates and nitrates, peak in the monsoon, supporting macrophyte growth but raising concerns about eutrophication. Dissolved oxygen (DO) levels were slightly lower in the monsoon, likely due to higher organic loads. Similar study conducted in 2021 stated that oxygen level was lower during higher inflows carrying loads of organic matter (14). Overall, the monsoon promotes nutrient influx and macrophyte proliferation, while summer conditions with higher temperatures and TDS was recorded (Table 1 and Figure 1).

Table 1: Seasonal variation of Physico-chemical properties of water recorded in Tavarekere lake (From Nov-2022 to Oct-2023)

Sl No	Parameters	Winter Season	Summer Season	Monsoon Season
1.	pH	7.6	7.8	6.3
2.	Water Temperature	26.2° C	28.8° C	26.9° C
3.	Conductivity (EC)	353µS/cm	401µS/cm	369µS/cm
4.	Total Dissolved Solids (TDS)	229.0 mg/L	238.5 mg/L	274.5 mg/L
5.	Total Alkalinity (TA)	97.0 mg/L	121.2 mg/L	90.2 mg/L
6.	Biochemical Oxygen Demand (BOD)	1.7 mg/L	1.4 mg/L	2.0 mg/L
7.	Chemical Oxygen Demand (COD)	1.1 mg/L	1.5 mg/L	1.3 mg/L
8.	Total Hardness (Ha)	69.0 mg/L	57.2 mg/L	48.2 mg/L
9.	Calcium (Ca)	25.9 mg/L	28.2 mg/L	27.2 mg/L
10.	Magnesium (Mg)	12.8 mg/L	14.1 mg/L	16.7 mg/L
11.	Chloride (Cl)	66.0 mg/L	72.2 mg/L	62.2 mg/L
12.	Phosphates (PO ₄)	0.08mg/L	0.07mg/L	0.09mg/L
13.	Nitrate (NO ₃)	1.0 mg/L	1.3 mg/L	1.0 mg/L
14.	Dissolved Oxygen (DO)	6.5 mg/L	6.6mg/L	6.2 mg/L

Figure 1: Seasonal variation of Physico-chemical properties of water Quality Parameter of Tavarekere Lake



Macrophytes distribution and diversity

The study of aquatic macrophyte diversity in Tavarekere Lake reveals that distinct seasonal variations among emergent, floating, submerged and rooted floating species were noted. Emergent macrophytes such as *Alternanthera philoxioides* (Alligator Weed), *Polygonum glabrum* (Common Marsh) and *Ipomoea carnea* (Bush Morning Glory) are observed all over the year. However, *Bergia capensis* (White Water Fire) only appears during the monsoon and Summer, indicating it thrives under specific moisture conditions. Floating plants like *Salvinia molesta* (Kariba Weed) and *Eichhornia crassipes* (Floating Water Hyacinth) are also consistently found throughout the year, whereas *Azolla pinnata* (Mosquito Fern) and *Lemna minor* (Common Duckweed) are only present during the monsoon and Summer, suggesting their preference for higher nutrient and moisture levels. Among submerged macrophytes, *Utricularia vulgaris* (Common Bladderwort) is found in winter and absent in monsoon and Summer, possibly due to water level fluctuation. At the same time, *Ceratophyllum demersum* (Hornwort) remains present throughout the year, highlighting its resilience. Rooted floating macrophytes exhibit significant seasonal variability; *Nymphoides indica* (Water Snowflake) and *Ipomoea aquatica* (Water Spinach) are present only in summer, while *Nelumbo nucifera* (Sacred Lotus) is found throughout all seasons. *Ludwigia adscendens* (Water Primrose) appears during the monsoon and Summer seasons, likely benefiting from increased water levels and nutrient availability. Overall, the seasonal distribution of macrophytes in Tavarekere Lake is influenced by presence of water, temperature and nutrient levels, with the monsoon period providing optimal conditions for macrophyte growth (Table 2).

Table 2: Distribution of Aquatic macrophytes recorded in different seasons in Tavarekere Lake

Emergent Macrophytes						
SN	Scientific name	Common name	Family	Winter	Monsoon Season	Monsoon Season
1	<i>Alternanthera philoxioides</i> (Mart, Griseb.)	Alligator Weed	Amaranthaceae	+	+	+
2	<i>Polygonum glabrum</i> (Willd.)	Common marsh	Polygonaceae	+	+	+
3	<i>Ipomoea carnea</i> (Jacq.)	Bush Morning Glory	Convolvulaceae	+	+	+
4	<i>Bergia capensis</i> (Linnaeus, Mant.)	White water fire	Elantinaaceae	-	+	+
Floating Macrophytes						
5	<i>Salvinia molesta</i> (D.S. Mitchell)	Kariba Weed	Salviniaceae	+	+	+
6	<i>Eichhornia crassipes</i> (Martius)	Floating water hyacinth	Pontederiaceae	+	+	+
7	<i>Azolla pinnata</i> (R. Brown)	Mosquito fern	Salvinaceae	-	+	+
8	<i>Lemna minor</i> (Carl Linnaeus)	Common duckweed	Lemnaceae	-	-	+
Submerged Macrophytes						
9	<i>Utricularia vulgaris</i> (Carl Linnaeus)	Common Bladderwort	Lentibulariaceae	+	-	-
10	<i>Ceratophyllum demersum</i> (Carl Linnaeus)	Hornwort	Ceratophyllaceae	+	+	+
Rooted Floating						
11	<i>Nymphoides Indica</i> (Carl Linnaeus, Kuntze.)	Water Snowflake	Menyanthaceae	-	-	+
12	<i>Nelumbo nucifera</i> (Gaertn.)	sacred lotus	Nelumbonaceae	+	+	+
13	<i>Ipomoea aquatica</i> (Forsk)	Water spinach	Convolvulaceae	-	-	+
14	<i>Ludwigia adscendens</i> (H.Hara)	Water primrose	Ongraceae	-	+	+

Note: + (Presence) and -(Absence)

Seasonal variation of macrophytes diversity, abundance, frequency, relative dominance, relative abundance, relative frequency of Tavarekere Lake

The seasonal diversity indices of macrophytes in Tavarekere Lake reveals significant variations in species distribution and abundance across winter, summer and monsoon seasons. The data includes diversity (D), abundance (A), frequency (F), relative dominance (RD), relative abundance (RA), relative frequency (RF) and importance value index (IVI) for each species. During the winter season, *Eichhornia crassipes* (Floating Water Hyacinth) showed the highest dominance and importance with a high IVI of 80.88, indicating it was the most significant species in terms of biomass. Similarly, *Salvinia molesta* (Kariba Weed) and *Nelumbo nucifera* (Sacred Lotus) also exhibited high IVI values of 51.84 and 41.93, respectively. *Alternanthera philoxioides* (Alligator Weed) was notable for its consistent diversity and abundance across all seasons, indicating its adaptability.

In the summer season, the dominance of *Eichhornia crassipes* remains evident with an IVI of 42.74, indicating it is still a key species, while *Salvinia molesta* showed a slightly decreased IVI of 32.65. The presence of *Ceratophyllum demersum* (Hornwort) also contributed significantly to the macrophyte community with an IVI of 30.77, highlighting its importance in aquatic ecosystems. Also, hornwort can be important in stabilizing and maintaining a clear water state even at high phosphorus concentrations (15).

During the monsoon, a few species such as *Azolla pinnata* and *Ludwigia adscendens* appeared, showing their preference for the increased water levels and nutrient availability during this season. *Lemna minor* (Common Duckweed) exhibited remarkable abundance with an IVI of 49.08, emphasizing its suitability for monsoon conditions. Overall, the data indicates that the distribution and diversity of aquatic macrophytes in Tavarekere Lake are significantly influenced by seasonal changes. The other species like *Eichhornia crassipes* and *Salvinia molesta* dominate during specific seasons, while others thrive in the nutrient-rich conditions of the monsoon (Table 3).

Table3: Seasonal macrophytes diversity (D), abundance (A), frequency (F), relative dominance (RD), relative abundance (RA), relative frequency (RF) of Tavarekere Lake

Species	WINTER							SUMMER							MONSOON						
	D	A	F	RD	RA	RF	IVI	D	A	F	RD	RA	RF	IVI	D	A	F	RD	RA	RF	IVI
<i>Alternanthera philoxioides</i>	28	28	100	12.65	12.56	13.33	38.55	28.25	28.25	100	9.67	9.64	10.25	29.58	62.75	62.75	100	10.28	10.28	7.69	28.26
<i>Polygonum glabrum</i>	7.25	7.25	100	3.27	3.25	13.33	19.86	5.25	5.25	100	1.79	1.79	10.25	13.84	15.25	15.25	100	2.5	2.5	7.69	12.69
<i>Nelumbo nucifera</i>	31.75	31.75	100	14.35	14.24	13.33	41.93	30.75	30.75	100	10.53	10.50	10.25	31.29	57.5	57.5	100	9.42	9.42	7.69	26.54
<i>Ipomoeacarnea</i>	2	2.66	75	0.90	1.19	10	12.10	2.25	3	75	0.77	1.02	7.69	9.48	4	4	100	0.65	0.65	7.69	9.00
<i>Salvinia molesta</i>	42.75	42.75	100	19.32	19.18	13.33	51.84	32.75	32.75	100	11.21	11.18	10.25	32.65	36.5	36.5	100	5.98	5.98	7.69	19.65
<i>Eicchornia crassipes</i>	75	75	100	33.89	33.65	13.33	80.88	47.5	47.5	100	16.26	16.22	10.25	42.74	63	63	100	10.32	10.32	7.69	28.34
<i>Utricularia vulgaris</i>	2.75	3.66	75	1.24	1.64	10	12.88														
<i>Ceratophyllumdemersum</i>	31.75	31.75	100	14.35	14.24	13.33	41.93	30	30	100	10.27	10.24	10.25	30.77	36.5	36.5	100	5.98	5.98	7.69	19.65
<i>Azolla pinnata</i>								44.5	44.5	100	15.23	15.20	10.25	40.69	75.5	75.5	100	12.37	12.37	7.69	32.44
<i>Ludwigia adscendens</i>								20	20	100	6.84	6.83	10.25	23.93	26.25	26.25	100	4.30	4.30	7.69	16.29
<i>Bergia capensis</i>								50.75	50.75	100	17.38	17.33	10.25	44.97	64.75	64.75	100	10.61	10.61	7.69	28.92
<i>Nymphoides Indica</i>															18.5	18.5	100	3.03	3.03	7.69	13.75
<i>Lemna minor</i>															126.25	126.25	100	20.69	20.69	7.69	49.08
<i>Ipomoea aquatic</i>															23.25	23.25	100	3.81	3.81	7.69	15.31

Seasonal macrophytes diversity indices in Tavarekere Lake

The diversity indices of aquatic macrophytes in Tavarekere Lake shows significantly varied. In the monsoon season increased water level creates the favorable condition for species diversity. During the monsoon, the lake recorded the highest species richness (TaxaS) with 13 species and the largest number

of individuals (2,440), compared to 10 species and 1,168 individuals in summer and 8 species with 885 individuals in winter. This indicates that the monsoon season provides ideal conditions, such as higher water levels and increased nutrients, allowing more species to thrive.

In terms of species dominance (D), winter shows the highest value (0.2108), meaning that a few species dominate the macrophyte community. This is also reflected in the lower Simpson's index (1-D) for winter (0.7892), indicating reduced diversity. In contrast, monsoon has the lowest dominance (0.1116) and the highest Simpson's index (0.8884), reflecting a more evenly distributed and diverse community during this season.

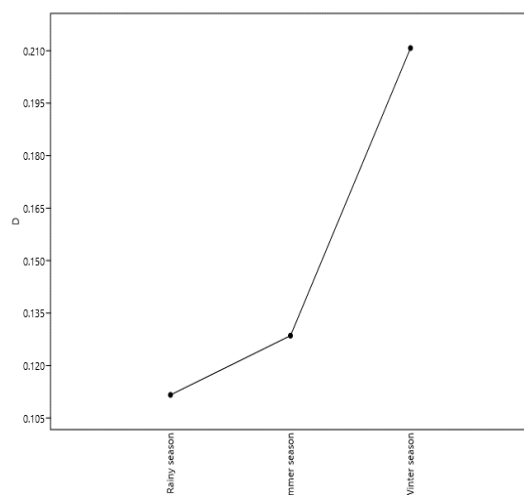
The Shannon-Wiener index (H), which accounts for both species richness and evenness, follows a similar trend. The highest Shannon value is observed during the monsoon (2.342), followed by summer (2.122) and the lowest in winter (1.712). This suggests that the monsoon supports a more balanced and diverse macrophyte population, while winter shows fewer species and less even distribution.

Evenness, which measures how uniformly individuals are spread across species, is highest in summer (0.8346), followed by the monsoon (0.8) and lowest in winter (0.6927). Although summer has fewer species than the monsoon, the species present are more evenly distributed, while winter sees a greater dominance of fewer species.

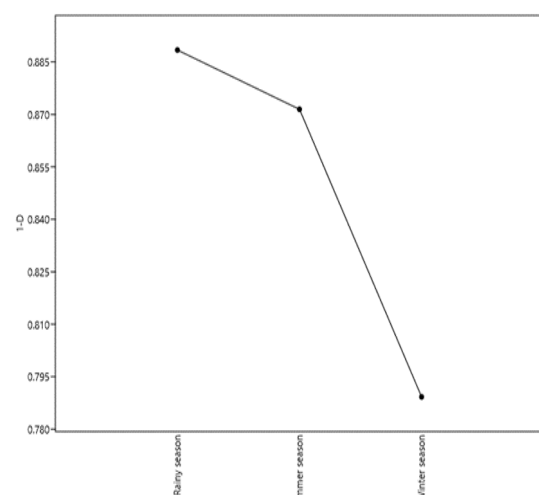
The diversity indices highlight the monsoon season as the period with the greatest species diversity and abundance in Tavarekere Lake, with favorable conditions allowing for a more even and varied macrophyte community. Summer supports relatively high evenness despite fewer species, while winter sees reduced diversity, with dominance by a few species due to less favorable environmental conditions. These seasonal variations emphasize the importance of the monsoon in maintaining the biodiversity of the lake (Table 4 and Fig 2).

Table 4. Diversity indices observed in different seasons in Tavarekere Lake

Diversity indices	Monsoon season	Summer season	Winter season
Taxa_S	13	10	8
Individuals	2440	1168	885
Dominance_D	0.1116	0.1286	0.2108
Simpson_1-D	0.8884	0.8714	0.7892
Shannon_H	2.342	2.122	1.712
Evenness_e^H/S	0.8	0.8346	0.6927



Dominance-D



Simpson_1-D

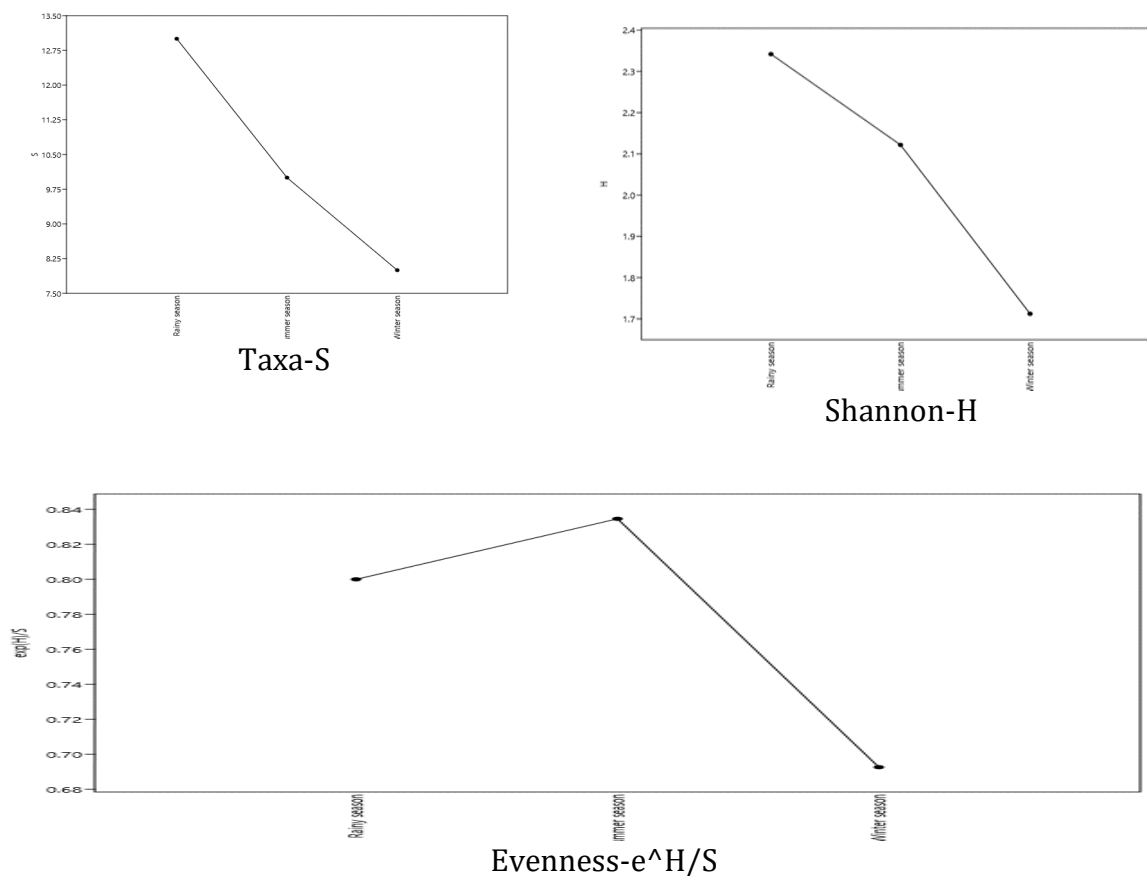


Fig 2. Diversity indices of macrophytes in Tavarekere Lake

CONCLUSION

The study emphasizes that water quality characteristics is strongly influenced on distribution and diversity of macrophytes. The monsoon season witnessed higher levels of nutrients as well as enough water level promoted the rich diversity of macrophytes. This is evidenced that with the support of the occurrence of higher species richness (13 species), evenness (2,440), lower species dominance ($D=0.1116$) and highest diversity (Shannon-H = 2.342) indicating favorable conditions for macrophyte growth. In contrast, winter displayed the lowest diversity, with higher species dominance and reduced evenness. Dominant species such as *Eichhornia crassipes* and *Salvinia molesta* are present year-round, while species like *Azolla pinnata* and *Lemna minor* flourish mainly during the monsoon. In contrast, winter shows the lowest diversity, with increased species dominance and reduced evenness, while the summer season maintains moderate diversity with fewer species. The study findings highlight that seasonal environmental factors play a crucial role in maintaining biodiversity and the ecological balance of Tavarekere Lake. Considering the anthropogenic effect and natural stress facing the degradation of water bodies. Therefore, regular monitoring and proper management is essential and further conservation is the need of the hour to maintain a healthy ecosystem.

REFERENCES

1. Pott, V. J., Pott, A., Lima, L. C. P., Moreira, S. N. & Oliveira, A. K. (2011). Aquatic macrophyte diversity of the Pantanal wetland and upper basin. *Brazilian Journal of Biology*, 71: 255-263.
2. Ahmad, U., Parveen, S., Hasan, T. & Bhat, B. N. (2015). Diversity of aquatic macrophytes of Aligarh, UP India. *Int. J. Curr. Microbiol. App. Sci*, 4(4):494-505.
3. Akasaka, M., Takamura, N., Mitsuhashi, H., & Kadono, Y. (2010). Effects of land use on aquatic macrophyte diversity and water quality of ponds. *Freshwater Biology*, 55(4):909-922.
4. Dar, N. A., Pandit, A. K. & Ganai, B. A. (2014). Factors affecting the distribution patterns of aquatic macrophytes. *Limnological Review*, 14(2):75-81.

5. Agbogidi, O. M., Nwabueze, A. A., Onochie, P., Ukre, R. & Stephen, O. F. (2022). Species Diversity of Macrophytes and Physicochemical Parameters of Ponds of Abraka Inland, Delta State, Nigeria. *European Journal of Botany*, 1(1):1-5.
6. Sahin-Yigit, S., & Dogan, M. (2021). Diversity and Distribution of Aquatic Vascular Macrophytes in Gaziantep Ponds, Turkey. *Fresenius Environmental Bulletin*, 30(8): 10096-10112.
7. Bubíková, K. & Hrivnák, R. (2018). Artificial ponds in Central Europe do not fall behind the natural ponds in terms of macrophyte diversity. *Knowledge & Management of Aquatic Ecosystems*, 419:8.
8. American Public Health Association (APHA). *Standards Methods for the Examination of water and Wastewater*. 23rd ed. American Public Health Association, American Water Work Association, Water Work Federation, Washington DC; 2017.
9. Cook, C. D., Gut, B. J., Rix, E. M. & Schneller, J. (1974). *Water plants of the world: a manual for the identification of the genera of freshwater macrophytes*. Springer Science & Business Media.
10. Parray, S. Y., Najar, M. A., Akhter, R. & Zuber, S. M. (2014). Diversity and distribution of macrophytes in Chatlam wetland-a freshwater wetland in Kashmir himalayas.
11. Mukherjee, A. K. (1964). Acidity of Monsoon Rain Water. *MAUSAM*, 15(2):267-270. <https://doi.org/10.54302/mausam.v15i2.5541>
12. Olesen B. & Madsen T. V. (2000). Growth and physiological acclimation to temperature and inorganic carbon availability by two submerged aquatic macrophyte species, *Callitriche cophocarpa* and *Elodea canadensis*. *Funct. Ecol.* 14:252-260. 10.1046/j.1365-2435.2000.00412.x
13. Riis T., Olesen B., Clayton J. S., Lambertini C., Brix H., Sorrell B. K. (2012). Growth and morphology in relation to temperature and light availability during the establishment of three invasive aquatic plant species. *Aquat. Bot.* 102: 56-64. 10.1016/j.aquabot.2012.05.002
14. Mamun, M., Atique, U., Kim, J. Y. & An, K. G. (2021). Seasonal Water Quality and Algal Responses to Monsoon-Mediated Nutrient Enrichment, Flow Regime, Drought, and Flood in a Drinking Water Reservoir. *International journal of environmental research and public health*, 18(20): 10714. <https://doi.org/10.3390/ijerph182010714>.
15. Maszyk, M., Lenard, T., Olech, M., Martyna, A., Poniewozik, M., Boguszevska-Czubara, A., & Kubiński, K. (2024). *Ceratophyllum demersum* the submerged macrophyte from the mining subsidence reservoir Nadrybie Poland as a source of anticancer agents. *Scientific Reports*, 14(1):6661.

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