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Physical Parameters as Drivers of Macrophyte Distribution in Dal Lake: An Ecological Perspective

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Abstract - Dal Lake, located in Kashmir Valley, India, is a vital freshwater ecosystem that supports a diverse range of macrophytes. These aquatic plants play a crucial role in maintaining water quality and biodiversity. The spatial distribution of macrophytes in Dal Lake is influenced by various physical parameters. The biodiversity of Dal Lake is not only important for maintaining the health and ecological balance of the lake, but also provides numerous ecosystem services. Light is a crucial physical parameter that affects macrophyte growth and distribution in Dal Lake. The transparency of the lake's water, which measures the depth at which light can penetrate, ranged from 0.1m to 1.0m. Notably, the highest transparency value was recorded during winter, indicating that the water is clearer during this season. This suggests that macrophytes in Dal Lake have adapted to low light conditions during winter months Temperature is another critical physical parameter that influences macrophyte distribution. In Dal Lake, temperature followed a clear seasonal trend, with maximum temperatures of 33°C in summer and minimum temperatures of 4°C in winter. This suggests that macrophytes in Dal Lake are adapted to a wide range of temperatures. In contrast this water depth is a physical parameter that affects macrophyte growth and distribution. In Dal Lake, the depth varied significantly, ranging from 1.8m to 4.5m. This suggests that macrophytes in Dal Lake are adapted to a range of depths. The study found that water depth, transparency, and temperature were the most influential physical parameters affecting macrophyte distribution. The study identified three distinct macrophyte communities, each associated with specific physical parameter ranges. The findings of this study contribute to our understanding of the complex relationships between physical parameters and macrophyte distribution in freshwater ecosystems. The findings of this study have important implications for aquatic ecology, conservation biology, and environmental management.

Key words: macrophytes, physical parameters, spatial distribution, Dal Lake, freshwater ecosystem, conservation management, biodiversity, water quality, aquatic ecology

1. INTRODUCTION

Macrophytes are aquatic plants that grow in freshwater ecosystems, including lakes, rivers, and wetlands (Wetzel, 2001; Chambers et al., 2008). These plants play a crucial role in maintaining the ecological balance of freshwater ecosystems, providing habitat and food for aquatic organisms, stabilizing sediments, and regulating water quality (Lacoul and Freedman, 2006; Murphy, 2002). Macrophytes are diverse, ranging from floating plants like water lilies and duckweeds to submerged plants like coontails and elodea, and emergent plants like cattails and bulrushes (Cook, 1990; Riis and Hawes, 2002). They are adapted to survive in a variety of aquatic environments, from shallow ponds to deep lakes, and from slow-moving rivers to fast-flowing streams (Barko et al., 1991; Smith, 2003). The growth and distribution of macrophytes are influenced by various environmental factors, including light, temperature, water depth, and nutrient availability (Wetzel, 2001; Chambers et al., 2008). Understanding the ecology of macrophytes is essential for managing and conserving freshwater ecosystems, as they provide important ecosystem services and support biodiversity (Scheffer, 2004; Pandit, 2008).

Dal Lake, a vital freshwater ecosystem in Kashmir Valley, India, is renowned for its exceptional biodiversity and ecological significance. As a crucial component of freshwater ecosystems, macrophytes play a pivotal role in maintaining water quality, supporting aquatic life, and regulating ecosystem processes (Wetzel, 2001; Chambers et al., 2008). The spatial distribution of macrophytes in Dal Lake is influenced by a complex interplay of physical parameters, including light, temperature, water depth, and sediment characteristics (Lacoul and Freedman, 2006; Murphy, 2002). Understanding the relationships between

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physical parameters and macrophyte distribution is essential for managing and conserving freshwater ecosystems (Smith, 2003; Scheffer, 2004). Physical parameters can affect macrophyte growth, survival, and reproduction, ultimately influencing their distribution and abundance (Barko et al., 1991; Riis and Hawes, 2002). In Dal Lake, the unique combination of physical parameters creates a diverse range of habitats that support a wide variety of macrophyte species (Pandit, 2008). This study aims to investigate the relationships between physical parameters and macrophyte distribution in Dal Lake, providing insights into the ecological processes that shape this freshwater ecosystem. By examining the interactions between physical parameters and macrophyte distribution, this research contributes to our understanding of the complex dynamics of freshwater ecosystems and informs conservation and management strategies for Dal Lake and similar ecosystems.

2. STUDY AREA: Dal Lake, Kashmir Valley, India

The Kashmir Valley nestled between the Lesser and Greater Himalayas, is home to numerous aquatic ecosystems of immense ecological and economic significance. The freshwater bodies of the Kashmir Himalayas serve as vital sources of drinking water, irrigation, navigation, fishery, agriculture, socioeconomic development, and recreation. The lake lies at an altitude of 1586 meters above sea level, between 34°5'–34°9' N latitude and 74°49'–74°52' E longitude. However, due to increasing anthropogenic pressures, including population growth, floating gardens, land masses, and marshes, the lake's surface area has shrunk significantly to 10.4 km2. This reduction in size has been accompanied by deterioration in water quality, posing health hazards to the local population.

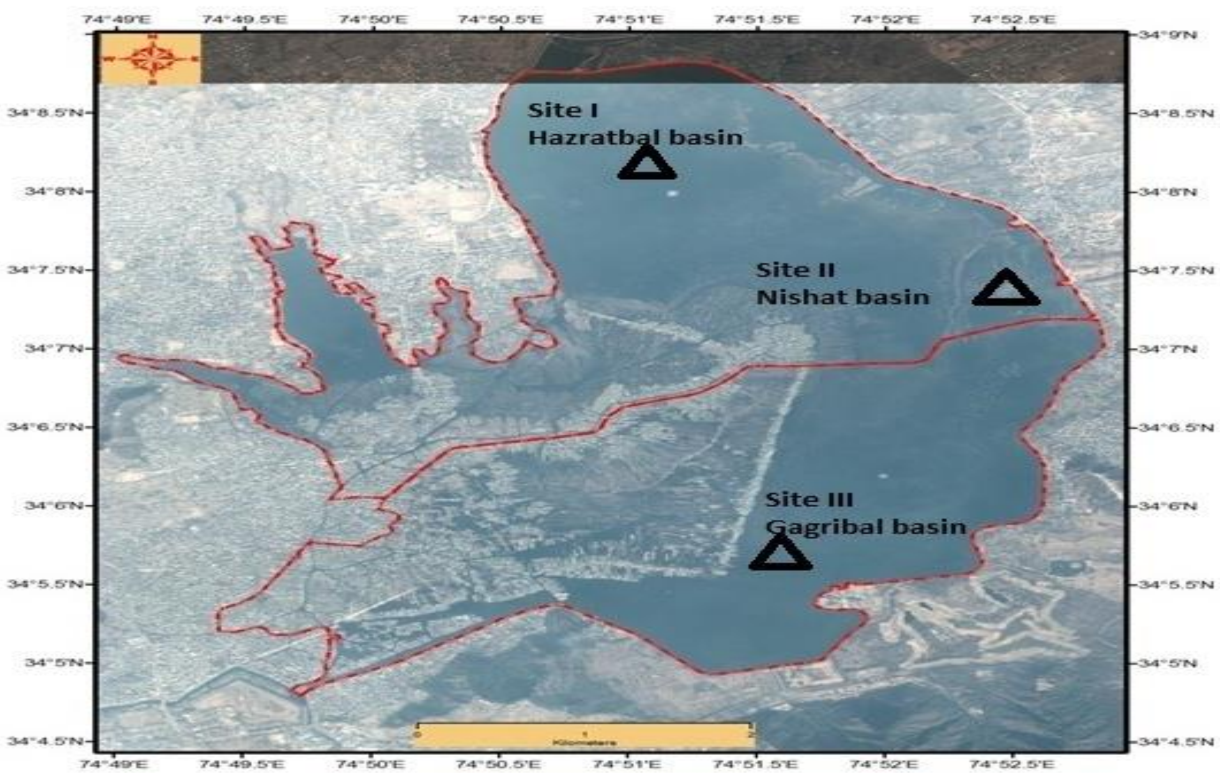
3. STUDY SITES AND GEOLOGICAL ORIGIN AND MORPHOLOGY

Dal Lake is believed to have originated from the River Jhelum, with its formation attributed to the ox-bows of the river. The lake is a multi-basined urban valley lake, comprising four distinct basins: Hazratbal, Boddal, Gagribal, and Nagin Lake as shown in table 1. The present study was carried out in the 3 basins of Dal Lake for a period of one year from May 2022 to May 2023. For the present study, six sampling sites were selected on the basis of location, water depth, and availability of the experimental macrophytes two sites in Hazratbal basin, two site in Nishat and two sites in Gagribal basin. For studying the Macrophytes as Monitoring and Assessment tools for determining the Ecological Status of Dal Lake in Kashmir.

Table: 1: Showing general geographical features of three sampling sites.

Sites	Code	Latitude	Longitude
Hazratbal basin	I	34° 08′ 03.8″ N	74° 50′ 40.1″ E
Hazratbal basin	II	34° 07′ 31.6″ N	74° 50′ 45.8″ E
Nishat basin	III	34° 05′ 12.5″N	74° 51′ 05.5″ E
Nishat basin	IV	34° 07′ 32.6″ N	74°52′ 37.7″ E
Gagribal basin	V	34° 06′ 33.1″ N	74° 52′40.0″ E
Gagribal basin	VI	34° 05′ 25.5″ N	74° 51′ 05.5″ E

Figure:1. Study area and sampling sites.



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4. MATERIALS AND METHOD

The present study was carried out in the dal lake during five months in three basins namely as (I Hazratbal basin, II Nishat basin, III Gagribal basin) and the material was collected from the 3 basins (Fig. 1). Transparency was measured using a Secchi disk (20 cm diameter) at 10 sampling stations across Dal Lake. The Secchi disk was lowered into the water until it was no longer visible, and the depth at which it disappeared was recorded as the transparency value. Depth was measured using a portable depth sounder (Garmin, USA) at each sampling station. The depth sounder was calibrated before use. Additionally, the maximum depth of the lake was measured using a weighted rope and a depth meter. Temperature was measured using a digital thermometer (Hanna Instruments, USA) at each sampling station at 10 cm depth intervals from the surface to the bottom of the lake. The thermometer was calibrated before use.

5. RESULTS AND DISCUSSIONS

5.1. Depth

The depth of Dal Lake was measured at various locations over a two-year study period (2022-2023). The maximum depth of 4.5 meters was recorded at Site VI during autumn 2022, while the minimum depth of 1.8 meters was recorded at Site I during winter 2023. The average depth measurements for each site are presented in Table 5.1. Site VI had the highest average depth of 4.2 ± 0.2 meters, while Site I had the lowest average depth of 2.0 ± 0.1 meters (Fig.5.1).

5.2. Transparency

Dal Lake exhibited high turbidity levels throughout the study period, with water transparency showing a distinct seasonal trend. Transparency levels were higher during the colder months (winter) and lower during the warmer months (summer). This trend suggests that increased runoff and sedimentation during the warmer months contribute to reduced water transparency. The lake's waters were characterized by significant suspended sediment loads, algae growth, and other substances that contributed to its turbidity. The highest transparency (1.0 m) was recorded at Site II during winter, while the lowest transparency (0.1 m) was recorded at the same site during summer. The mean transparency values for each site are presented in Table 5.2. Site IV had the highest mean transparency (0.6 ± 0.2 m), while Site III had the lowest mean transparency (0.3 ± 0.2 m)(Fig.5.2)

5. 3. Air temperature

The air temperature recordings at Dal Lake exhibited a distinct seasonal trend during the study period (2022-2023). A maximum air temperature of 32 °C was recorded during summer at Site V, while a minimum air temperature of 4.5 °C was recorded during winter at Site III. The seasonal mean air temperature values for each site are presented in Table 5.3. Site VI recorded the highest seasonal mean temperature (19.7±8.3 °C), while Site III recorded the lowest seasonal mean temperature (17.6±9.0 °C) (Fig 5.3).

Table 5.1. Seasonal Depth (m) fluctuations with (Mean±SD) in Dal Lake (spring 2022 - winter 2023).

Sites	Spring	Summer	Autumn	Winter	Mean±SD
Site I	2	1.9	2.3	1.8	**2.0±0.1**
Site II	3	2.5	2.4	2	**2.4±0.3**
Site III	2.5	3	2.75	2.6	**2.7±0.1**
Site IV	2.9	2.7	2	2.5	**2.5±0.3**
Site V	3.9	3	2.8	3	**3.1±0.4**
Site VI	4	4	4.5	4.3	**4.2±0.2**

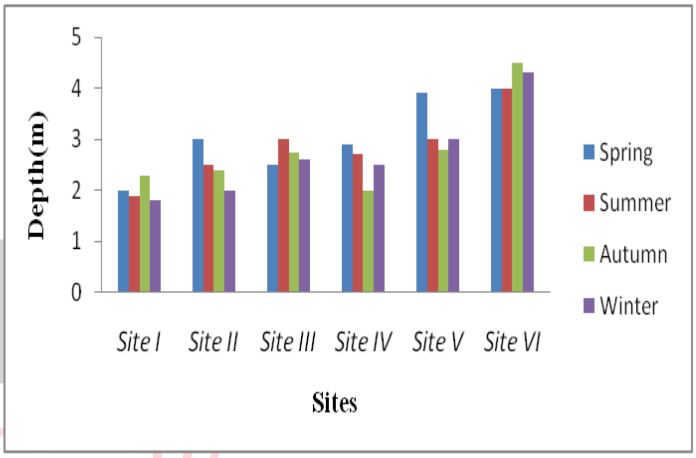

Fig. 5.1. Seasonal Depth (m) fluctuations with (Mean) in Dal Lake (Spring 2022 - Winter 2023).

Table 5. 2. Seasonal transparency (m) fluctuations with (Mean±SD) in Dal Lake (Spring 2022 - Winter 2023).

Sites	Spring	Summer	Autumn	Winter	Mean± SD
Site I	0.3	0.25	0.3	0.4	**0.3±0.1**
Site II	0.4	0.1	0.5	1	**0.5±0.3**
Site III	0.3	0.2	0.4	0.7	**0.3±0.2**
Site IV	0.6	0.3	0.9	0.6	**0.6±0.2**
Site V	0.4	0.3	0.5	0.9	**0.5±0.2**
Site VI	0.3	0.2	0.4	0.6	**0.3±0.1**

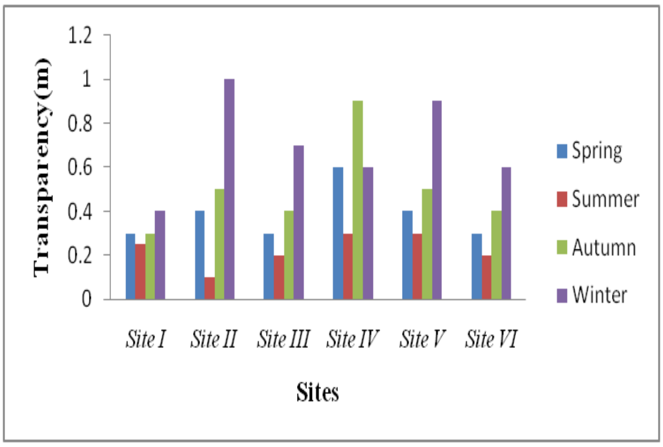

Fig. 5. 2. Seasonal transparency (m) fluctuations with (Mean) in Dal Lake (Spring 2022 - Winter 2023)

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Table 5.3. Seasonal air temperature (ºC) fluctuations with (Mean±SD) in Dal Lake (Spring 2022 - Winter 2023).

Sites	Spring	Summer	Autumn	Winter	Mean± SD
Site I	20.0	30.4	17.0	7.5	**18.7±8.1**
Site II	19.0	29.5	18.0	6.1	**18.1±8.3**
Site III	18.5	30.0	17.5	4.5	**17.6±9.0**
Site IV	20.2	31.3	16.0	6.0	**18.3±9.0**
Site V	21.0	32.0	18.0	7.0	**19.5±8.9**
Site VI	20.5	31.0	20.0	7.5	**19.7±8.3**

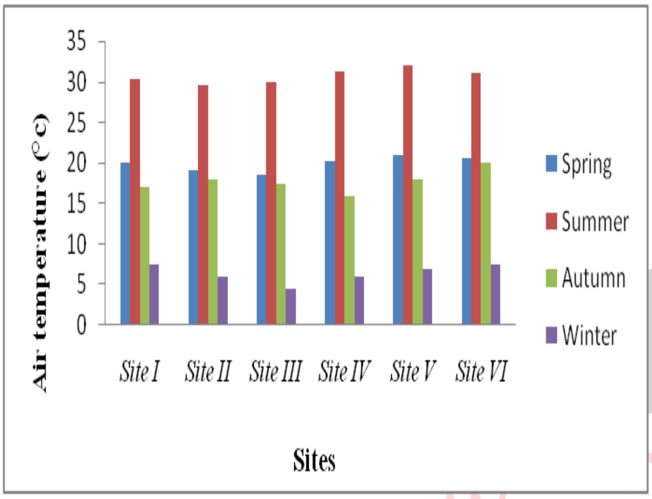

Fig. 5.3. Seasonal air temperature ºC fluctuations with (Mean) in Dal Lake (Spring 2022 - Winter 2023).

6. DISCUSSIONS

Dal Lake's water quality has deteriorated due to untreated sewage discharge, posing threats to its ecosystem and biodiversity (Mushtaq et al., 2020). The lake's physical and chemical environment has fluctuated significantly. Located in the Kashmir Himalayas, Dal Lake is a vital water body with an average depth of 2.5 m (Pandit, 2002). Its depth varies significantly, ranging from 1.8 m to 4.5 m, with notable seasonal and spatial fluctuations. The lake's depth is influenced by hydrological factors, geological characteristics, land use patterns, and climatic conditions (Hutchinson, 1957; Wetzel, 2001). Seasonal fluctuations in water depth are driven by precipitation and evaporation patterns. The lake's thermal regime is affected by its depth and volume, impacting its heat capacity, mixing patterns, and thermal dynamics (Atobatele and Ugumba, 2008).

The water transparency of Dal Lake, ranging from 1.0 m to 0.1 m, is consistent with the findings of Wetzel and Likens (2000), who reported that water transparency is a crucial indicator of water quality. The highest transparency (1.0 m) recorded at Site II in winter 2023, and the lowest (0.1 m) at Site I in summer 2023, also align with the seasonal patterns observed by Mahar (2003) in Dal Lake. The positive relationship between submerged macrophytic vegetation and water transparency at Site II supports the findings of De-Vicente et al. (2006) and Huang et al. (2007), who reported that aquatic vegetation can enhance water clarity by stabilizing sediments, reducing turbulence, and promoting water clarity.

The observed fluctuations in water transparency at Dal Lake can be attributed to various biological and physical factors. During spring, high biological activity, particularly phytoplankton growth, and increased silt-laden runoff contribute to reduced water transparency (Hakanson and Boulion, 2002).

The observed correlation between air and water temperature in Dal Lake is consistent with previous studies (Ried and Wood, 1976; Mahar, 2003). Similarly, the seasonal trend in air temperature, ranging from 4°C (winter) to 33°C (summer), is comparable to other lakes in similar climates (Mustapha and Omotosho, 2005; Ayoade *et al.*, 2006). The optimal temperature range for aquatic organisms (3.9°C to 26.7°C) observed in Dal Lake is also consistent with other studies (Boyd, 1979). This suggests that the lake's thermal regime is suitable for supporting a diverse array of aquatic life. Furthermore, the positive correlation between water temperature and bright sunshine duration observed in Dal Lake is similar to findings from other studies (Munawar, 1970; Harshey *et al.*, 1982). This highlights the significant impact of solar radiation on heating and warming of lake waters.

7. CONCLUSION

The physical parameters of Dal Lake, including water depth, transparency, and temperature, play a crucial role in driving the distribution of macrophytes and influencing the lake's ecological dynamics. The observed fluctuations in these parameters are attributed to various biological and physical factors, such as precipitation, evaporation, and solar radiation. The study highlights the importance of submerged macrophytic vegetation in enhancing water clarity and promoting a healthy aquatic ecosystem. The optimal temperature range for aquatic organisms and the positive correlation between water temperature and bright sunshine duration underscore the significance of the lake's thermal regime in supporting a diverse array of aquatic life. Overall, this study provides valuable insights into the physical parameters driving macrophyte distribution in Dal Lake, emphasizing the need for sustainable management practices to protect the lake's ecological integrity and biodiversity.

Recommendations

1. Monitoring and management: Regular monitoring of physical parameters and implementation of management strategies to mitigate the impacts of pollution, eutrophication, and climate change.

2. Conservation of macrophytes: Protection and conservation of submerged macrophytic vegetation to

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maintain water clarity and promote a healthy aquatic ecosystem.

3. Sustainable land use practices: Implementation of sustainable land use practices in the catchment area to reduce nutrient loading and sedimentation.

4. Climate change mitigation: Development of strategies to mitigate the impacts of climate change on the lake's thermal regime and ecological dynamics.

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