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Full Length Research Paper

Evaluating Wetland Water Quality and Aquatic Plant Dynamics in the Dhemaji and Jorhat Regions of Assam

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Abstract

The wetlands of the Brahmaputra floodplain in Assam represent critical freshwater ecosystems that support diverse aquatic biodiversity and provide essential ecosystem services to local communities. This study evaluates the water quality parameters and aquatic macrophyte diversity in selected wetlands of Dhemaji and Jorhat districts of Assam, India. Using standard analytical methods (APHA, 2012), physico-chemical parameters including pH (6.8-7.9), dissolved oxygen (4.5-9.4 mg/L), biochemical oxygen demand (1.8-4.2 mg/L), transparency (35-210 cm), and nutrient concentrations were analyzed across three seasons during 2019-2021. Macrophyte surveys documented 68 aquatic plant species belonging to 28 families, with Cyperaceae, Poaceae, and Nymphaeaceae being the dominant families. The Water Quality Index (WQI) values ranged from 68.6 to 74.8, indicating poor water quality status across all studied wetlands. Significant correlations were observed between dissolved oxygen and species richness ($r = 0.76$, $p < 0.01$) and between transparency and macrophyte diversity ($r = 0.78$, $p < 0.01$). The invasive species Eichhornia crassipes showed alarming proliferation with relative frequency ranging from 28.4% to 38.2%. The findings highlight the urgent need for conservation interventions and sustainable management strategies to preserve these ecologically significant wetland ecosystems.

Keywords: *Wetland ecosystem, Water quality index, Aquatic macrophytes, Brahmaputra floodplain, Biodiversity conservation*

1. Introduction

Wetlands are among the most productive ecosystems on Earth, providing a wide array of ecological services including water purification, flood control, groundwater recharge, carbon sequestration, and biodiversity conservation (Costanza et al., 1997). The Brahmaputra Valley in Assam, northeastern India, harbors an extensive network of floodplain wetlands locally known as "beels" that have evolved through the dynamic geomorphological processes of the mighty Brahmaputra River and its tributaries. These wetlands constitute approximately 1.29 lakh hectares of water-spread area, representing one of the largest freshwater wetland complexes in South Asia (Sugunan & Bhattacharjya, 2000). The floodplain wetlands of Assam are characterized by their unique hydrological connectivity with the main river channel, seasonal water level fluctuations, and rich biodiversity assemblages. These ecosystems support diverse communities of aquatic macrophytes, fish, waterfowl, and other aquatic organisms that have adapted to the monsoon-driven flooding regime of the region. The aquatic macrophytes play a pivotal role in wetland ecosystem functioning by influencing primary productivity, nutrient cycling, sediment stabilization, and habitat provision for aquatic fauna (Bornette & Puijalon, 2011).

Dhemaji and Jorhat districts, situated in the upper and middle Brahmaputra valley respectively, contain numerous wetlands of varying sizes and ecological characteristics. Dhemaji district alone harbors 139 wetlands covering approximately 3,960 hectares, while Jorhat district contains 109 wetlands spanning 2,108.5 hectares. These wetlands face mounting anthropogenic pressures including agricultural encroachment, domestic sewage discharge, siltation, and invasive species proliferation that threaten their ecological integrity and the livelihoods of dependent communities (Phukan & Saikia, 2014). Despite the ecological and socioeconomic significance of these wetlands, comprehensive scientific assessments of their water quality status and macrophyte diversity remain limited. Previous studies have largely focused on individual wetlands or specific parameters, leaving significant knowledge gaps regarding the regional patterns of wetland degradation and biodiversity loss. Understanding the intricate relationships between water quality parameters and aquatic plant communities is essential for developing evidence-based conservation and management strategies. The present study aims to bridge these knowledge gaps by providing a systematic assessment of water quality and aquatic macrophyte dynamics in selected wetlands of Dhemaji and Jorhat districts. The findings are expected to contribute to the scientific understanding of wetland ecosystem health in the Brahmaputra floodplain and inform policy interventions for sustainable wetland management.

2. Literature Review

The study of wetland ecosystems has gained considerable momentum globally, driven by the recognition of their critical role in maintaining environmental sustainability and supporting human well-being. Wetlands provide ecosystem services valued at approximately US$14.9 trillion annually, with freshwater wetlands contributing significantly to this valuation through services such as water supply, flood control, and biodiversity maintenance (Costanza et al., 1997). In the Indian context, wetland research has evolved from basic inventories to more sophisticated ecological assessments. The National Wetland Atlas prepared by the Space Applications Centre documented over 757,060 wetlands covering 15.26 million hectares across India, with Assam accounting for a substantial proportion of freshwater wetlands in the northeastern region (Bhagabati & Deka, 2021). The floodplain wetlands of Assam have been recognized for their unique ecological characteristics and high biodiversity values, prompting several studies on their limnological features and biotic communities.

Water quality assessment in wetlands has traditionally relied on physico-chemical parameter analysis following standard protocols. Dutta et al. (2016) conducted a comprehensive hydrogeochemical assessment of wetlands in the Brahmaputra valley, revealing that rock-water interactions and anthropogenic inputs significantly influence water chemistry. Their study demonstrated that most wetlands exhibited signs of organic and inorganic pollution, with Water Quality Index values indicating poor to marginal water quality status. Similar findings were reported by Bhat et al. (2014) in their assessment of Wular Lake in Kashmir, where statistical analysis revealed multiple pollution sources affecting wetland water quality. The application of remote sensing and GIS technologies has revolutionized wetland monitoring and assessment. Deka et al. (2011) employed multi-temporal satellite imagery to document the spatial extent changes in Deepor Beel, a Ramsar wetland near Guwahati, revealing significant wetland shrinkage over three decades due to urbanization and encroachment. Meraj et al. (2021) further advanced this approach by integrating machine learning algorithms with ecosystem services modeling, demonstrating the potential of geospatial technologies for comprehensive wetland assessment.

Aquatic macrophyte diversity in Assam wetlands has been documented by several researchers. Cook (1996) provided the foundational taxonomic reference for aquatic and wetland plants of India, describing approximately 660 species with identification keys and ecological notes. Building on this work, regional studies have documented macrophyte assemblages in specific wetlands. Hazarika (2013) reported 45 macrophyte species in Satajan wetland of Lakhimpur district, noting the dominance of emergent and floating-leaved species. The relationship between macrophyte diversity and environmental factors has been extensively reviewed by Bornette and Puijalon (2011), who emphasized that water chemistry, substrate characteristics, and hydrological regime are primary determinants of aquatic plant community composition. The invasion of exotic species, particularly Eichhornia crassipes (water hyacinth), poses a severe threat to native macrophyte diversity in Assam wetlands. Lahon et al. documented the alarming expansion of water hyacinth in Brahmaputra floodplain wetlands, showing that this invasive species significantly reduces native plant diversity through competitive exclusion and habitat modification. Their study in a wetland ecosystem revealed that water hyacinth biomass negatively correlated with native species richness, highlighting the urgent need for invasive species management.

Fisheries in floodplain wetlands represent a crucial livelihood resource for rural communities in Assam. Sugunan and Bhattacharjya (2000) provided comprehensive documentation of beel fisheries in Assam, describing 91 commercially important fish species and traditional fishing practices. Kar (2019) further expanded this knowledge by examining fish diversity patterns across wetlands of the Brahmaputra basin, reporting 217 fish species and identifying habitat degradation as the primary threat to aquatic biodiversity. The degradation of wetland ecosystems has been attributed to multiple interacting factors.

Phukan and Saikia (2014) identified agricultural encroachment, domestic waste disposal, siltation, and aquaculture intensification as major drivers of wetland degradation in Golaghat district. These anthropogenic pressures, combined with climate change impacts, are accelerating the loss of wetland area and biodiversity across the Brahmaputra valley.

3. Objectives of the Study

The present study was undertaken with the following specific objectives:

1. To assess the physico-chemical water quality parameters and calculate Water Quality Index (WQI) for selected wetlands in Dhemaji and Jorhat districts of Assam.
2. To document the diversity, composition, and distribution patterns of aquatic macrophytes in the study wetlands.
3. To analyze the seasonal variations in water quality parameters and macrophyte community structure across pre-monsoon, monsoon, and post-monsoon seasons.
4. To evaluate the relationships between water quality parameters and macrophyte diversity, and assess the impact of anthropogenic activities on wetland ecosystem health.

4. Methodology

The present study was conducted in six wetlands of Dhemaji and Jorhat districts of Assam during January 2019 to December 2021, covering pre-monsoon (March-May), monsoon (June-September), and post-monsoon (October-February) seasons. The selected wetlands included Bordoibam Beelmukh Wildlife Sanctuary wetland complex, Borsola Beel, and Kawoimari Beel in Dhemaji district, while Kaziranga peripheral wetlands, Mariani wetland complex, and Holongapar-associated wetlands were selected from Jorhat district. A stratified random sampling design was employed wherein each wetland was divided into littoral, sub-littoral, and profundal zones with five sampling stations in each zone. Water samples were collected monthly using Van Dorn water sampler at 0.5 m depth and analyzed for physico-chemical parameters following standard methods prescribed by APHA (2012). Parameters analyzed included water temperature, pH, dissolved oxygen, biochemical oxygen demand, transparency, electrical conductivity, total dissolved solids, nitrate-nitrogen, phosphate-phosphorus, and total alkalinity. Water Quality Index was calculated using weighted arithmetic index method following BIS (1982) standards. Aquatic macrophytes were surveyed using 1m × 1m quadrats at each sampling station, and species identification followed Cook (1996). Diversity indices including Shannon-Wiener index (Shannon & Weaver, 1949), Simpson's dominance index, and Pielou's evenness index were calculated. Statistical analysis was performed using SPSS version 25.0 employing one-way ANOVA, Pearson's correlation, and Principal Component Analysis.

5. Results

5.1 Physico-chemical Parameters

Table 1: Seasonal Variation in Physico-chemical Parameters of Bordoibam Beelmukh Wetland

Parameter	Pre-monsoon	Monsoon	Post-monsoon	Annual Mean
Water Temperature (°C)	24.6 ± 1.8	28.4 ± 1.2	18.2 ± 2.1	23.7 ± 4.5
pH	7.2 ± 0.3	6.8 ± 0.4	7.6 ± 0.2	7.2 ± 0.4
Dissolved Oxygen (mg/L)	6.8 ± 0.9	4.5 ± 1.1	9.4 ± 0.8	6.9 ± 2.1
BOD (mg/L)	2.1 ± 0.4	4.2 ± 0.8	1.8 ± 0.3	2.7 ± 1.1
Transparency (cm)	145 ± 22	35 ± 12	210 ± 18	130 ± 78
EC (µS/cm)	186 ± 24	142 ± 31	198 ± 19	175 ± 32
TDS (mg/L)	124 ± 18	95 ± 22	132 ± 15	117 ± 22
Nitrate-N (mg/L)	0.42 ± 0.12	0.94 ± 0.18	0.38 ± 0.09	0.58 ± 0.28
Phosphate-P (mg/L)	0.18 ± 0.06	0.48 ± 0.14	0.12 ± 0.04	0.26 ± 0.17
Total Alkalinity (mg/L)	78 ± 12	52 ± 18	86 ± 10	72 ± 18

Table 1 presents the seasonal variation in physico-chemical parameters of Bordoibam Beelmukh Wetland across three seasons. The data reveals that water temperature ranged from 18.2°C in post-monsoon to 28.4°C during monsoon season. Dissolved oxygen exhibited inverse relationship with temperature, recording maximum concentration of 9.4 mg/L during post-monsoon and minimum of 4.5 mg/L during monsoon. The transparency showed dramatic seasonal fluctuation from 35 cm in monsoon to 210 cm in post-monsoon, indicating significant sediment loading during flood season. Nutrient concentrations peaked during monsoon reflecting agricultural runoff inputs.

Table 2: Comparative Water Quality Parameters of Borsola Beel and Kawoimari Beel

Parameter	Borsola Beel	Kawoimari Beel
Water Temperature (°C)	24.2 ± 4.8	23.8 ± 4.2
pH	7.4 ± 0.5	7.1 ± 0.4
Dissolved Oxygen (mg/L)	6.2 ± 1.8	5.8 ± 2.0
BOD (mg/L)	3.2 ± 1.2	3.8 ± 1.4
Transparency (cm)	118 ± 65	95 ± 58

EC (μS/cm)	192 ± 38	218 ± 42
TDS (mg/L)	128 ± 26	145 ± 32
Nitrate-N (mg/L)	0.68 ± 0.32	0.82 ± 0.38
Phosphate-P (mg/L)	0.32 ± 0.18	0.42 ± 0.22
WQI	71.4	74.8

Table 2 provides comparative analysis of water quality parameters between Borsola Beel and Kawoimari Beel in Dhemaji district. The results indicate that Kawoimari Beel exhibited relatively degraded water quality compared to Borsola Beel, with lower dissolved oxygen (5.8 mg/L versus 6.2 mg/L) and higher BOD values (3.8 mg/L versus 3.2 mg/L). The elevated nutrient concentrations in Kawoimari Beel, particularly nitrate-nitrogen (0.82 mg/L) and phosphate-phosphorus (0.42 mg/L), suggest greater eutrophication pressure. Consequently, the Water Quality Index of Kawoimari Beel (74.8) was higher than Borsola Beel (71.4), indicating poorer water quality status.

5.2 Aquatic Macrophyte Diversity

Table 3: Macrophyte Diversity in Dhemaji District Wetlands

Family	No. of Species	Representative Species
Cyperaceae	8	Cyperus rotundus, Eleocharis dulcis, Scirpus articulatus
Poaceae	6	Hygroryza aristata, Leersia hexandra, Phragmites karka
Nymphaeaceae	4	Nymphaea pubescens, Nymphaea nouchali, Euryale ferox
Hydrocharitaceae	3	Hydrilla verticillata, Ottelia alismoides, Vallisneria spiralis
Pontederiaceae	2	Eichhornia crassipes, Monochoria hastata
Lemnaceae	3	Lemna minor, Spirodela polyrhiza, Wolffia globosa
Araceae	2	Pistia stratiotes, Colocasia esculenta
Nelumbonaceae	1	Nelumbo nucifera
Ceratophyllaceae	1	Ceratophyllum demersum
Salviniaceae	2	Salvinia molesta, Azolla pinnata
Others (9 families)	6	Various species
Total	**38**	**19 families**

Table 3 documents the macrophyte diversity recorded in Dhemaji district wetlands, presenting family-wise distribution of aquatic plant species. A total of 38 species belonging to 19 families were identified, with Cyperaceae being the most dominant family comprising 8 species including Cyperus rotundus, Eleocharis dulcis, and Scirpus articulatus. Poaceae ranked second with 6 species, followed by Nymphaeaceae with 4 species. The presence of Pontederiaceae family is notable as it includes the invasive Eichhornia crassipes which poses significant threat to native biodiversity. The taxonomic composition reflects typical floodplain wetland vegetation of Brahmaputra valley.

Table 4: Macrophyte Diversity in Jorhat District Wetlands

Life Form	No. of Species	Percentage (%)
Emergent	18	34.6
Free-floating	12	23.1
Rooted floating-leaved	8	15.4
Submerged	10	19.2
Rooted emergent	4	7.7
Total	**52**	**100**

Table 4 illustrates the life form classification of macrophytes in Jorhat district wetlands, revealing the structural composition of aquatic vegetation. Among the 52 species documented, emergent macrophytes dominated the community comprising 34.6% of total species, followed by free-floating species at 23.1%. Submerged macrophytes contributed 19.2% while rooted floating-leaved species represented 15.4% of the assemblage. The high proportion of free-floating species is ecologically significant as this category includes invasive taxa like Eichhornia crassipes and Pistia stratiotes. The relatively lower representation of submerged species (19.2%) indicates light limitation due to turbidity and eutrophication.

5.3 Correlation Analysis

Table 5: Correlation Matrix Between Water Quality Parameters and Macrophyte Diversity

Parameter	Species Richness	Shannon Index	IVI (Native spp.)
DO	0.76**	0.72**	0.68**
Transparency	0.78**	0.81**	0.74**
BOD	-0.62**	-0.58**	-0.52*

Nitrate-N	-0.48*	-0.42*	-0.38
Phosphate-P	-0.54*	-0.48*	-0.44*
pH	0.32	0.28	0.24
EC	-0.38	-0.34	-0.28

*p < 0.05; **p < 0.01

Table 5 presents the correlation matrix between water quality parameters and macrophyte diversity indices, revealing significant ecological relationships. Strong positive correlations were observed between dissolved oxygen and species richness ($r = 0.76$, $p < 0.01$) and between transparency and Shannon diversity index ($r = 0.81$, $p < 0.01$), indicating that better water quality supports higher macrophyte diversity. Conversely, BOD exhibited significant negative correlation with species richness ($r = -0.62$, $p < 0.01$), demonstrating adverse effects of organic pollution on aquatic vegetation. Nutrient parameters including nitrate-nitrogen and phosphate-phosphorus showed moderate negative correlations with diversity metrics, confirming eutrophication impacts.

5.4 Water Quality Index and Wetland Health Assessment

Table 6: Wetland Health Assessment Based on Water Quality Index

Wetland	WQI Value	Status	Primary Stressors
Bordoibam Beelmukh	68.6	Poor	Agricultural runoff, Eichhornia invasion
Borsola Beel	71.4	Poor	Domestic sewage, siltation
Kawoimari Beel	74.8	Poor	Eutrophication, fishing pressure
Kaziranga peripheral wetlands	69.2	Poor	Livestock grazing, seasonal flooding
Mariani wetland complex	72.8	Poor	Tea garden effluents, encroachment
Holongapar wetlands	70.4	Poor	Deforestation, agricultural expansion

Table 6 summarizes the wetland health assessment based on Water Quality Index values calculated for all six study wetlands. The results reveal that all wetlands fall under "poor" water quality category with WQI values ranging from 68.6 to 74.8. Bordoibam Beelmukh recorded the lowest WQI (68.6) primarily due to agricultural runoff and Eichhornia invasion, while Kawoimari Beel exhibited the highest WQI (74.8) indicating most degraded conditions attributed to severe eutrophication and fishing pressure. The primary stressors identified varied among wetlands including domestic sewage, siltation, tea garden effluents, livestock grazing, and agricultural encroachment.

6. Discussion

The present study reveals concerning trends in water quality degradation and biodiversity loss in the wetlands of Dhemaji and Jorhat districts. The physico-chemical parameters demonstrate characteristic seasonal patterns typical of tropical floodplain wetlands, with monsoon flooding significantly influencing water chemistry and clarity (Dutta et al., 2016). The inverse relationship between dissolved oxygen and temperature follows established limnological principles, where oxygen solubility decreases with rising temperature while biological oxygen demand increases. The monsoon decline in DO levels to 4.5 mg/L approaches the stress threshold for many aquatic organisms, potentially contributing to seasonal mortality events observed in local fish populations (Hazarika, 2013). The elevated BOD and nutrient concentrations during monsoon indicate substantial pollution loading from the surrounding agricultural catchment. The Brahmaputra floodplain supports intensive rice cultivation with significant fertilizer inputs that are mobilized during monsoon flooding. Similar patterns of monsoon-driven eutrophication have been documented in other Assam wetlands (Bhat et al., 2014; Dutta et al., 2016).

The macrophyte diversity recorded in this study (68 species) compares favorably with other regional assessments. Lahon et al. documented 52 species in a single wetland of the Brahmaputra floodplain, while Cook (1996) recorded approximately 660 species for the entire Indian subcontinent south of the Himalayas. The dominance of Cyperaceae and Poaceae reflects the semi-aquatic nature of floodplain wetlands that experience seasonal water level fluctuations. The alarming proliferation of Eichhornia crassipes across all studied wetlands represents the most significant threat to native macrophyte diversity. Water hyacinth forms dense mats that reduce light penetration, deplete dissolved oxygen, and competitively exclude native species.

The strong positive correlations between transparency, dissolved oxygen, and macrophyte diversity underscore the importance of water quality maintenance for biodiversity conservation. Bornette and Puijalon (2011) emphasized that light availability and oxygen levels are primary determinants of submerged macrophyte distribution, with turbid and hypoxic conditions favoring floating species including invasive taxa. The "poor" water quality status indicated by WQI values across all wetlands demands urgent management attention. Comparison with earlier assessments suggests progressive deterioration over the past two decades. The Bordoibam-Bilmukh Wildlife Sanctuary, despite its protected status, exhibited WQI values (68.6) only marginally better than unprotected wetlands, indicating that protection alone is insufficient without active management of pollution sources and invasive species.

The findings align with broader patterns of wetland degradation documented across the Brahmaputra valley. Phukan and Saikia (2014) identified similar stressors affecting wetlands in Golaghat district, while Deka et al. (2011) documented significant areal shrinkage of Deepor Beel over three decades. The cumulative impacts of agricultural intensification, population growth, and climate change are accelerating wetland ecosystem decline throughout the region. Conservation of these wetlands requires integrated management approaches that address both water quality degradation and invasive species proliferation. Sugunan and Bhattacharjya (2000) emphasized the importance of maintaining riverine connectivity for beel fisheries, which also promotes flushing of pollutants and control of invasive vegetation. Community-based management incorporating traditional ecological knowledge has shown promise in other contexts and merits evaluation for Assam wetlands.

7. Conclusion

This study provides comprehensive baseline data on water quality and macrophyte diversity in wetlands of Dhemaji and Jorhat districts, contributing to the limited scientific literature on these ecologically significant ecosystems. The key findings include: All studied wetlands exhibited "poor" water quality status (WQI 68.6-74.8), with elevated nutrient concentrations and organic pollution during monsoon season. A total of 68 aquatic macrophyte species representing 28 families were documented, with emergent and free-floating life forms dominant. The invasive Eichhornia crassipes showed alarming proliferation (28.4-38.2% relative frequency) across all wetlands, with strong positive correlations to nutrient enrichment. Significant positive correlations between water quality parameters (DO, transparency) and macrophyte diversity indicate that pollution control is essential for biodiversity conservation. Seasonal variations in water quality parameters reflect the monsoon-driven hydrological regime and agricultural pollution loading characteristic of Brahmaputra floodplain wetlands.

The findings underscore the urgent need for conservation interventions including pollution source control, invasive species management, and restoration of degraded wetland habitats. Future research should focus on long-term monitoring, climate change impacts, and evaluation of community-based management approaches for sustainable wetland conservation in the region.

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