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Interplay Of Aquatic Flora And Wetland Health: A Water Quality Study In Assam's Dhemaji And Jorhat Districts

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ABSTRACT

Wetlands serve as critical transitional ecosystems between terrestrial and aquatic environments, providing indispensable ecological services including water purification, biodiversity conservation, and carbon sequestration. This research investigates the intricate relationship between aquatic macrophytes and water quality parameters in selected wetlands of Dhemaji and Jorhat districts of Assam, India. The primary objectives encompass documenting macrophyte diversity, assessing physicochemical water quality parameters, examining correlations between aquatic vegetation and water quality indicators, and evaluating overall wetland health status. A mixed-method approach integrating field sampling, laboratory analysis, and statistical correlation was employed across six wetland sites during 2019-2021. The hypothesis posited that macrophyte abundance significantly influences water quality parameters, thereby determining wetland health. Results revealed significant variations in dissolved oxygen (4.5-9.4 mg/L), pH (6.8-7.6), and nutrient concentrations across sites, with macrophyte-dominated areas exhibiting distinct water quality profiles. Statistical analysis confirmed significant negative correlations between free-floating macrophyte density and dissolved oxygen levels ($r=-0.72$, $p<0.05$). The study concludes that aquatic flora composition serves as a reliable bioindicator of wetland health, necessitating integrated conservation strategies for sustainable wetland management in northeastern India.

Keywords: Aquatic Macrophytes, Water Quality Index, Wetland Health, Brahmaputra Floodplain, Bioindicators

1. INTRODUCTION

Wetlands represent one of the most productive and biologically diverse ecosystems on Earth, functioning as transitional zones between terrestrial and aquatic environments that support unique assemblages of flora and fauna (Mitsch & Gosselink, 2015). The state of Assam in northeastern India is endowed with approximately 1,392 floodplain wetlands, locally known as beels, encompassing nearly 100,000 hectares within the Brahmaputra and Barak River basins (Sarkar & Borah, 2018). These wetlands perform critical ecological functions including flood mitigation, groundwater recharge, carbon sequestration, and serving as natural water purification systems (Bassi et al., 2014). The Brahmaputra valley wetlands, particularly those in Dhemaji and Jorhat districts, constitute significant repositories of aquatic biodiversity while simultaneously supporting the livelihoods of rural communities dependent on fisheries and wetland-based agriculture. Aquatic macrophytes, comprising emergent, submerged, free-floating, and rooted floating vegetation, play a pivotal role in maintaining wetland ecosystem functioning (Rameshkumar et al., 2019). These aquatic plants influence water quality through nutrient uptake, oxygen production, sediment stabilization, and providing habitat for diverse aquatic organisms (Srivastava et al., 2008). Species such as Eichhornia crassipes, Hydrilla verticillata, Nymphaea spp., and Ceratophyllum demersum are commonly distributed across Assam's wetlands, each exhibiting specific ecological preferences and functional roles (Deka & Sarma, 2014). The relationship between macrophyte composition and water quality parameters has emerged as a critical area of investigation, given the potential of aquatic vegetation to serve as bioindicators of ecosystem health (Tripathi & Shukla, 1991).

Contemporary wetland ecosystems face unprecedented anthropogenic pressures from urbanization, agricultural intensification, industrial effluent discharge, and invasive species proliferation (Das et al., 2003). In Assam, wetland degradation has accelerated due to encroachment, siltation, and eutrophication, threatening both biodiversity and ecosystem services (Bora & Goswami, 2017). The Water Quality Index approach has emerged as a comprehensive tool for assessing wetland health status by integrating multiple physicochemical parameters into a unified metric (Gogoi et al., 2015). Understanding the interplay between aquatic flora and water quality assumes paramount significance for developing evidence-based conservation and management strategies for these imperiled ecosystems.

The Dhemaji and Jorhat districts of upper Assam harbor numerous floodplain wetlands of varying sizes and ecological characteristics (Hussain & Biswas, 2011). Dhemaji district, situated in the northern floodplains of Brahmaputra, encompasses several important wetlands including Bordoibam Beelmukh Bird Sanctuary, while Jorhat district hosts wetlands like Borsola Beel that support diverse aquatic communities (Hazarika, 2013). Despite their ecological significance, comprehensive studies examining the relationship between aquatic vegetation and water quality in these specific districts remain limited. This research addresses this critical knowledge gap by systematically investigating the interplay between aquatic macrophytes and physicochemical water quality parameters across selected wetlands of both districts.

2. LITERATURE REVIEW

The scientific understanding of wetland-macrophyte-water quality interactions has evolved substantially over the past decades, with researchers across the globe contributing to this interdisciplinary field. Gopal (1987) provided foundational insights into water hyacinth ecology, establishing the framework for understanding invasive macrophyte impacts on tropical wetlands. These theoretical foundations have informed contemporary investigations into wetland ecosystem functioning and the complex relationships between aquatic vegetation and water quality dynamics in floodplain systems. Research on Indian wetlands has documented extensive macrophyte diversity and their ecological significance. Ghosh (2005) catalogued aquatic and wetland plants in eastern India, identifying over 200 species with distinct ecological preferences and distributional patterns. In Assam specifically, Sarma and Saikia (2010) examined wetland resource utilization in Nagaon district, documenting the ethnobotanical importance of aquatic vegetation while highlighting conservation concerns. Deka and Sarma (2014) subsequently investigated the macrophyte status in Nalbari district wetlands, recording 82 species across diverse growth forms and demonstrating seasonal variation in species composition. Nath (2012) documented aquatic macrophytes of Laokhowa Wildlife Sanctuary, contributing valuable baseline data for protected wetland areas in Assam.

Water quality assessment methodologies have advanced considerably, with multiple indices developed for comprehensive evaluation. Rameshkumar et al. (2019) demonstrated that submerged aquatic vegetation serves as a key indicator of water quality, with species presence correlating strongly with dissolved oxygen levels and nutrient concentrations. Their study of Tamil Nadu wetlands revealed Water Quality Index values exceeding 76%, indicating poor conditions associated with reduced macrophyte diversity. Similarly, Bora and Goswami (2017) applied the WQI approach to Kolong River in Assam, establishing methodological precedents for regional water quality assessment. These investigations have demonstrated the utility of integrating biological and physicochemical parameters for holistic ecosystem evaluation. The relationship between macrophytes and nutrient cycling has received particular attention given eutrophication concerns. Boyd (1970) established that aquatic plants effectively remove mineral nutrients from polluted waters, demonstrating their phytoremediation potential. More recently, Jasrotia et al. (2017) evaluated aquatic plant species performance for arsenic-contaminated water treatment, confirming the bioaccumulation capabilities of common macrophytes. The phytoremediation capacity of Eichhornia crassipes has been extensively documented, with studies reporting significant removal efficiency for heavy metals including copper, lead, and cadmium (Srivastava et al., 2008). This remediation potential underscores the functional importance of macrophyte communities in maintaining wetland health.

Studies specifically addressing northeastern India's wetlands have revealed unique ecological characteristics. Hazarika (2013) investigated physicochemical properties of Satajan wetland in Assam, documenting seasonal variations in water quality parameters and their relationship with fish diversity. Hussain and Biswas (2011) characterized flood plain lakes of Dhemaji district, establishing baseline water quality data for the region. Gogoi et al. (2015) assessed water quality in relation to fishery perspectives in Subansiri basin wetlands, demonstrating the interconnections between limnological parameters and biological productivity. Recent investigations by Dash et al. (2020) applied environmetric tools for geochemistry and water quality assessment in Deepor Beel, demonstrating the application of advanced statistical approaches for pollution source apportionment. These studies collectively indicate deteriorating water quality trends in Assam's wetlands, necessitating comprehensive monitoring and intervention. Conservation frameworks for Indian wetlands have evolved in response to documented degradation. Bassi et al. (2014) provided comprehensive review of wetland extent, ecosystem benefits, threats and management strategies across India, establishing policy-relevant baseline information. Research by Sarkar and Borah (2018) highlighted the vulnerability of floodplain wetlands to climate change, emphasizing the need for adaptive management approaches. The integration of scientific understanding with policy frameworks represents a critical pathway for ensuring the long-term sustainability of Assam's wetland ecosystems.

3. OBJECTIVES

1. To document and characterize the diversity and distribution of aquatic macrophytes across selected wetlands of Dhemaji and Jorhat districts.
2. To assess the physicochemical water quality parameters and compute Water Quality Index for evaluating wetland health status.

3. To examine correlations between aquatic macrophyte composition and water quality indicators for establishing bioindicator relationships.
4. To formulate evidence-based recommendations for sustainable wetland conservation and management in the study area.

4. METHODOLOGY

The present investigation employed a comprehensive mixed-method research design integrating field-based ecological surveys, laboratory analysis of water quality parameters, and statistical correlation analysis. The study was conducted across six selected wetland sites, with three wetlands each from Dhemaji district (Bordoibam Beel, Simen Chapori Beel, and Jiadhal Beel) and Jorhat district (Borsola Beel, Maijan Beel, and Chalchali Beel). Site selection was based on accessibility, ecological significance, and representation of varying anthropogenic pressure gradients. The geographical coordinates of study sites ranged between 27°07'N to 27°35'N latitude and 93°45'E to 95°23'E longitude, encompassing the Brahmaputra floodplain wetlands characteristic of upper Assam.

Sampling was conducted seasonally over a two-year period from January 2019 to December 2020, covering pre-monsoon (February-May), monsoon (June-September), and post-monsoon (October-January) seasons. At each wetland site, three sampling stations were established representing inlet areas, central regions, and outlet zones to capture spatial heterogeneity. Water samples were collected in triplicate using standard protocols outlined by the American Public Health Association (APHA, 2005) in pre-cleaned polyethylene bottles. Samples for dissolved oxygen and biological oxygen demand analysis were collected in BOD bottles and fixed immediately using Winkler's reagents. Physicochemical parameters analyzed included water temperature, pH, electrical conductivity, total dissolved solids, dissolved oxygen, biological oxygen demand, chemical oxygen demand, total alkalinity, total hardness, chloride, phosphate, nitrate, and turbidity. Temperature and pH were measured in situ using a portable multiparameter water quality meter. Dissolved oxygen was determined by the azide modification of Winkler's method, while BOD was measured through five-day incubation at 20°C. Chemical oxygen demand, alkalinity, hardness, and chloride were analyzed through titrimetric methods. Nutrient parameters including nitrate and phosphate were determined spectrophotometrically. Water Quality Index was calculated using the weighted arithmetic method incorporating nine parameters with assigned weightages based on their relative significance.

Macrophyte surveys were conducted using the quadrat sampling method with randomly placed 1m×1m quadrats at each sampling station. A minimum of ten quadrats were sampled per station during each seasonal visit. Macrophyte species were identified following standard taxonomic keys and regional floristic literature. Plant density was calculated as the number of individuals per square meter, while percent cover was estimated visually within each quadrat. Species were categorized into growth forms including emergent, submerged, free-floating, and rooted floating macrophytes. Dominant species were determined based on Importance Value Index calculations incorporating relative frequency, relative density, and relative dominance. Statistical analysis was performed using SPSS software version 25.0. Descriptive statistics including mean, standard deviation, and range were computed for all parameters. One-way analysis of variance (ANOVA) was employed to examine seasonal and site-wise variations in water quality parameters. Pearson correlation coefficients were calculated to assess relationships between macrophyte abundance and water quality indicators. Principal Component Analysis was applied to identify underlying factors explaining variance in the dataset. Significance was established at $p<0.05$ for all statistical tests.

4. RESULTS

Table 1: Seasonal Variation in Physicochemical Water Quality Parameters in Dhemaji District Wetlands (Mean ± SD)

Parameter	Pre-Monsoon	Monsoon	Post-Monsoon	Annual Mean
Water Temperature (°C)	24.6 ± 2.1	28.3 ± 1.5	20.8 ± 1.8	24.6 ± 3.2
pH	7.2 ± 0.3	6.9 ± 0.2	7.4 ± 0.3	7.2 ± 0.3
Dissolved Oxygen (mg/L)	6.8 ± 1.2	5.2 ± 0.9	8.1 ± 1.0	6.7 ± 1.5
BOD (mg/L)	2.4 ± 0.6	3.8 ± 0.8	1.8 ± 0.5	2.7 ± 1.0
Conductivity (µS/cm)	248 ± 42	196 ± 38	286 ± 52	243 ± 51
Total Alkalinity (mg/L)	98 ± 18	72 ± 15	112 ± 22	94 ± 23
Nitrate-N (mg/L)	0.42 ± 0.12	0.68 ± 0.18	0.34 ± 0.10	0.48 ± 0.18
Phosphate-P (mg/L)	0.28 ± 0.08	0.45 ± 0.12	0.22 ± 0.06	0.32 ± 0.12

The physicochemical analysis of Dhemaji district wetlands revealed significant seasonal fluctuations across all measured parameters as presented in Table 1. Water temperature demonstrated typical tropical patterns with monsoon maxima (28.3°C) and post-monsoon minima (20.8°C), while pH values remained within the neutral to slightly alkaline range favorable for aquatic biota. Dissolved oxygen concentrations exhibited inverse relationship with temperature, with highest values during cooler post-monsoon months (8.1 mg/L) and lowest during monsoon (5.2 mg/L). The elevated BOD and nutrient concentrations during monsoon indicate substantial organic loading from agricultural runoff and floodwater influx, suggesting anthropogenic influences on wetland water quality consistent with observations by Hussain and Biswas (2011).

Table 2: Seasonal Variation in Physicochemical Water Quality Parameters in Jorhat District Wetlands (Mean ± SD)

Parameter	Pre-Monsoon	Monsoon	Post-Monsoon	Annual Mean
Water Temperature (°C)	25.2 ± 1.8	29.1 ± 1.4	21.4 ± 2.0	25.2 ± 3.5
pH	7.0 ± 0.2	6.8 ± 0.3	7.5 ± 0.3	7.1 ± 0.4
Dissolved Oxygen (mg/L)	6.2 ± 1.0	4.8 ± 0.8	7.6 ± 1.2	6.2 ± 1.4
BOD (mg/L)	2.8 ± 0.7	4.2 ± 0.9	2.1 ± 0.6	3.0 ± 1.1
Conductivity (µS/cm)	312 ± 58	228 ± 45	358 ± 62	299 ± 72
Total Alkalinity (mg/L)	108 ± 22	82 ± 18	124 ± 26	105 ± 26
Nitrate-N (mg/L)	0.52 ± 0.14	0.78 ± 0.22	0.42 ± 0.12	0.57 ± 0.21
Phosphate-P (mg/L)	0.35 ± 0.10	0.52 ± 0.14	0.28 ± 0.08	0.38 ± 0.14

Comparative analysis of Jorhat district wetlands (Table 2) revealed generally higher nutrient concentrations and conductivity values compared to Dhemaji, indicating greater anthropogenic influence in these wetlands. The dissolved oxygen levels in Jorhat wetlands were consistently lower across all seasons, with monsoon minimum (4.8 mg/L) approaching stress thresholds for sensitive aquatic organisms as documented by Gogoi et al. (2015). Higher BOD values (annual mean 3.0 mg/L) suggest elevated organic pollution loads, potentially associated with surrounding agricultural activities and urban expansion. The elevated conductivity (299 μS/cm annual mean) and alkalinity indicate mineral enrichment from catchment sources, contributing to the eutrophic tendencies observed in these wetland systems.

Table 3: Macrophyte Species Diversity and Distribution Across Study Sites

Species Name	Growth Form	Dhemaji Sites	Jorhat Sites	Overall IVI
Eichhornia crassipes	Free-floating	+++	+++	42.8
Hydrilla verticillata	Submerged	++	+++	28.6
Nymphaea nouchali	Rooted floating	++	++	24.2
Ceratophyllum demersum	Submerged	+	++	18.4
Salvinia cucullata	Free-floating	++	++	16.8
Ipomoea aquatica	Emergent	++	++	14.6
Lemna minor	Free-floating	+	++	12.4
Pistia stratiotes	Free-floating	+	+	10.2
Vallisneria spiralis	Submerged	+	+	8.6
Nelumbo nucifera	Rooted floating	+	+	7.4

Note: +++ = Highly abundant, ++ = Moderately abundant, + = Sparse; IVI = Importance Value Index

The macrophyte diversity assessment documented 28 species across all study sites, with ten dominant species listed in Table 3 based on Importance Value Index calculations. Eichhornia crassipes emerged as the most dominant species with highest IVI (42.8), particularly abundant in nutrient-enriched wetlands exhibiting eutrophic characteristics as described by Gopal (1987). Free-floating macrophytes collectively constituted 45% of total vegetation cover, followed by submerged (28%), rooted floating (15%), and emergent (12%) growth forms. Jorhat district wetlands exhibited higher macrophyte density but lower species diversity compared to Dhemaji, suggesting that nutrient enrichment promotes proliferation of competitive species while suppressing diversity, consistent with findings by Deka and Sarma (2014). The Shannon-Wiener diversity index ranged from 1.82 to 2.64 across sites.

Table 4: Water Quality Index Values and Classification for Study Sites

Wetland Site	Pre-Monsoon WQI	Monsoon WQI	Post-Monsoon WQI	Annual WQI	Quality Status
Bordoibam Beel	68.4	82.6	62.8	71.3	Poor
Simen Chapori Beel	72.8	88.4	68.2	76.5	Poor
Jiadhal Beel	65.2	78.8	58.4	67.5	Poor

Borsola Beel	78.6	94.2	72.4	81.7	Very Poor
Maijan Beel	82.4	98.6	76.8	85.9	Very Poor
Chalchali Beel	74.2	92.4	68.6	78.4	Poor

Water Quality Index calculations presented in Table 4 revealed concerning water quality conditions across all study sites, with values ranging from 67.5 to 85.9 indicating poor to very poor status. Monsoon season consistently recorded highest WQI values (poorest quality) due to elevated organic loads, nutrient influx, and reduced dissolved oxygen levels. Jorhat district wetlands (Borsola and Maijan Beels) exhibited significantly higher WQI values compared to Dhemaji sites, reflecting greater anthropogenic pressure from surrounding land use activities as observed by Hazarika (2013). The Jiadhal Beel in Dhemaji district demonstrated relatively better water quality (annual WQI 67.5), potentially associated with its remote location. Seasonal analysis confirmed significant variation (ANOVA, $F=14.82$, $p<0.001$).

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

Parameter	E. crassipes	H. verticillata	N. nouchali	Total Macrophyte
Dissolved Oxygen	-0.72**	0.48*	0.32	-0.58**
BOD	0.68**	-0.42*	-0.28	0.54**
Nitrate-N	0.78**	0.12	0.24	0.62**
Phosphate-P	0.82**	0.18	0.28	0.68**
pH	-0.24	0.36*	0.42*	0.12
Conductivity	0.56**	0.22	0.18	0.48*

Note: ** Significant at $p<0.01$; * Significant at $p<0.05$

Correlation analysis (Table 5) revealed significant relationships between macrophyte abundance and water quality parameters, confirming the bioindicator potential of aquatic vegetation as established by Tripathi and Shukla (1991). Eichhornia crassipes density exhibited strong positive correlations with nutrient parameters (nitrate $r=0.78$, phosphate $r=0.82$, $p<0.01$), confirming its preference for eutrophic conditions. Notably, strong negative correlation between E. crassipes and dissolved oxygen ($r=-0.72$, $p<0.01$) indicates the oxygen-depleting effects of dense water hyacinth coverage through light limitation and decomposition. Conversely, submerged macrophyte Hydrilla verticillata showed positive correlation with dissolved oxygen ($r=0.48$, $p<0.05$), reflecting its photosynthetic oxygen contribution to the water column as documented by Boyd (1970).

Table 6: Principal Component Analysis Results for Water Quality Variables

Variable	PC1 (38.6%)	PC2 (24.2%)	PC3 (16.8%)	Communality
Dissolved Oxygen	-0.842	0.186	0.124	0.762
BOD	0.768	0.284	-0.142	0.698
Nitrate-N	0.824	-0.168	0.212	0.758
Phosphate-P	0.856	-0.124	0.186	0.784
Conductivity	0.642	0.486	0.128	0.668

pH	-0.186	0.782	0.242	0.712
Temperature	0.124	0.684	-0.382	0.628
Alkalinity	0.342	0.628	0.448	0.724

Principal Component Analysis extracted three components explaining 79.6% of total variance in water quality data (Table 6). The first component (PC1, 38.6% variance) exhibited high loadings for organic pollution indicators including BOD, nutrients, and negative loading for dissolved oxygen, representing an anthropogenic pollution dimension consistent with findings by Dash et al. (2020). PC2 (24.2% variance) captured natural geochemical variability with high loadings for pH, temperature, and alkalinity, reflecting seasonal and spatial heterogeneity in wetland characteristics. This multivariate analysis confirms that anthropogenic nutrient enrichment represents the primary driver of water quality variation across the study wetlands.

6. DISCUSSION

The present investigation provides comprehensive insights into the intricate relationships between aquatic macrophytes and water quality dynamics in the floodplain wetlands of Dhemaji and Jorhat districts of Assam. The findings contribute significantly to understanding wetland ecosystem functioning in the Brahmaputra valley context, with implications for conservation and management strategies. The physicochemical water quality assessment revealed substantial spatial and temporal heterogeneity across study sites, consistent with previous investigations on Assam's wetlands. The dissolved oxygen concentrations ranging from 4.8 to 8.1 mg/L align closely with values reported by Gogoi et al. (2015) for Subansiri basin wetlands and Hazarika (2013) for Satajan wetland, indicating regional consistency in oxygen dynamics. The observed seasonal pattern of elevated dissolved oxygen during post-monsoon months correlates with reduced water temperatures and enhanced photosynthetic activity following flood recession. However, monsoon minima approaching 4.8 mg/L in some Jorhat wetlands raise concerns regarding stress thresholds for sensitive aquatic species, particularly given the additional oxygen demands from decomposing organic matter during flood periods.

The nutrient concentrations documented in this study indicate moderate to high eutrophication levels across study wetlands. Phosphate values exceeding 0.3 mg/L and nitrate concentrations above 0.5 mg/L in Jorhat wetlands surpass recommended levels for healthy freshwater ecosystems. These findings corroborate observations by Dash et al. (2020) who identified nutrient loading from agricultural runoff and domestic waste as primary pollution sources in Deepor Beel. The correlation between elevated nutrient levels and Water Quality Index deterioration underscores the necessity of addressing non-point source pollution through watershed management interventions. Agricultural intensification in catchment areas, combined with inadequate sanitation infrastructure in surrounding villages, likely contributes to the nutrient enrichment patterns observed. The dominance of Eichhornia crassipes across all study sites represents a significant ecological concern consistent with broader patterns of water hyacinth invasion in South Asian wetlands documented by Gopal (1987). The species' highest Importance Value Index (42.8) reflects its competitive superiority under eutrophic conditions, enabled by efficient nutrient uptake and rapid vegetative reproduction. The strong positive correlations between E. crassipes density and nutrient parameters (nitrate r=0.78, phosphate r=0.82) confirm the species' indicator value for eutrophication assessment while simultaneously highlighting its role in perpetuating ecological degradation through oxygen depletion and light limitation as established by Srivastava et al. (2008).

The Water Quality Index analysis classified all study wetlands within poor to very poor categories, indicating substantial ecosystem stress requiring management intervention. These findings align with WQI assessments conducted by Bora and Goswami (2017) for Kolong River, suggesting regional patterns of wetland quality deterioration in Assam. The significantly higher WQI values in Jorhat district wetlands (annual means 78.4-85.9) compared to Dhemaji (67.5-76.5) reflect differential anthropogenic pressure intensities, with Jorhat's proximity to urban centers and agricultural areas contributing to elevated pollution loads. Seasonal deterioration during monsoon periods emphasizes the influence of flood-mediated pollutant transport from catchment sources. The correlation analysis establishing significant relationships between macrophyte composition and water quality parameters confirms the bioindicator potential of aquatic vegetation for wetland monitoring applications as proposed by Tripathi and Shukla (1991). The strong negative correlation between free-floating macrophyte density and dissolved oxygen (r=-0.72) demonstrates the ecological consequences of excessive macrophyte growth, particularly water hyacinth mats that limit atmospheric oxygen diffusion. Conversely, the positive correlation between submerged macrophyte Hydrilla verticillata and dissolved oxygen levels suggests the beneficial oxygenation effects of rooted submerged vegetation, supporting findings by Rameshkumar et al. (2019). These differential relationships among growth forms provide nuanced understanding for management applications.

The management implications emerging from this research emphasize the need for integrated approaches addressing both aquatic vegetation management and water quality improvement as recommended by Bassi et al. (2014). Mechanical removal of excessive water hyacinth biomass may provide short-term relief from oxygen depletion, but sustainable solutions require addressing underlying nutrient enrichment driving macrophyte proliferation. The phytoremediation potential documented by Jasrotia et al. (2017) suggests that strategic management of certain macrophyte species could contribute to water quality improvement. Research by Sarkar and Borah (2018) highlighted the vulnerability of floodplain wetlands to climate change, emphasizing the need for adaptive management approaches integrating ecological restoration with community-based conservation strategies.

7. CONCLUSION

The present investigation comprehensively examined the interplay between aquatic flora and wetland health across selected wetlands of Dhemaji and Jorhat districts of Assam, yielding significant findings with implications for conservation and management. The study documented 28 macrophyte species across diverse growth forms, with Eichhornia crassipes emerging as the dominant species indicative of widespread eutrophication. Physicochemical water quality analysis revealed significant seasonal and spatial variations, with monsoon period exhibiting poorest water quality conditions associated with organic and nutrient loading from catchment runoff. Water Quality Index calculations classified all study wetlands within poor to very poor categories, with Jorhat district sites demonstrating greater deterioration reflecting higher anthropogenic pressures from surrounding urban and agricultural activities. The correlation analysis confirmed the hypothesis that macrophyte composition significantly influences water quality parameters, establishing aquatic vegetation as reliable bioindicators for wetland health monitoring. The strong negative correlation between free-floating macrophyte density and dissolved oxygen levels demonstrates the ecological consequences of invasive species proliferation, while positive correlations between submerged macrophytes and oxygen indicate their beneficial roles in maintaining aquatic ecosystem functioning. Principal Component Analysis revealed that anthropogenic pollution loading represents the primary driver of water quality variation, emphasizing the necessity of addressing human-mediated inputs for effective wetland conservation.

The findings underscore the urgent need for integrated management strategies combining water quality improvement, invasive species control, and community-based conservation approaches. Future research should focus on long-term monitoring of wetland health indicators, evaluation of restoration interventions, and assessment of climate change impacts on wetland ecosystems. Conservation efforts must address both direct anthropogenic pressures and watershed-level processes influencing wetland health, ensuring sustainable utilization of these vital ecosystems for present and future generations in Assam's Brahmaputra valley.

REFERENCES

1. American Public Health Association [APHA]. (2005). *Standard methods for the examination of water and wastewater* (21st ed.). APHA-AWWA-WEF.
2. Bassi, N., Kumar, M. D., Sharma, A., & Pardha-Saradhi, P. (2014). Status of wetlands in India: A review of extent, ecosystem benefits, threats and management strategies. *Journal of Hydrology: Regional Studies*, 2, 1-19.
3. Bora, M., & Goswami, D. C. (2017). Water quality assessment in terms of water quality index (WQI): Case study of the Kolong River, Assam, India. *Applied Water Science*, 7(6), 3125-3135.
4. Boyd, C. E. (1970). Vascular aquatic plants for mineral nutrient removal from polluted waters. *Economic Botany*, 24, 95-103.
5. Das, A. C., Baruah, B. K., Baruah, D., & Sengupta, S. (2003). Study on wetlands of Guwahati City: Water quality of rivers and drains. *Pollution Research*, 22(1), 117-119.
6. Dash, S., Borah, S. S., & Kalamdhad, A. S. (2020). Application of environmetrics tools for geochemistry, water quality assessment and apportionment of pollution sources in Deepor Beel, Assam, India. *International Journal of Environmental Analytical Chemistry*, 102(15), 3944-3965.
7. Deka, U., & Sarma, S. K. (2014). Present status of aquatic macrophytes of the wetlands of Nalbari district of Assam, India. *Asian Journal of Plant Science and Research*, 4(3), 67-75.
8. Ghosh, S. K. (2005). *Illustrated aquatic and wetland plants in harmony with mankind*. Standard Literature.
9. Gogoi, B., Kachari, A., Dutta, R., Darshan, A., & Biswas, S. P. (2015). Assessment of water quality in relation to fishery perspective in flood plain wetlands of Subansiri River Basin, Assam, India. *Journal of Fisheries and Aquatic Science*, 10(3), 171-180.
10. Gopal, B. (1987). *Water hyacinth*. Elsevier Science Publishers.

11. Hazarika, L. P. (2013). A study of certain physico-chemical characteristics of Satajan wetland with special reference to fish diversity indices, Assam, India. *European Journal of Experimental Biology*, 3(3), 173-180.
12. Hussain, M., & Biswas, S. P. (2011). Physicochemical characteristics of a flood plain lake of Dhemaji, Assam, India. *Journal of Inland Fisheries Society of India*, 43(2), 35-42.
13. Jasrotia, S., Kansal, A., & Mehra, A. (2017). Performance of aquatic plant species for phytoremediation of arsenic-contaminated water. *Applied Water Science*, 7(2), 889-896.
14. Mitsch, W. J., & Gosselink, J. G. (2015). *Wetlands* (5th ed.). John Wiley & Sons.
15. Nath, S. K. (2012). Aquatic macrophytes of Laokhowa Wildlife Sanctuary, Assam, India. *International Journal of Engineering Research and Applications*, 2(5), 1911-1913.
16. Rameshkumar, S., Radhakrishnan, K., Aanand, S., & Rajaram, R. (2019). Influence of physicochemical water quality on aquatic macrophyte diversity in seasonal wetlands. *Applied Water Science*, 9, Article 12.
17. Sarkar, U. K., & Borah, B. C. (2018). Flood plain wetland fisheries of India: With special reference to impact of climate change. *Wetlands Ecology and Management*, 26(1), 1-15.
18. Sarma, S. K., & Saikia, M. (2010). Utilization of wetland resources by the rural people of Nagaon district, Assam. *Indian Journal of Traditional Knowledge*, 9, 145-151.
19. Srivastava, J., Gupta, A., & Chandra, H. (2008). Managing water quality with aquatic macrophytes. *Reviews in Environmental Science and Bio/Technology*, 7, 255-266.
20. Tripathi, B. D., & Shukla, S. C. (1991). Biological treatment of wastewater by selected aquatic plants. *Environmental Pollution*, 69(1), 69-78.