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RESEARCH ON FLOATING AQUATIC MACROPHYTES WITHIN THE CHHATRAPATI SAMBHAJINAGAR DISTRICT OF MAHARASHTRA

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ABSTRACT

Aquatic macrophytes are crucial components of freshwater ecosystems, serving as bioindicators of environmental health and enhancing ecological stability. They support aquatic biodiversity by providing habitats for fish, zooplankton, and macro-invertebrates, and they improve water quality through nutrient uptake, sediment stabilization, and oxygenation. However, their diversity is increasingly affected by human-induced pressures such as urban runoff, sewage, industrial waste, and seasonal climatic variations. These stressors often result in eutrophication, which disrupts species composition and reduces the overall abundance of macrophytes. This research documents the diversity of floating and free-floating aquatic macrophytes in the Chhatrapati Sambhajinagar district of Maharashtra, a semi-arid region with diverse freshwater ecosystems, including lakes, ponds, and wetlands. Field surveys conducted across various water bodies recorded 22 species from 13 families. The dominant plant families included Araceae, Salviniaceae, and Pontederiaceae, with key species such as Eichhornia crassipes, Pistia stratiotes, and Salvinia molesta, all known for their phytoremediation potential and ecological functions in nutrient cycling and pollution control. The adaptability of these species to nutrient-rich, disturbed waters highlights their value as indicators of ecosystem stress. The findings are in line with previous studies from the Marathwada region, particularly in Jalna district, underscoring the significance of macrophytes in maintaining water quality and biodiversity. This baseline study offers

important insights for ecological monitoring and supports the formulation of conservation and restoration strategies for freshwater ecosystems in central India.

KEYWORDS: Aquatic vegetation, Management of lakes, Wetland areas, Emergent, submerged, and floating macrophytes, Biodiversity, Water resources.

1. INTRODUCTION

Aquatic macrophytes are essential components of aquatic and wetland ecosystems. As primary producers, they serve as the basis for herbivorous and detritivorous food webs. They provide nourishment to aquatic life while also acting as a reservoir of organic carbon for bacteria. Their structures serve as a substrate for periphyton and a habitat for numerous aquatic species (Dvorak 1996).

Aquatic macrophytes play a significant role in the preservation of water quality (Bhat et al. 2018a, b). They influence biogeochemical cycles, as well as the dynamics of water and sediment within aquatic environments. Their ability to absorb substantial quantities of nutrients through their roots and leaves contributes to the enhancement of water quality. It is noteworthy that aquatic macrophytes can be utilized to reduce the concentrations of harmful phytoplankton and nutrients such as nitrogen and phosphorus in water bodies (Steward 1970). Free-floating macrophytes, including water hyacinth (Eichhornia crassipes), duckweed (Lemna gibba, L. minor, Spirodela polyrhiza), and water ferns (Azolla caroliniana, A. filiculoides, and A. pinnata), are effective in treating polluted water bodies (Sutton and Ornes 1975). Certain macrophytes are also vital for supplying food, biomass, and construction materials to human communities (Costanza et al. 1997; Engelhardt and Ritchie 2001; Egertson et al. 2004; Bornette and Puijalon 2011). However, the death and decomposition of macrophytes can increase nutrient levels in water bodies, leading to eutrophication. Thus, maintaining a balance between these two simultaneous processes is essential for preserving the quality of aquatic environments. A thorough understanding of the role of aquatic macrophytes in these ecosystems is crucial for comprehending the fundamental operations of these systems. This knowledge can be beneficial for ecosystem restoration, wastewater management, and monitoring invasive species (Lavoie 2010; Casanova 2011).

Floating macrophytes (FAMs) represent a unique group of aquatic macrophytes, as they are directly exposed to the atmosphere and can function as producers in both turbid and deep-water environments. Typically, they favor water bodies with minimal or no movement

(Srivastava et al., 2008) and utilize mechanisms such as phytoextraction, phytodegradation, phytovolatilization, and rhizofiltration to eliminate contaminants (Dhiret al., 2009). Additionally, they promote microbial decomposition in aquatic systems by linking with secondary carbon sources and aiding in nitrogen removal through denitrification (Hamersley et al., 2001). Despite certain disadvantages, including hindering the photosynthesis of submerged organisms and acting as a barrier to oxygen transfer from the atmosphere to water bodies (Srivastava et al., 2008), floating aquatic macrophytes are vital for pollutant removal and generate biomass that is nutritionally rich (Sooknah and Wilkie, 2004; Hamersley et al., 2001; Mitchell, 1974).

Floating aquatic macrophytes exhibit a remarkable capability to extract various contaminants, especially nutrients, from wastewater. Given their rapid growth rates, it is crucial to ensure the safe disposal of the resultant biomass from the system. The final macrophyte biomass consists of lignocellulose and possesses improved nutritional and energy characteristics. As a result, it can be utilized as a valuable resource for applications such as bioenergy production, fertilizer, and animal feed. Nevertheless, its application remains limited, and comprehensive studies are few. The effectiveness of floating aquatic macrophytes in removing heavy metals, nutrients, and organic pollutants from different types of wastewater has been documented by Sayanatha et al., 2024. Consequently, a survey was conducted to identify floating and free-floating aquatic macrophytes in the Sambhajinagar district of Maharashtra, India.

2 Study Area: Chhatrapati Sambhajinagar District

2.1 Geographical Location & Area

Chhatrapati Sambhajinagar, previously known as Aurangabad, is situated in the central region of Maharashtra, primarily within the Godavari Basin and partially within the Tapi Basin. It is positioned between latitudes 19° to 20° North and longitudes 74° to 76° East. The district covers a total geographical area of approximately 10,100 square kilometers. Of this area, around 141 km^2 (1.4%) is classified as urban, while the remainder is rural. The district features a varied topography, including notable ranges such as Antur (826 m), Abbasgad (671 m), and Ajintha (578 m), with southern elevations ranging from 600 to 670 meters above sea level. Most of the region is part of the Deccan Traps geological formation.

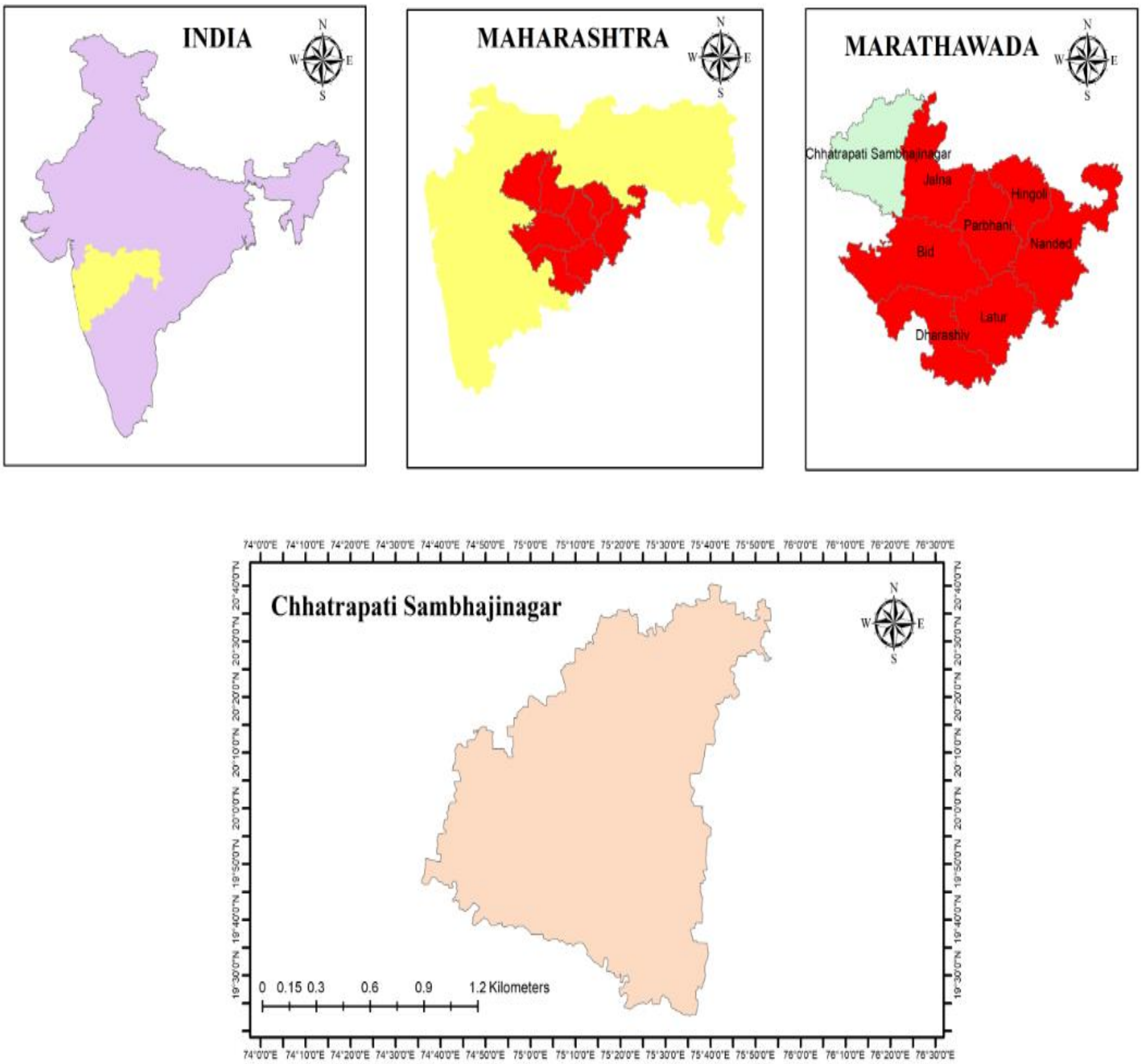

Figure 1: Map illustrating the study area of the Chatrapati Sambhajinagar district.

2.2 Forest Cover: Approximately 135.75 square kilometers of the district are covered by forests, which constitutes about 9% of the overall land area. These forest areas are essential for preserving biodiversity and regulating the local climate.

2.3 Drainage & Rivers: The drainage network exhibits a dendritic configuration and is primarily influenced by two significant river basins: the Godavari River to the south and the Purna River to the north. Various tributaries, including the Shivna, Kham, Dudhna, Galhati, and Girjarivers, traverse the district and enhance the Godavari system. These rivers are vital for irrigation and water supply in the area.

2.4 Climate & Rainfall: The district experiences a climate that ranges from semi-arid to subtropical. The year is categorized into three principal seasons:

- *Summer (March to May):* This season is hot and dry, with peak temperatures frequently surpassing 40°C. May is noted as the hottest month, with an average temperature of 41°C.
- *Monsoon (June to September):* This season, influenced by the southwest monsoon, accounts for nearly 83% of the total annual rainfall. The average annual precipitation is approximately 710 to 734 mm, with July being the month that receives the most rainfall.
- *Winter (October to February):* This season is marked by cool and dry conditions. December is the coldest month, with average maximum and minimum temperatures of 30.5°C and 10.5°C, respectively.

The humidity levels are typically low, particularly during the summer months when afternoon humidity can drop to 20–25%. Wind patterns fluctuate with the seasons-generally light to moderate, but intensifying during the hot season and monsoon.

2.5 Soil & Topography: The geology of the region is characterized by horizontal lava flows originating from the Deccan Traps, leading to the formation of basaltic rocks. The predominant soil type is black cotton soil, known for its fertility and suitability for agricultural practices. The average elevation in urban locales is approximately 568 meters above sea level.

2.6 Population & Demographics: As per the 2011 Census, the district's population was estimated to be around 3.7 million. Out of this total, roughly 37.5% inhabit urban areas, whereas 62.5% live in rural settings. The primary languages spoken in the region include Marathi, Urdu, Hindi, and English.

3. Methodology for Surveying Floating and Free-Floating Aquatic Macrophytes

The survey of floating and free-floating aquatic macrophytes in Chhatrapati Sambhajinagar district was carried out across selected lakes, ponds, reservoirs, and stretches of slow-flowing rivers. The methodology employed a seasonal sampling design to ensure a thorough documentation of species diversity throughout the annual climatic cycle. Sampling occurred during three primary seasons-monsoon (June–September), winter (October–February), and summer (March–May)-to encompass the complete range of temporal variation in the distribution of aquatic plants.

Macrophyte specimens were mainly gathered from the littoral and surface zones of water bodies where floating vegetation is typically prevalent. Standardized methods were adhered to, which included manual collection through hand-picking and scooping with fine-mesh nets in shallow regions, in accordance with the guidelines established by Narayana and Somashekar (2002). Field sampling was performed monthly over a span of four years, from June 2018 to May 2022. The targeted plant groups comprised typical free-floating species (e.g., Eichhorniacrassipes, Lemna spp., Azolla spp., Salviniamolesta) as well as rooted floating-leaved plants (e.g., Nymphaea spp., Nelumbonucifera, Hydrocharisdubia).

Collected specimens were gently washed in the field using ambient water to eliminate mud and debris, then placed on blotting paper to absorb excess moisture, and finally stored in clean polyethylene bags or sample jars for transportation to the laboratory. In the laboratory, the samples were preserved in 10% formalin for long-term storage and subsequent identification.

Species identification was conducted using dichotomous keys and field guides from established references, including Edmondson (1959), Fassett (2000), Cook (1996), as well as regional floras by Subramanyam (1962), Henry et al. (1989), and Yadav & Sardesai (2002). The identification process was validated through comparisons with herbarium specimens and consultations with regional experts and online botanical databases.

This methodology facilitated the thorough documentation of floating and free-floating aquatic macrophytes from various aquatic habitats within the Chhatrapati Sambhajinagar district, taking into account both spatial and seasonal diversity.

4. RESULTS AND DISCUSSION

The examination of floating and free-floating aquatic macrophytes in the primary water bodies, adjacent wetlands, and riparian zones of the Chhatrapati Sambhajinagar district has uncovered a significant diversity of species. The resulting compilation of floating and free-floating macrophytes identified in the principal water bodies, surrounding areas, and wetland regions within the Chhatrapati Sambhajinagar district is detailed in Table 1. A total of 22 species from 12 families were recorded in the study area, highlighting the rich and diverse aquatic plant life present in the district's freshwater ecosystems.

Table 1: Compilation of floating and free-floating macrophytes identified in significant water bodies, their surrounding areas, and wetlands within the study region (the list is representative, not comprehensive).

Sr. No.	Scientific Name (Family)	Common Name
1	*Azollapinnata* (Azollaceae)	Feathered mosquito fern
2	*Chara vulgaris* (Characeae)	Common stoneworth
3	*Eichhorniacrassipes* (Pontederiaceae)	Water hyacinth
4	*Eichhorniaazurea* (Pontederiaceae)	Anchored water hyacinth/orchid
5	*Enhydrafluctuans* (Compositae)	Hinchesak
6	*Hydrocharisdubia* (Hydrocharitaceae)	Backer/ frog-bit
7	*Ipomoea aquatica (reptans)* (Convolvulaceae)	Water spinach
8	*Lemnagibba* (Araceae)	Fat duckweed
9	*Lemna minor* (Araceae)	Duckweed
10	*Nelumbonucifera (Nelumbonaceae)*	Water lily/teratai
11	*Nymphaeapubescens* (Nymphaeceae)	Hairy water lily
12	*Nymphoidescristatum* (Menyanthaceae)	Crested floating heart
13	*Nymphoidesindicum* (Menyanthaceae)	Water snowflake
14	*Pistiastratiotes* (Araceae)	Water lettuce
15	*Salviniaauriculata* (Salviniaceae)	Water fern
16	*Salviniamolesta* (Salviniaceae)	Giant Salvinia
17	*Salviniarotundifolia* (Salviniaceae)	Common Salvinia
18	*Spirodelapolyrhiza* (Spirodela, Areaceae)	Duckmeat
19	*Spirogyra* (Zygnemataceae)	Water silk
20	*Trapabispinosa* (Trapaceae)	Batnut /water chestnut
21	*Trapanatans* (Trapaceae)	Water chestnut
22	*Wolffiaglobosa* (Lemnaceae)	Asian watermeal

Among the species observed, the family Lemnaceae (Araceae) emerged as the most prevalent, featuring several species including Lemnagibba, Lemna minor, Spirodelapolyrhiza, and Wolffiaglobosa, which are characteristic of eutrophic aquatic environments. Likewise, the occurrence of Salviniaceae, represented by three species (Salvinia auriculata, S. molesta, S. rotundifolia), along with Pontederiaceae, which includes Eichhornia crassipes and Eichhornia azurea, signifies a high nutrient load and organic matter presence in these ecosystems.

The dominance of invasive species such as Eichhornia crassipes (water hyacinth) and Salvinia molesta (giant Salvinia) indicates considerable ecological stress resulting from human activities and uncontrolled nutrient influx. These invasive species are notorious for creating dense mats on water surfaces, obstructing sunlight penetration, diminishing oxygen levels, and negatively impacting native aquatic flora and fauna (Gopal, 1987; Villamagna & Murphy, 2010).

Species like Azolla pinnata, Spirodela polyrhiza, and Lemna minor are recognized for their utility in phytoremediation and serve as bio-indicators of nutrient-rich waters. Their presence may reflect heightened nitrogen and phosphorus concentrations, likely stemming from agricultural runoff or sewage discharge. Ipomoea aquatica, Nelumbo nucifera, and Nymphaea pubescens were primarily noted in semi-natural or rural pond systems, where they are utilized for ornamental, culinary, or traditional medicinal purposes.

Additionally, it is important to highlight that species such as Trapa bispinosa and Trapa natans (water chestnuts) are economically significant aquatic crops found in stagnant water bodies. In contrast, Chara vulgaris, a green alga with a hard texture, was identified in cleaner, less eutrophic ponds, often considered an indicator of high water quality. The structure of aquatic vegetation in the Chhatrapati Sambhajinagar district illustrates a combination of natural diversity and changes brought about by human activities. Details regarding the various families of macrophyte species are presented in Table 2. Ongoing monitoring and effective ecological management are essential to manage invasive macrophytes and to support the conservation of indigenous species.

Table 2: Total species of Floating and Free Floating macrophytes categorized by family in Chhatrapati Sambhajinagar District.

Sr. No.	Family of free floating / floating macrophyte	Number of Species
1	Areaceae	4
2	Azollaceae	1
3	Characeae	1
4	Compositae	1
5	Convolvulaceae	1
6	Hydrochaitaceae	1
7	Lemnaceae	1
8	Menyanthaceae	2
9	Nelumbonaceae	2
10	Potntederiaceae	2
11	Salviniaceae	2
12	Trapaceae	2
13	Zygnemataceae	1
Total 13 Families		22 species

The aquatic ecosystems found in the Chhatrapati Sambhajinagar district exhibit a rich variety of macrophytes, prominently featuring the family Araceae (also known as Lemnaceae in certain classifications). This family includes four key species—Lemnagibba, Lemna minor, Spirodelapolyrhiza, and Pistiastratiotes—which are typically found in stagnant or slowmoving eutrophic water bodies. These free-floating plants frequently create extensive surface mats that obstruct light penetration into the water column, thereby limiting the growth of submerged vegetation. Their capacity for rapid growth in nutrient-rich environments allows them to outcompete other species, significantly affecting aquatic productivity, community structure, and ecosystem dynamics. The species diversity observed in the study area is analyzed in terms of their percentages and illustrated graphically in Fig.2.

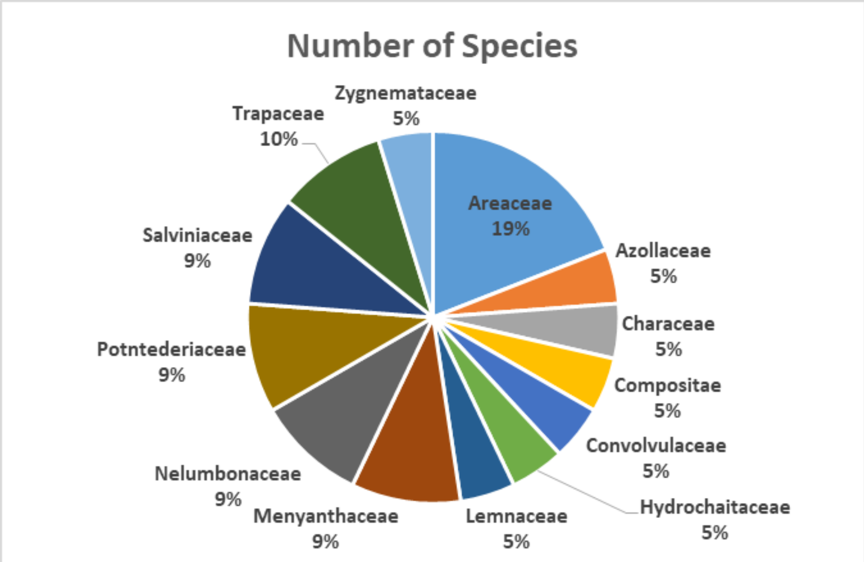

Figure 2: Presentation of floating and free-floating macrophytes categorized by family, as documented in the Chhatrapati Sambhajinagar district of Maharashtra.

The occurrence of species from the Salviniaceae family (Salvinia auriculata, S. molesta, and S. rotundifolia) and the Pontederiaceae family (Eichhornia crassipes and E. azurea) further substantiates the assumption of elevated nutrient levels, likely resulting from human activities. These species are well-suited to nutrient-rich environments and are commonly found in disturbed or unmanaged wetland areas.

Of particular concern are the invasive species Eichhornia crassipes (water hyacinth) and Salvinia molesta (giant Salvinia), which are recognized for their aggressive colonization of water surfaces, creating dense mats that block sunlight, diminish oxygen levels, and hinder water flow. Their uncontrolled proliferation not only disrupts the ecological equilibrium of aquatic ecosystems but also adversely affects local economies by impacting fisheries, water transport, and irrigation systems (Gopal, 1987; Villamagna & Murphy, 2010).

Certain macrophytes, such as Azolla pinnata, Lemna minor, and Spirodela polyrhiza, are crucial for phytoremediation and act as bioindicators of water quality. Azolla pinnata, a nitrogen-fixing aquatic fern belonging to the Azollaceae family, flourishes in shallow, nutrient-dense settings like rice paddies and drainage ditches. These species have the ability to absorb excess nitrogen and phosphorus from the water, thus enhancing water quality and mitigating the likelihood of algal blooms. Their prevalent occurrence in agricultural and peri-urban water bodies likely indicates increased nutrient levels due to fertilizer runoff, sewage discharge, and the accumulation of organic waste.

In more natural or semi-managed aquatic environments, a distinct array of species is dominant. Indigenous aquatic plants like Ipomoea aquatica (water spinach), Nelumbonucifera (sacred lotus), and Nymphaeapubescens (white water lily) were primarily documented in rural ponds and lakes. These species are frequently cultivated or safeguarded due to their economic and cultural importance. For example, Nelumbonucifera is esteemed in traditional Indian culture and extensively utilized in herbal medicine, whereas Ipomoea aquatica is grown as a leafy vegetable. Their continued presence in specific ponds implies that ecosystems with lower nutrient levels and greater stability favor these aesthetically pleasing and economically significant species.

Additionally, it is important to note the presence of economically valuable aquatic crops such as Trapabispinosa and T. natans (water chestnuts), which belong to the family Trapaceae. These species are typically located in calm, nutrient-rich waters and are harvested for their edible fruits. Their occurrence suggests the capacity of certain wetlands to sustain productive, multifunctional ecosystems that integrate biodiversity conservation with sustainable resource utilization.

Among the submerged macrophytes, Chara vulgaris (Characeae) was primarily found in clearer, less eutrophic water bodies. This green alga is recognized for its calcified texture and its role in stabilizing sediments and enhancing water clarity. Its presence is often regarded as a sign of good water quality, as it flourishes in low-nutrient, well-oxygenated environments that support balanced aquatic ecosystems. Similarly, families represented by single species—such as Hydrocharitaceae, Zygnemataceae, Characeae, and Compositae—underscore the diversity of niche-specialized taxa within the district.

In summary, the structure of aquatic vegetation in the Chhatrapati Sambhajinagar district exemplifies a complex interaction between natural ecological diversity and human-induced factors. The prevalence of nutrient-rich and invasive species indicates significant eutrophication, largely caused by agricultural runoff, domestic sewage, and urban waste. In contrast, the existence of native and economically significant species in relatively untouched habitats highlights areas of ecological stability and cultural importance.

To promote the long-term health and biodiversity of these freshwater ecosystems, ongoing ecological monitoring and focused management strategies are crucial. Prioritizing the control of invasive macrophytes, the restoration of degraded wetlands, and the conservation of native species is essential to sustain ecological functions, support local economies, and bolster the resilience of aquatic environments amid persistent environmental changes.

Recent studies on floating and free-floating aquatic macrophytes in the Chhatrapati Sambhajinagar district have uncovered a diverse array of 22 species across 13 families. This research builds upon previous studies by Jadhav and Babare (2025i), who investigated emergent macrophyte vegetation in the adjacent Jalna district and identified Cyperaceae as the predominant emergent family. While their findings offered valuable insights into the role of emergent macrophytes in sustaining ecological balance and alleviating eutrophication, the current emphasis on floating and free-floating taxa addresses a significant research void in aquatic plant ecology within the Marathwada region.

Furthermore, the importance of aquatic macrophytes in environmental remediation and phytoremediation has been thoroughly documented by researchers such as Shingadgaon and Chavan (2016, 2018, 2019), who illustrated the capability of macrophytes to extract heavy metals and contaminants from polluted waters. Their research corroborates the presence of bioindicator species such as Eichhorniacrassipes, Pistiastratiotes, and Salviniamolesta in the present study. These species are recognized for their rapid growth and effectiveness in nutrient absorption and have been suggested as natural methods for water purification.

The review by Shingadgaon and Chavan (2016) investigates the use of wild macrophytes for environmentally sustainable phytoremediation strategies in water bodies contaminated with heavy metals, emphasizing the relevance of this green technology. Phytoremediation utilizing selected native plant species is a dependable method for rendering contaminated wetlands suitable for agricultural production. The research conducted by Shingadgaon and Chavan

(2018) analyzes the contribution of macrophytes to enhancing water quality by diminishing nutrient levels, using Eichhorniacrassipes and Hydrillaverticillata as case studies. It underscores the necessity of balancing macrophyte proliferation with potential decomposition impacts that may release nutrients back into the aquatic environment. Macrophytes serve as natural instruments for improving water quality by lowering nutrient levels and functioning as effective bio-filters. The work of Shingadgaon and Chavan (2018) encapsulates the categorization of macrophytes and their significance in wetland ecosystems, particularly concerning nutrient cycling. It also addresses how eutrophication can diminish macrophyte diversity and favor dominant competitors.

The research conducted by Shingadgaon and Chavan (2018) indicated that submerged macrophytes can increase carbon emissions (CO_2 and CH_4) in wetlands, particularly during the warmer months. They emphasized that submerged macrophytes are vital to ecosystem processes, affecting the physical, chemical, and biological dimensions of aquatic environments (Shingadgaon and Chavan (2018a). Aquatic vegetation is essential for sustaining the ecological equilibrium of aquatic ecosystems, influencing water quality, biodiversity, and stability. Additionally, it plays a role in nutrient cycling, offers habitat, and helps stabilize shorelines (Shingadgaon and Chavan, 2018b).

Moreover, the structural features of macrophytes have been examined by Singadgaon and Chavan (2017, 2018a, 2018b), who noted the simplicity and uniformity of submerged macrophyte habitats due to their limited structural complexity. These findings correspond with the floating forms observed in Chhatrapati Sambhajinagar, which also create uniform habitat structures. As highlighted by Daspute-Taur et al. (2018), such habitats affect species richness and trophic interactions.

In spite of these contributions, researchers such as Stahr and Kaemingk (2017) have stressed the necessity for additional research on the functional roles of submerged and floating macrophytes. This is in line with the current study's objective to document and assess floating macrophyte diversity as a precursor to more comprehensive ecological and functional evaluations in regional aquatic ecosystems.

5. CONCLUSION

The diversity of floating and free-floating aquatic macrophytes in Chhatrapati Sambhajinagar district includes a total of 22 species belonging to 13 different botanical families. This diversity highlights the ecological richness and variability of the aquatic habitats in the area, which comprise ponds, lakes, streams, and wetlands.

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