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FLORISTIC RICHNESS AND ECOLOGY OF AQUATIC MACROPHYTES IN THE RESERVOIR OF FAZENDA ESCOLA DE CASTANHAL - UFRA: STRUCTURE, FUNCTION AND ECOLOGICAL IMPORTANCE

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ABSTRACT

Aquatic macrophytes play a key role in aquatic ecosystems, influencing water quality, habitat stability and local biodiversity. This study aimed to analyze the floristic richness, ecological structure and environmental function of aquatic macrophytes in the reservoir of the Federal Rural University of the Amazon (UFRA), in Castanhal-PA. For this, the Howard-Williams (1975) square methodology was used, allowing the systematic sampling of aquatic vegetation. A total of 45 species belonging to 24 botanical families were identified, with a predominance of Poaceae, Cyperaceae and Asteraceae. Species such as *Cabomba aquatica and Utricularia gibba* stood out for their ecological relevance, acting as substrate

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and environmental bioindicators, contributing to the retention of nutrients in the ecosystem. In addition, the analysis of the physicochemical parameters indicated that the water in the reservoir is classified as Class II, suitable for aquaculture and recreation, according to CONAMA Resolution No. 357/2005. The results reinforce the importance of macrophytes in the ecological stability of aquatic ecosystems, evidencing their role in nutrient retention and in supporting biodiversity. These findings highlight the need for ongoing studies to assess the dynamics of these plant communities and their relationship with environmental factors.

Keywords: Aquatic macrophytes. Biodiversity. Aquatic ecosystems. Water quality. Phytoremediation.

INTRODUCTION

Aquatic macrophytes exert a significant influence on the dynamics of aquatic ecosystems, acting on nutrient cycling, sediment stability, and the formation of habitats for aquatic organisms (Bornette & Puijalon, 2011; Coughlan et al., 2018). These plants are essential for the maintenance of biodiversity and water quality, and are widely used in phytoremediation, as they have the ability to remove heavy metals and other pollutants from contaminated environments (Pott & Pott, 2002; Coutinho et al., 2018).

The presence and distribution of macrophytes are directly related to environmental factors, such as water quality, depth, and degree of anthropization (Fares et al., 2020). In tropical aquatic ecosystems, such as those in the Amazon, macrophytes play a critical role in maintaining biodiversity and structuring aquatic habitats (Cabral et al., 2025). In addition, the presence of these plants directly influences hydrodynamics, reducing water velocity and promoting the deposition of fine sediments, factors that directly impact the availability of nutrients in the aquatic environment (Ferreira et al., 2024).

The functional diversity of macrophytes reflects the adaptation of these species to different environmental conditions. In ecosystems subject to high nutrient levels, some submerged macrophytes can form dense plant mats, while floating species proliferate rapidly in eutrophic areas, altering water transparency and affecting light penetration (Zhang et al., 2024). Thus, the study of the floristic and ecological composition of macrophytes is essential to understand the interactions between these plants and ecosystem processes.

In Brazil, the School Farm of the Federal Rural University of the Amazon (UFRA), located in Castanhal-PA, is a strategic site for studies of aquatic macrophytes due to its importance in the training of professionals and the representativeness of its aquatic ecosystems (Dos Passos et al., 2021). The recent land regularization of the site highlights its potential for environmental and agricultural research, expanding scientific interest in the aquatic biodiversity present in the region (Agência Pará, 2021). The UFRA reservoir has been used for research on water quality and biodiversity, being an ideal environment to evaluate the structure and function of aquatic macrophytes (Dos Passos et al., 2021).

The use of macrophytes in the recovery of contaminated environments has been widely studied in several parts of the world. According to Ansari et al. (2020), these plants act as biofilters, removing contaminants from the water through physical, chemical, and biological processes. Species such as *Eichhornia crassipes* and *Pistia stratiotes* have been shown to be efficient in removing pollutants, contributing to the improvement of water quality and the maintenance of ecological balance (Wang et al., 2023). In environments where there is a high nutrient intake, these species can act in the retention of nitrogenous and phosphate compounds, reducing eutrophication and promoting greater ecological stability (Zhang et al., 2024).

In addition to their role in water quality, macrophytes also influence the emission of greenhouse gases in aquatic environments. Studies show that the removal of macrophytes can directly impact CO_2 and CH_4 emissions, affecting carbon dynamics in ecosystems (Harpenslager et al., 2022). Thus, understanding the role of these plants in ecological processes is essential for the sustainable management of aquatic environments.

In view of the above, this study aims to analyze the floristic richness, ecological structure and environmental function of aquatic macrophytes in the UFRA reservoir, focusing on their importance for water quality and local biodiversity.

METHODOLOGY

FIELD OF STUDY

This study was conducted in the reservoir of the Castanhal School Farm (FEC), belonging to the Federal Rural University of the Amazon (UFRA), located on BR-316, km 23, Boa Vista branch, municipality of Castanhal, Pará. The dam was built with the objective of enabling practical classes for the institution's Fisheries and Aquaculture Engineering courses, in addition to serving as a base for academic research, dissertations and theses in the environmental area. The location of the study area can be seen in Figure 1.

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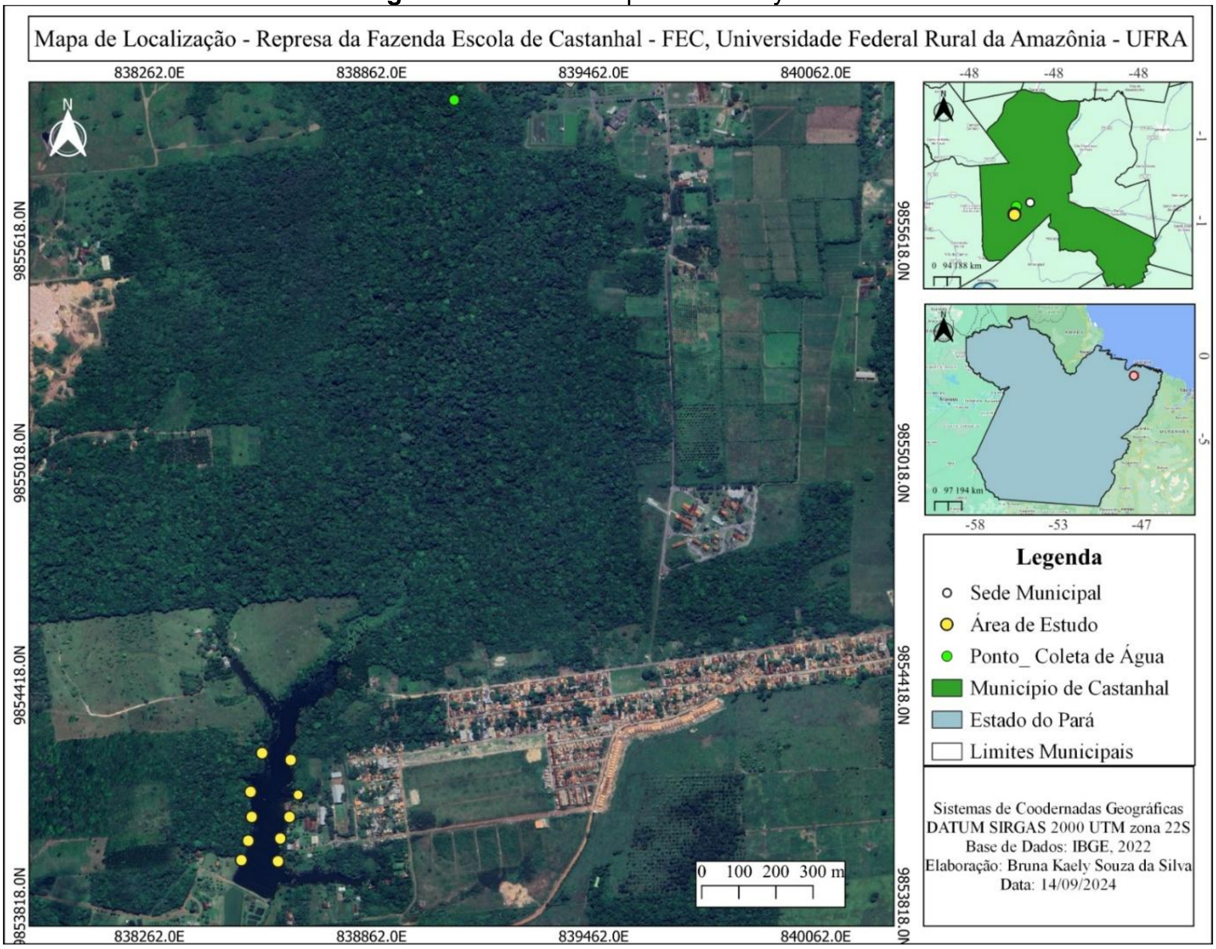
Figure 1. Location map of the study area.



Source: Authors.

COLLECTION AND IDENTIFICATION OF SPECIES

Samples of aquatic macrophytes were collected along the FEC reservoir, following the methodology proposed by Moura-Junior et al. (2015) for floristic surveys in aquatic environments. Plots of 1 x 1 meter were established, selected based on the heterogeneity of the plant species present. Within these plots, all macrophyte specimens were collected manually and packed in plastic bags for transport.

The taxonomic identification followed the protocols of herborization and botanical classification, being carried out in partnership with the Graduate Program in Ecology at UFPA and the Graduate Program in Biological Sciences – Tropical Botany (UFRA/Museu Emílio Goeldi). The collected material was later incorporated into the botanical collection of the Fisheries and Aquaculture Center (NUPA) of IFPA, Castanhal Campus. Figure 2 presents some stages of the sample collection and sorting process.

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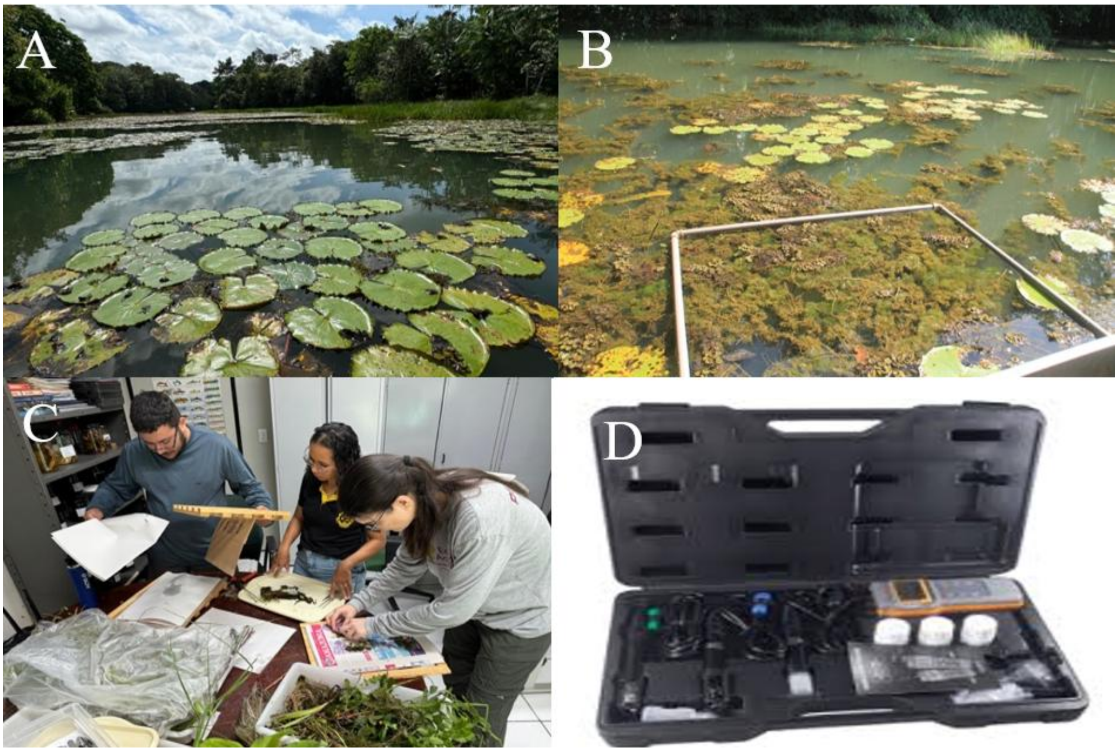
Figure 2. Sampling and processing of the collected macrophyte species. A: Area of study; B: Sample area with PVC square; C: Taxonomic identification of the collected material; D: AKSO AK88v2 Multi-Parameter Probe.



Source: Authors.

PHYSICOCHEMICAL PARAMETERS OF WATER

The water quality of the reservoir was evaluated by measuring six physicochemical variables, namely: pH (Hydrogen Potential), Dissolved Oxygen (DO), Temperature (TºC), Electrical Conductivity (CON), Salinity (SAL) and Total Dissolved Solids (TDS).

The collections were carried out at ten points distributed on the left and right banks of the reservoir. The parameters were measured using an AKSO multiparameter probe model AK88v2 (Figure 3). For comparison purposes, water samples were also collected from the main spring of the studied area, located at the Federal Institute of Pará (IFPA) – Castanhal Campus, at geographic coordinates 1°18'0.5"S 47°57'12.2" W. This spring is located in a permanent preservation area, as established by the Brazilian Forest Code (Law No. 12,651, of May 25, 2012), which determines the protection of springs with a minimum radius of 50 meters of native vegetation (BRASIL, 2012).

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Figure 3. Collection of samples and measurement of physicochemical parameters at the spring.

Source: Authors.

SAMPLE PROCESSING AND LABORATORY ANALYSIS

The biological samples were processed according to standardized methodologies for studies of aquatic macrophytes (Pott & Pott, 2002). The plant material was pressed using newspapers to remove moisture and subjected to drying in an oven at 70ºC for 120 hours at the Laboratory of Aquaculture of Tropical Species (LAET) of IFPA - Castanhal. After this period, the samples were organized in properly labeled exsiccates, serving as testimonial material for future consultations and comparative studies.

DATA PROCESSING

The collected data were statistically analyzed to verify patterns in the floristic composition and physicochemical parameters of the water. The differences between the sample points were evaluated using analysis of variance (ANOVA) and post-hoc tests, when applicable. For floristic richness, the Shannon-Wiener (H') and Pielou (J') diversity indices were calculated, ensuring a detailed evaluation of the distribution and dominance of the species in the study environment.

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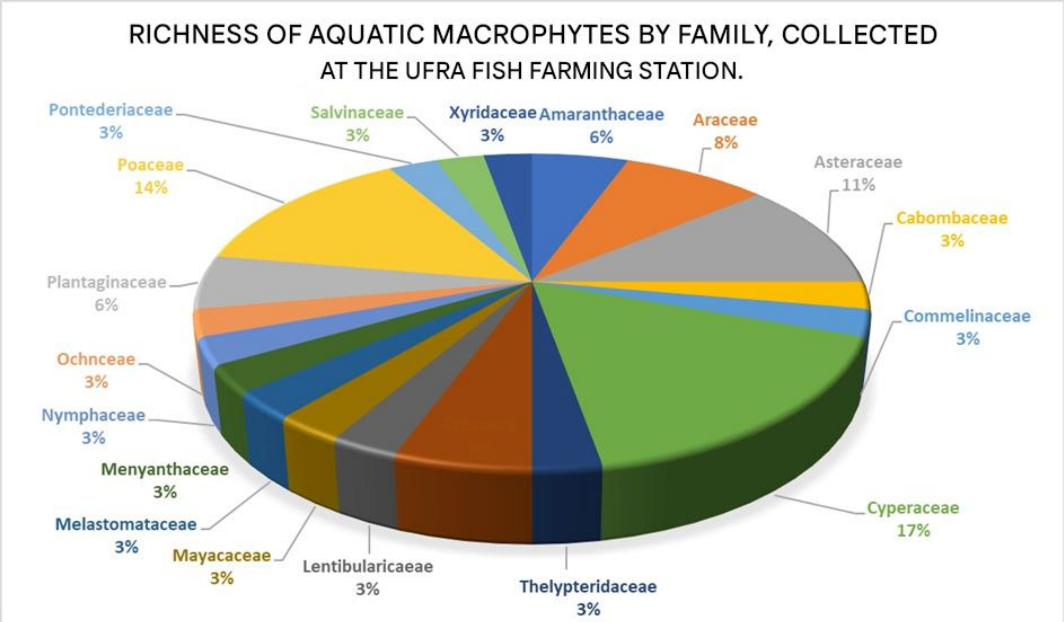
RESULTS

The floristic survey in the reservoir of the UFRA School Farm resulted in the identification of 45 species of aquatic macrophytes, distributed in 24 families and 39 genera. The Poaceae family presented the highest specific richness, with 6 species distributed in 6 genera, followed by Cyperaceae, which registered 5 genera, with a predominance of the genus *Cyperus* (5 species). Other representative families include Asteraceae (4 genera) and Araceae (3 genera). The other families presented between 1 and 2 species, as illustrated in Graph 1.

Graph 1. Frequency of the main families found, in relation to the number of species collected in the reservoir of the School Farm of the Federal Rural University of the Amazon (UFRA), of different species within the same genus.



Source: Authors.

FLORISTIC COMPOSITION

The families with the highest representativeness and their main species were:

- Cabombaceae: *Cabomba aquatica*;
- Salvinaceae: *Salvinia auriculata*;
- Menyanthaceae: *Nymphoides humboldtiana*;
- Nymphaceae: *Nymphaea rudgeana*;
- Lentibulariaceae: *Utricularia gibba*;
- Cyperaceae: *Eleocharis interstincta*, *Cyperus brepharoleptos*, *Cyperus aspan*, *Cyperus brevifolius*, *Cyperus eragrotis*, *Cyperus esculentus*.

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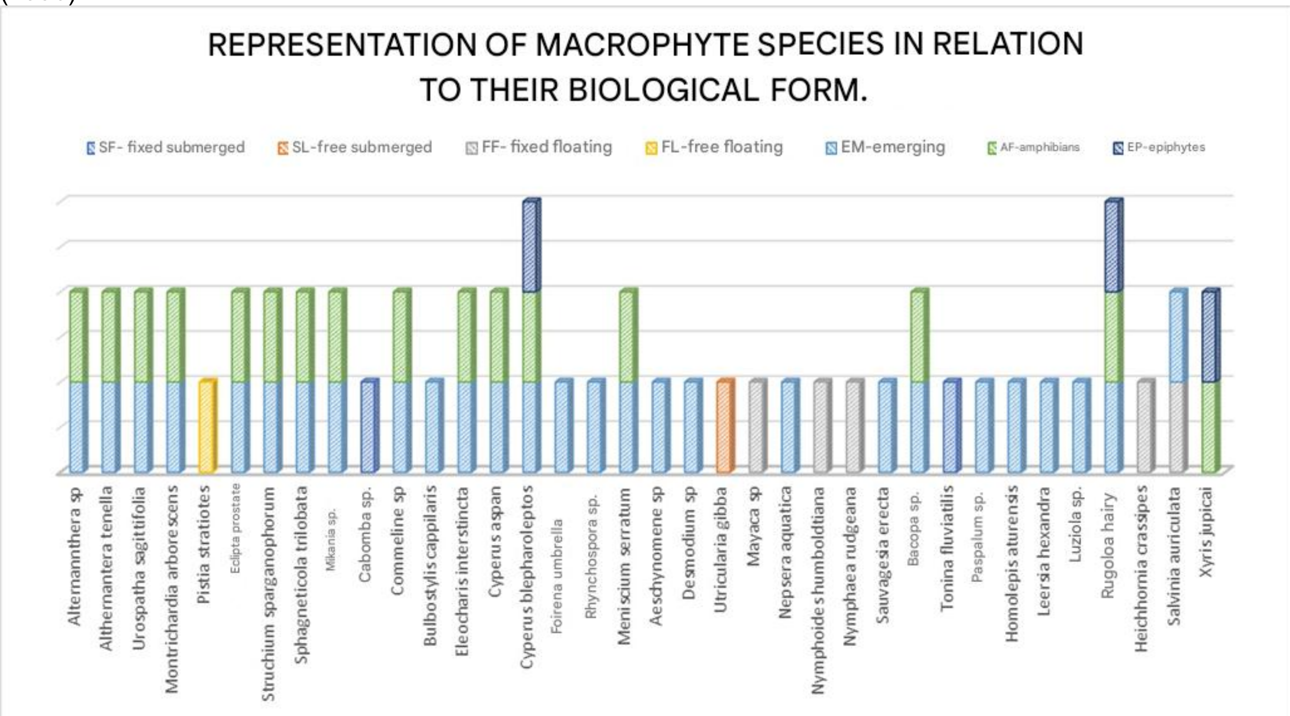
Significant ecological interactions were observed between the species, such as the use of *Cabomba aquatica* by *Utricularia gibba* as a substrate for fixation. In addition, *Salvinia auriculata* served as a support for epiphytic species of the genus *Cyperus*, which complete their life cycle on floating macrophytes.

The spatial distribution revealed that *Nymphaea rudgeana* and *Nymphoides humboldtiana* prefer shallower environments, while *N. rudgeana* can develop at depths between 0.5 and 2 meters. With the increase in reservoir depth, macrophyte diversity decreased significantly, with dominance of *Eleocharis interstincta*, *Cabomba aquatica* and *Utricularia gibba*.

The diversity of species found reflects the richness and complexity of the ecosystems studied. The forty-nine species identified belong to nineteen different botanical families, showing a wide variety of life forms and ecological adaptations. In Graph 2 we can see the diversity of the biological forms of the species found in this environment.

Graph 2. Biological forms of aquatic macrophytes: SF- submerged fixed; SL- free submerged; FF- fixed floating; FL-free floating; EM- emerging; AF- amphibious; and EP- epiphytes. Modified from Irgang et al. (1996).



Source: Authors.

PHYSICOCHEMICAL PARAMETERS OF WATER

The physicochemical parameters of the water were analyzed both in the spring and in the reservoir of the UFRA School Farm. The mean results measured are presented in Table 1.

Table 1. Physicochemical parameters of the spring and reservoir of the UFRA School Farm

Parameter	Spring (Medium)	Reservoir (Medium)
ph	6,2	7,5
Dissolved Oxygen (mg/L)	5,8	7,2
Temperature (°C)	25,4	27,8
Conductivity (μS/cm)	42,3	185,6
Salinity (ppm)	0,2	0,5
Total Dissolved Solids (mg/L)	37,8	140,2

The average values indicate that the spring does not fully meet the Class I criteria (special waters) established by CONAMA Resolution No. 357/2005 (BRASIL, 2005), due to the low dissolved oxygen (5.8 mg/L), while the water in the reservoir falls into Class II, being suitable for recreational and aquaculture activities. The electrical conductivity was significantly higher in the reservoir, suggesting a greater presence of dissolved salts, while the spring presented typical characteristics of groundwater.

DISCUSSION

FLORISTIC RICHNESS AND COMPOSITION OF MACROPHYTES

The diversity of aquatic macrophytes found in the UFRA reservoir (45 species distributed in 24 families) demonstrates the structural complexity of tropical aquatic ecosystems. Previous studies corroborate this high diversity, such as the survey carried out by Moura Júnior et al. (2015), which identified a wide variety of aquatic macrophytes in the northern region of Brazil. This significant number of species may be related to habitat heterogeneity and resource availability, factors often cited as drivers of floristic diversity in aquatic environments (Cabral et al., 2025).

The predominance of the Poaceae, Cyperaceae and Asteraceae families in the study reflects trends already recorded for aquatic ecosystems in the Amazon. Moura Júnior et al. (2015) reported that these families have a wide distribution in the region and play an essential role in the composition of aquatic vegetation. In addition, species such as *Cabomba aquatica* and *Utricularia gibba*, identified in the study area, have already been described as environmental bioindicators due to their sensitivity to changes in water quality (Ansari et al., 2020).

ECOLOGICAL DISTRIBUTION AND INTERACTIONS BETWEEN SPECIES

The distribution of species followed a gradient of depth, with floating and emerging species dominating shallow areas and submerged species prevailing in deeper regions. Studies such as those by Zhang et al. (2024) and Wang et al. (2023) highlight that depth variation directly influences the composition of macrophyte communities, altering light penetration and nutrient availability.

Another relevant aspect observed was the interaction between species. The presence of *Utricularia gibba* using *Cabomba aquatica* as a substrate demonstrates an important mechanism of spatial occupation in aquatic environments, also documented by Fletcher et al. (2024) in studies on ecological interactions in tropical macrophytes. The relationship between *Salvinia auriculata* and epiphytic species of the genus *Cyperus* reinforces the role of floating macrophytes in the creation of microhabitats for other plants and aquatic organisms (Bornette & Puijalon, 2011).

PHYSICOCHEMICAL PARAMETERS AND WATER QUALITY

The analysis of the water quality revealed that the main spring does not meet the Class I criteria of CONAMA Resolution No. 357/2005, due to the low dissolved oxygen (5.8 mg/L), while the reservoir falls into Class II, suitable for recreational and aquaculture activities. This pattern has been observed in other studies in the Amazon, such as the one by Ferreira et al. (2024), which analyzed mining impacts on Amazonian streams and recorded similar patterns in the variation of electrical conductivity and dissolved solids concentration.

The higher conductivity and concentration of dissolved solids in the reservoir can be explained by the accumulation of organic matter and sediment input, as also reported by Macedo et al. (2024) in studies on the impacts of invasive aquatic plants on aquatic ecosystems. The variation in physicochemical parameters between the spring and the reservoir suggests that processes such as organic matter decomposition and gas exchange significantly influence water quality (Lukwambe et al., 2019).

ECOLOGICAL IMPLICATIONS AND MANAGEMENT RECOMMENDATIONS

The presence of aquatic macrophytes plays a crucial role in maintaining ecological balance, influencing everything from habitat structuring to water quality. However, their overgrowth can result in negative impacts, such as reduced biodiversity and the

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proliferation of opportunistic species (Macedo et al., 2024). Therefore, sustainable management strategies, such as biological control and selective removal, should be considered to avoid ecological imbalances (HarpenSlager et al., 2022).

Recent studies highlight the importance of macrophytes in the phytoremediation of contaminated aquatic environments, due to their ability to absorb heavy metals and nitrogenous compounds (Nabi et al., 2025). Species such as *Eichhornia crassipes* and *Pistia stratiotes* are often used in this type of approach, demonstrating effectiveness in removing pollutants and restoring water quality (Wang et al., 2021).

The results of this study provide subsidies for the implementation of management and conservation strategies, contributing to the protection of Amazonian aquatic ecosystems and promoting the sustainability of water resources. Future research can deepen the analysis of the temporal dynamics of macrophytes in the study area, considering factors such as seasonal variations and anthropogenic impacts.

CONCLUSION

This study identified an expressive floristic diversity of aquatic macrophytes in the reservoir of the UFRA School Farm, reinforcing its ecological relevance in the structuring of aquatic habitats. The presence of 45 species distributed in 24 families demonstrates the importance of these plants for nutrient cycling, ecosystem stabilization and water quality improvement, indicating their fundamental role in the environmental sustainability of the region. The predominance of the Poaceae, Cyperaceae and Asteraceae families suggests a strong influence of local environmental conditions on the distribution of species, with emphasis on the high occurrence of *Cabomba aquatica* and *Utricularia gibba*, which act as environmental bioindicators and contribute to the retention of nutrients in the ecosystem.

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