DOI: 10.24906/isc/2023/v37/i4/43714

Search And Survey

Seasonal Variation in Macrophytic Diversity of River Ami Maghar, Sant Kabir Nagar, Uttar Pradesh

Divakar and Anil Kumar Dwivedi†

Abstract

This study investigates the seasonal dynamics of aquatic macrophytes in the Ami River ecosystem across a 12-month cycle from mid-2021 to 2023. Total 37 macrophyte species were identified from the Ami River. The study reveals notable fluctuations in the presence of various macrophyte species, characterized by their abundance or absence during different seasons. During the summer months, numerous macrophytes thrive, suggesting favorable conditions for growth in warmer weather. As the rainy season commences, some species persist while others decline, potentially due to changes in water levels and environmental factors. A mixed pattern emerges in winter, with certain species enduring and others waning, likely influenced by colder temperatures and reduced sunlight. These findings highlight the dynamic nature of the Ami River's ecosystem and its responsiveness to seasonal variations, shedding light on the intricate interplay between macrophytes and their environment. Understanding these seasonal fluctuations is paramount for effective ecosystem management and conservation efforts in the Ami River.

Keywords: Macrophytes, Seasonal Variation, Ami River, Ecosystem.

Introduction

Aquatic macrophytes, herein referred to as macrophytes, represent unwanted vegetation within aquatic ecosystems. Their presence can lead to adverse economic and ecological consequences by disrupting the balance of the aquatic environment. These disturbances affect various aspects, including the aquatic ecosystem, irrigation systems, navigation, public health, and fisheries development in a nation. Notably, macrophytes thrive in tropical and subtropical regions characterized by high temperatures, which favor their rapid growth and proliferation.

Macrophytes are among Earth's most prolific plant species and positively and negatively influence aquaculture. Excessive macrophyte growth negatively impacts aquaculture productivity by absorbing nutrients from the water, impeding plankton production, diminishing sunlight penetration, causing significant variations in dissolved oxygen levels between day and night, providing shelter to harmful insects and fish predators, demanding substantial oxygen for decomposition after death, resulting in harmful dissolved oxygen levels, lowering water pH (due to the release of carbon dioxide during respiration

†PEARL, Department of Botany, DDU Gorakhpur University, Gorakhpur, Uttar Pradesh, India
Email: divakar7838@gmail.com
ORCID: Divakar: https://orcid.org/0000-0003-1028-8442
ORCID: Anil Kumar Dwivedi: https://orcid.org/0000-0002-0589-8708

and decomposition), and interfering with fish movements and fishing operations. It is important to note that certain macrophyte species have industrial significance, producing products such as agar, alginates, and carrageenan, and are cultivated commercially worldwide as independent enterprises. Furthermore, many aquatic plants possess remarkable potential for phytoremediation (bioremediation) of polluted or wastewater due to their innate ability to remove toxic substances effectively [1]. Macrophytes represent a crucial component of aquatic ecosystems. They are vital to biological production because they provide numerous species with structural support, thermal insulation, and oxygen. Larger than most algae, these plants represent a diversified group that prefers to thrive in aquatic or wet conditions. While the roots of certain macrophytes are firmly established in the sediment, others choose to stay above water. Macrophyte species richness is an indicator of ecosystem health. They permeate many bodies of water, especially with little depth, and are widespread in tropical and subtropical regions. Macrophytes play an important role in aquatic ecosystems as indicators of water pollution and agents of pollution reduction.

Studies on macrophyte production in India are limited [2], and their role in energy input, nutrient budgets, and nutrient recycling in water bodies has been documented [3]. Unfortunately, there have been few attempts to survey or study the occurrence of aquatic macrophytes in the state of Maharashtra [4]. The study of Raut and Pejaver[5] highlights the impact of pollution on aquatic biodiversity in Thane City's lakes, observing shifts in flora and fauna, with an increase in pollution-tolerant macrophytes like Pontederia crassipes *(formerly Eichhornia crassipes)*. This study aims to contribute to understanding macrophyte dynamics in the specified region and their potential implications for the local aquatic ecosystem.

Study Area

The current study area is the Ami River, which spans a length of 147 kilometers and encompasses approximately 5,000 hectares across 330 villages, holding a significant place in the region. Its waters are paramount, contributing substantially to the social, environmental, and economic aspects of a vital aquatic ecosystem. From a geographical assessment, the Ami River basin extends from 26°31'N to 27°15'N latitude and 83°26'E to 83°35'E longitude.

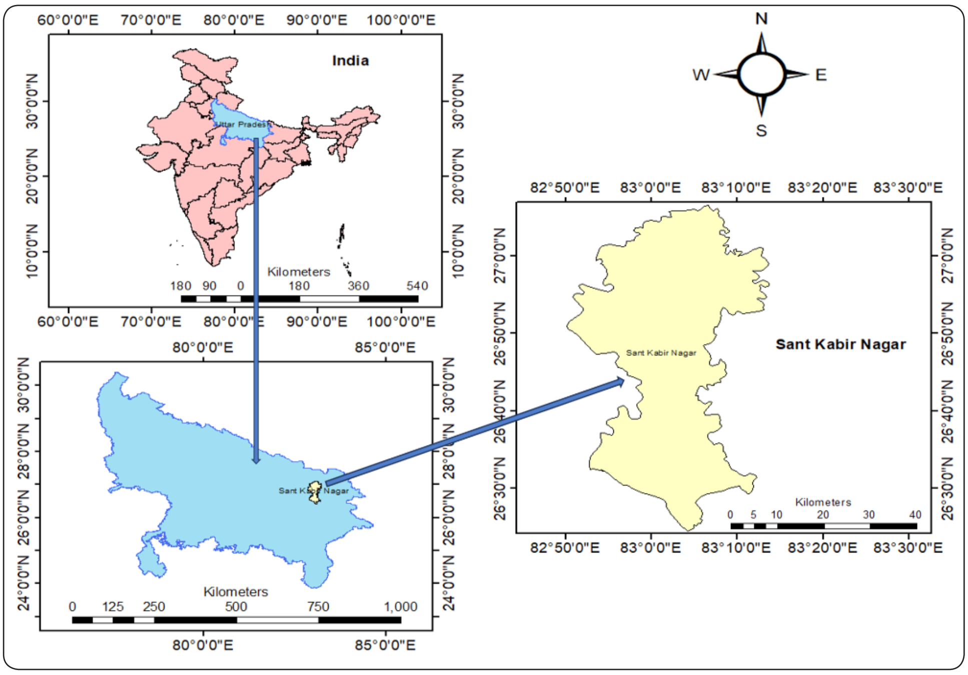


Figure 1 : Geographical position of the study area (Maghar, Sant Kabir Nagar, Uttar Pradesh)

Material and Method:

Our primary goal in this study was to learn more about the seasonal shifts and unique characteristics of some aquatic macrophytes along the Ami River in Maghar, Sant Kabir Nagar, Uttar Pradesh. We carefully selected specified study location and collected the plants from the same nearby area for two years. Using a metal hook and string, the aquatic macrophytes for this study were collected at predetermined sites and then carefully transferred to polythene bags for shipment to the lab. After being transported to the lab, the macrophytes were washed thoroughly under running water to remove any dirt or debris. The harvested plants were treated for one minute with 10% silver sulphate dissolved in 90% ethanol to prevent fungal and bacterial infestations. The macrophytes were then carefully dried using blotting paper, organized, and pressed onto herbarium sheets for long-term storage and study. Literature and taxonomy databases were consulted to aid in the identification process. Seasonal shifts in aquatic vegetation were tracked during the study's two-year duration (mid-2021 to 2023). Different aspects of the aquatic vegetation were recorded monthly, along with visual assessments of the macrophytes. The systematic collecting, processing, and analysis of aquatic macrophytes was made possible by this all-encompassing methodology, shedding light on seasonal variations and the features of these plant species in the designated area.

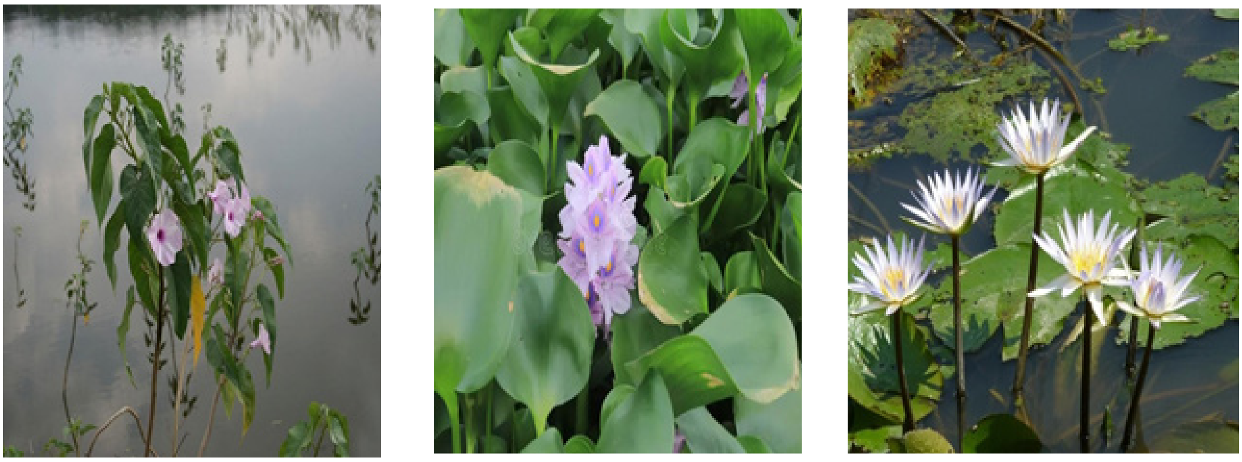
Result and Discussion:

Total 37 macrophytes species were identified from the Ami River. Based on their preferred environment, aquatic macrophytes in the Ami River were divided into three distinct classes: submerged, free-floating, and marshy amphibious. All sorts of plants fall under these umbrella terms and have their own peculiar seasonal habits and ecological functions. The study provides crucial insights into the dynamics of the ecosystem by revealing important facts about the composition and behaviour of these aquatic macrophytes.

In this study, several macrophyte species appear to be abundant in the Ami River ecosystem throughout the year. These species constantly exhibit a presence (+) in several months throughout the seasons. Notable among these abundant species are *Bacopa monnieri, Pistia stratiotes, Lippia alba, Marsilea quadrifolia, Sagittaria graminea, Nymphaea nouchali, Azolla pinnata, Oenanthe fistulosa, Ammannia baccifera, Exacum pedunculatum, Blumea sps., Sopubia delphinifolia, Setaria pumila, Cyathocline purpurea, Canscora diffusa vahl., Saccharum spontaneum L., Commelina benghalensis L, Hoppea dichotoma, Murdannia sps., Ischaemum indicum, Themeda quadrivalvis, Hydrilla verticillata, Achyranthes aspera, Tripogon jacquemontii,* and *Sporobolus indicus*. The macrophytes in the Ami River constantly contribute to the aquatic vegetation across different months, suggesting their prevalence within the ecosystem. Nevertheless, it is crucial to acknowledge that although these species are constantly found, their relative abundance may differ, and a more comprehensive quantitative investigation would be required to accurately determine their ranking in terms of abundance within the ecosystem. During the winter months, specifically November, December, January, February, and March, there is a diverse array of species present, with some species maintaining their population levels while others see a decrease or complete disappearance. The growth and quantity of macrophytes can be influenced by the cooler temperatures and decreased sunlight experienced during the winter season. The fluctuations in macrophyte occurrence seen in the Ami River ecosystem can be attributed to the dynamic nature of the ecosystem, which is driven by seasonal variations in environmental conditions. Comprehending these patterns is of utmost importance in evaluating and overseeing the ecological well-being of the river.

The present study elucidates the various elements that exert influence on the diversity of macrophytes in the Ami River, as well as the patterns discerned from the collected data. The river demonstrates reduced species richness, although a higher abundance of individuals, leading to a diminished rich total species. The observed disparity can be ascribed to several environmental conditions, as evidenced by the studies conducted by Ondiba et al. [6] and Svitok et al. [7]. Several variables contribute to the degradation of aquatic ecosystems. These aspects encompass low water levels accompanied by sluggish water flow, heightened turbidity, elevated concentrations of humic substances, decreased pH levels, oxygen-depleted situations, and substantial anthropogenic activities. Certain environmental factors, such as reduced water flow and absence of oxygen, have the potential to create favourable conditions for species that are well-adapted to such habitats, while constraining the diversity of other species. The data demonstrates the phenomenon of "evenness" observed in macrophyte

Cyperus rotundus ***Lippia alba*** ***Marsilea quadrifolia***



Ipomoea fistulosa ***Pontederia crassipes*** ***Nymphaea nouchali***

Figure 2 : Macrophytes present during various seasons of Ami River, Maghar, Sant Kabir Nagar.

populations. Minor differences in species richness values among the site's growth forms suggest a more homogeneous population. This is particularly evident in the exceptionally high evenness of the water hyacinth. This indicates that this species has a significantly greater number of adult individuals, potentially outcompeting other species for resources [8].

Furthermore, the data underscores the impact of seasonal fluctuations on the composition of macrophyte communities in the Ami River. Changes primarily influence these fluctuations in hydrological conditions, bottom morphology, and sediment quality. As Lacoul and Freedman [9] highlighted, the growth conditions for different macrophyte species can vary significantly, resulting in seasonal shifts in dominance. Chambers et al. [10] also observed that macrophyte diversity for tropical regions tends to be higher than that of temperate regions. This observation aligns with higher diversity in the Western fringe of the Ami River, which experiences environmental conditions that are relatively unique to tropical ecosystems. Moreover, the discussion provides valuable insights into the interplay of environmental factors, species competition, and seasonal dynamics that influence macrophyte diversity in the Ami River. The consistency in the diversity index values across studies, as reported by Ghosh and Biswas, reinforces the data's reliability and the diversity index's utility as a tool for assessing and comparing ecosystem health and biodiversity across different regions.

Water nutrient levels, temperature,and pollutant inputs were all emphasized as environmental factors affecting aquatic macrophytes' composition. The diversity of species in the Ami River fluctuated throughout the year, highest in the winter and lowest in the summer. The results corroborate the involvement of abiotic variables in affecting the distribution of aquatic plants, as found in research by Patil [11] and Raut and Pejaver in various water bodies across India. In addition, the ability of some species, including *H. verticillata* and *N. minor*, to survive throughout the year despite fluctuating environmental conditions is evidence of their adaptability. The research also found that some species, such as *E. crassipes*, could better adapt to urban environments. However, partial pollution from human and cattle activities may affect various spots.

Brogan et al. [12] highlighted the critical role of submerged macrophytes in mitigating the adverse effects of insecticides in freshwater ecosystems. This research emphasizes the ecological significance of macrophytes in preserving ecosystem health, especially under environmental stressors like pollution. Similarly, the study of Dunne [13] on Lake Riley, Minnesota, revealed how lake management practices like invasive species control and nutrient sequestration positively impact macrophyte communities. This study underscored the importance of light in macrophyte germination, showing that improved water clarity enhances macrophyte diversity and biomass. Both studies offer valuable insights into the functional roles of macrophytes in freshwater ecosystems, aligning with and enriching the context of the seasonal dynamics of aquatic macrophytes in the Ami River ecosystem. The findings of Yu et al. [14] suggest that certain macrophytes can significantly reduce these nutrient levels, offering a promising, environmentally friendly solution for improving water quality in eutrophic ecosystems. This study's insights could be highly relevant to our study, especially in the context of managing river ecosystems like the Ami River.

Their research of Manolaki et al. [15] delved into the differences in nitrogen and phosphorus uptake between submerged and amphibious macrophytes. The findings suggest that the diversity in macrophyte growth forms can greatly influence the efficiency of nutrient uptake in aquatic ecosystems. This study emphasizes the importance of considering various macrophyte types in ecosystem management and restoration efforts, as they play a crucial role in maintaining water quality and nutrient balance. This perspective aligns with and extends the understanding of macrophyte functionality in ecosystems, like the Ami River environment. The study of Ma et al. [16] revealed that water depth is a crucial factor affecting the biodiversity-biomass pattern in macrophyte communities. This research adds to the understanding of aquatic ecosystem functioning by demonstrating how environmental factors like water depth can shape community structure and influence the ecological roles of macrophytes. Such findings are essential for conservation and restoration efforts, emphasizing the need to consider environmental variables in managing aquatic ecosystems. The study of De Wolf et al. [17] highlights the complex interactions between macrophytes and microbial assemblages, emphasizing the ecological importance of macrophytes in freshwater systems. Such insights are valuable for understanding the intricate roles of aquatic plants in ecosystem functioning, relevant to the themes discussed in the Ami River.

Moreover, this study adds to the understanding of these crucial plant species' ecological interactions and adaptations in response to changing environmental conditions by providing new insights into aquatic macrophytes' seasonal dynamics and distribution in the Ami River.

Conclusion

This study categorizes aquatic macrophytes in the Ami River into submerged, free-floating, and marshy amphibious types, each exhibiting distinct seasonal behaviors and ecological roles. Several macrophyte species consistently maintain their presence throughout the year, contributing to the river's aquatic vegetation. These include *Bacopa monnieri, Pistia stratiotes, Lippia alba, and Marsilea quadrifolia*. While these species are reliably present, their relative abundances may vary. In the winter months, some species persist, while others decline, reflecting the dynamic nature of the Ami River's ecosystem, influenced by changing seasonal conditions. Understanding these patterns is crucial for effectively assessing and managing the river's ecological health and biodiversity.

Acknowledgment:

The authors are highly thankful to the Authority, Department of Botany, DDU Gorakhpur University, Gorakhpur, U.P., India, for all the facilities provided during the experiment.

Table 1. Seasonal Variation of macrophytes in Ami River (April 2021 to March 2023)

Sl. No.	Macrophyte Species	Family	Habitat	Summar				Rainy				Winter			
				April	May	June	July	August	September	October	November	December	January	February	March
1.	*Bacopa monnieri*	*Scrophulariaceae*	MA	+	+	+	-	+	+	+	+	+	-	+	+
2.	*Pistia stratiotes*	*Araceae*	MA	+	+	+	+	+	+	-	+	+	-	-	+
3.	*Lippia alba*	*Verbenaceae*	MA	+	+	+	+	+	-	+	+	+	+	+	-
4.	*Marsilea quadrifolia*	*Marsileaceae*	MA	-	+	+	+	+	+	+	+	+	+	-	-
5.	*Sagittaria graminea*	*Alismataceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
6.	*Colocasia esculenta*	*Araceae*	MA	-	+	+	+	+	+	+	+	-	+	+	-
7.	*Saccharum spontaneum*	*Poaceae*	MA	+	-	+	-	+	+	+	+	+	+	+	+
8.	*Nymphaea nouchali*	*Nymphaeaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	-
9.	*Azolla pinnata*	*Salviniaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
10.	*Oenanthe fistulosa*	*Apiaceae*	MA	-	+	+	+	+	+	+	-	+	+	-	+
11.	*Ipomoea triloba*	*Convolvulaceae*	MA	+	+	+	+	+	-	+	-	+	+	+	+
12.	*Cyperus rotundus*	*Cyperaceae*	MA	+	+	+	+	+	+	-	+	-	-	+	-
13.	*Caesulia axillaries Roxb*	*Asteraceae*	MA	+	+	+	-	+	+	+	+	+	+	+	+
14.	*Ludwigia perennis L*	*Onagraceae*	MA	-	-	+	+	+	+	+	+	+	+	+	+
15.	*Ammannia baccifera L*	*Lythraceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
16.	*Exacum pedunculatum L*	*Gentianaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
17.	*Blumea lacera*	*Asteraceae*	MA	+	-	+	+	+	+	+	-	-	+	+	+
18.	*Sopubia delphinifolia*	*Scropulariaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
19.	*Setaria pumila*	*Poaceae*	MA	+	+	-	+	+	+	+	+	+	+	+	+
20.	*Cyathocline purpurea*	*Asteraceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
21.	*Canscora diffusa vahl*	*Gentianaceae*	MA	+	+	+	+	+	+	+	+	+	-	+	+
22.	*Saccharum spontaneum L*	*Poaceae*	MA	+	+	+	+	+	+	+	+	-	-	+	+
23.	*Commelina benghalensis L*	*Commelinaceae*	MA	+	+	+	-	+	+	+	+	+	+	-	+
24.	*Hoppea dichotoma*	*Gentianaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
25.	*Murdannia nudiflora L*	*Commelinaceae*	MA	+	+	+	+	+	-	+	+	+	+	+	+
26.	*Potamogeton nodosus*	*Potamogetonaceae*	FF	-	-	-	+	+	+	+	+	+	+	+	-
27.	*Pontederia crassipes*	*Araceae*	FF	+	+	+	+	+	-	-	+	+	+	+	+
28.	*Leersia hexandra Sw.*	*Poaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
29.	*Eragrostis unioloides*	*Poaceae*	MA	+	+	+	-	-	+	+	+	+	+	+	+
30.	*Ischamum indicum*	*Poaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
31.	*Hygrophila schulli*	*Acanthaceae*	MA	+	+	+	+	+	+	+	-	-	+	+	+
32.	*Vallisneria spiralis*	*Hydrocharitaceae*	RS	-	-	-	-	-	+	+	+	+	+	+	-
33.	*Themeda quadrivalvis*	*Poaceae*	MA	+	-	-	-	+	+	+	+	+	+	+	+
34.	*Hydrilla verticillata*	*Hydrocharitaceae*	RS	+	+	+	+	+	+	+	+	+	+	+	+
35.	*Achyranthes aspera*	*Amaranthaceae*	MA	+	+	+	+	+	+	+	+	-	-	-	+
36.	*Tripogon jacquemontii*	*Poaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+
37.	*Sporobolus indicus*	*Poaceae*	MA	+	+	+	+	+	+	+	+	+	+	+	+

RS - Rooted submerged, FF-Free floating, MA-Marshy amphibian

References

1. J I N Kumar, H Soni, R N Kumar, I Bhatt, Macrophytes in phytoremediation of heavy metal contaminated water and sediments in Pariyej Community Reserve, Gujarat, India, Turk J Fish Aquat Sci, Vol 8, No 2 , page 193-200, 2008.
2. A D Adoni, M Yadav, Chemical and productional characteristics of Potamogetonpectinatus (Linn.) and Hydrillaverticillata (Royle) in a eutrophic lake, Int Proceedings of the Nat. Symp. Pure and Appl Limnology, Vol 32, No 1, page 96-105, 1985.
3. B C Rana, J I N Kumar, Energy dispend analysis by X-rays of certain aquatic macrophytes , Indian J Weed Sci, Vol 20, No 1, page 46–49, 1988.
4. J I N Kumar, R Nirmal, B C Rana, Seasonal Variation in the macrophytes of two ponds, Ratheshwar and Tarapur, In Central Gujarat, Bomb J Nat Hist Soci, Vol 88, No1, page 210-214, 1990.
5. N S Raut, M K Pejaver, Study on biodiversity of some macrophytes infested lakes from Thane city, Maharashtra Nature Env Polln Tecno Vol 2, No 3, page 277-281, 2003.
6. R Ondiba, R Omondi, K Nyakeya, J Abwao, S Musa, E O Okoth , Environmental constraints on Macrophytes distribution and diversity in a tropical endorheic freshwater Lake Baringo, Int J Fish Aquat Stud , Vol 6 , No 3, page 251-259, 2018.
7. M Svitok, R Hrivnák, J Kochjarova, P Paľove-Balang, Environmental thresholds and predictors of Macrophytes species richness in aquatic habitats in central Europe, Folia Geobot, Vol 51 ,No 3, page 227-238, 2016. DOI: 10.1007/s12224-015-9211-2.
8. D Ghosh, K J Biswas, Biomonitoring macrophytes diversity and abundance for rating aquatic health of an oxbow lake ecosystem in Ganga River Basin, Am J Phytomed Clin Ther, Vol 3, No 10, page 602-621, 2015.
9. P Lacoul, B Freedman, Environmental influences on aquatic plants in freshwater ecosystems, Environ Rev, Vol 14, No 1, page 89-136, 2006.
10. P A Chambers, P Lacoul, K J Murphy, S M Thomaz, Global diversity of aquatic macrophytes in freshwater, Hydrobiologia ,Vol 1, No 1, page 9-26, 2008. DOI: 10.1007/s10750-007-9154-6.
11. S G Patil, Limnological investigations-biotic factors, Zoological Survey of India Wetland Ecosystem Series, Vol 3, No 1, page 27-61, 2002.
12. W R Brogan III, R William, R A Relyea, Submerged macrophytes mitigate direct and indirect insecticide effects in freshwater communities, PLOS ONE, Vol 10, No 1, 2015.
13. M A Dunne, The Response of Aquatic Macrophytes to Lake Management Practices and the Role of Light in the Germination of Macrophytes Propagules, Ph.D dissertation, University of Minnesota, 2017.
14. S Yu, C Miao, H Song, Y Huang, W Chen, X He, Efficiency of nitrogen and phosphorus removal by six macrophytes from eutrophic water, International Journal of Phytoremediation , Vol 21, No 7, page 643-651, 2019.
15. P Manolaki, M B Mouridsen, E Nielsen, A Olesen, S M Jensen, T L Lauridsen, A Baattrup-Pedersen, B K Sorrell, T Riis, A comparison of nutrient uptake efficiency and growth rate between different macrophytes growth forms, Journal of Environmental Management, Vol 274, No 1, 2020.
16. M Fei, L Yang, T Lv, Z Zuo, H Zhao, S Fan, C Liu, D Yu, The biodiversity–biomass relationship of aquatic macrophytes is regulated by water depth: a case study of a shallow mesotrophic lake in China, Frontiers in Ecology and Evolution, Vol 9, No 1, 2021.
17. D Wolf, E Ide, W J Calder, J Grant Harrison, G D Randolph, B E Noren, C Weinig, Aquatic macrophytes are associated with variation in biogeochemistry and bacterial assemblages of mountain lakes, Frontiers in Microbiology, Vol 12, No1, 2022.