Review of Ecological Significances and Roles of Aquatic Macrophytes

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Abstract

Macrophytes are huge and vast aquatic plants belonging to taxonomically diverse groups. They are adapted to grow in aquatic environment of fresh water bodies, sea water. This review is based on the strong study of literature and article based on work done on macrophytes. Review show that macrophytes form a significance component in the structure and functioning of an aquatic habitat. They play a vital role and important in the assistance of life by providing habitat, food, medicines and other useful products. They used as bioindicator, changes water quality, carryout nutrient cycling and minimise shore erosion. The review concluded that knowledge of plant abundance in any aquatic ecosystem is crucial as each and every plant has its role and they must be documented before they become eliminated with time without being observed. Researches have to scientifically study and extract the important constituents from unknown plant by identifying them with the help of indigenous people so that it can be further flourished for the welfare of mankind. The aim of this article is to review the abundance significances roles of macrophytes and to focus on the functioning of aquatic lives and the biological abundance within them, as are important for the livelihood and ecological balance.

Keywords *Aquatic, Macrophytes, Plant, Significance, Roles.*

Introduction

Macrophytes are large plants adapted to grow in aquatic habitat. They include submerged, floating or emergent aquatic plants and filamentous algae [1]. Cronk and Fennessy [2] divided macrophytes in to four ecological groups of emergent (E), rooted emergent (RE), submerged (S) and free-floating hydrophytes (F). Chambers *et al.* [3] analyzed the diversity and abundance of aquatic macrophytes and represented them in seven plant groups. These are *Chlorophyta, Cyanophyta, Xanthophyta, Rhodophyta, Bryophyta, Pteridophyta and Spermatophyta.* Macrophytes grow in aquatic ecosystem of fresh water bodies, brackish and sea and are adapted based on the physical and chemical parameters of their surroundings. Nutrient condition, salinity, dissolved oxygen, temperature, light, water level, water flow velocity, transparency, concentration of suspended particles, gas saturation and other limnological parameters determine the community composition of macrophytes.

Macrophytes are of large and abundance numbers in the form of food, fodder, medicine, oxygen, protection and habitat to different fauna and flora. They are significance source of livelihood for local people. As macrophytes respond to a diverse of ecological conditions they are important bioindicators. Their role in controlling water nutrient and its purification has also been well established [8-9]. Investigation of macrophyte variety and their ecosystem services have been established at different locations in India and abroad [2, 10-15]. This article reviews variety significances and roles of macrophytes.

Ecological Significances of Aquatic Macrophytes

Macrophyte vegetation is an important component of various types of aquatic ecosystems. Together with phytoplankton species, these autotrophic organisms are the primary producers that provide the conversion of light energy into organic carbon compounds, thereby contributing to the formation of the trophic structure of aquatic ecosystems. During photosynthesis, macrophytes not only synthesize organic substances, but also release oxygen, which is necessary for the respiration of aquatic organisms and decomposition of organic matter. Aquatic macrophytic vegetation is a food resource for a wide range of herbivores, both invertebrates (snails, crayfish, insect larvae) and vertebrates; in addition, many species of aquatic and wetland macrophyte plants is consumed by humans and used for medical purposes (Antonyak *et al.*, 2015). Macrophytes, especially submerged species, are important for aquatic food webs and affect the interaction between predatory, planktivorous and benthivorous fish, as well as between fish and invertebrates (Antonyak *et al.*, 2015). According to available data, 37 freshwater herbivorous fish species belonging to 24 families feed on macrophytes (Antonyak *et al.*, 2015). Some other aquatic or semi-aquatic vertebrates, such as waterfowl, turtle, nutria, muskrat, manatee, and others, use aqua tic macrophytes as food (Antonyak *et al.*, 2015). Freshwater and marine macrophytes also affect communities of animals and other aquatic organisms through a chain of habitat-related mechanisms, including by providing nursery, living and feeding places (Antonyak *et al.*, 2015).

Macrophytes, similarly to other aquatic organisms (e.g. phytoplankton, cyanobacteria), are producers and emitters of biologically active substances (allelochemicals), including low molecular weight volatile organic compounds, which play an important role in interspecies communication and competition. Allelochemicals released by aquatic plants perform a variety of functions, thereby affecting the composition and development of aquatic communities (Antonyak *et al.,* 2015). These substances mediate allelopathic activity against competitors, perform a protective role or can act as attractants, exhibit antimicrobial activity and inhibit the growth of pathogenic microorganisms and harmful algal blooms Andersen T and Pedersen O. (2002). It is assumed that inhibition of phytoplankton and bacterioplankton, including cyanobacteria species, by allelochemical compounds secreted by macrophytes contributes to the stabilization of clear water states in shallow lakes Andersen T and Pedersen O. (2002). Additionally, macrophytes affect aquatic ecosystems through their influence on hydrological regime of water bodies (e.g. flow velocity, formation of surface waves, etc.), bottom sediment formation and water quality Andersen T and Pedersen O. (2002). Noticeable changes in pH values, dissolved gas concentrations and ionic composition of water may result from their metabolism. Macrophytes that grow in near-shore areas can promote the stabilization of shores and contribute to reduction in erosion rates Andersen T and Pedersen O. (2002).

Macrophytes possess a great potential to concentrate mineral elements from the aquatic environment and bottom sediments, and some species are known as metal hyperaccumulators, which is based on their metabolic features and high metal tolerance Bitušík P. *et al.,* (2019). By absorbing mineral ions, these plants participate in the processes of biogeochemical cycling of elements, nutrient turnover and water self-purification; by removing excess nutrients such as phosphates and nitrogen compounds, macrophytes are capable of counteracting the eutrophication processes in water systems. On the other hand, aquatic and wetland macrophytes are capable of accumulating non-metallic inorganic and organic pollutants; moreover, macrophyte species can detoxify some organic xenobiotics by absorbing them from the aquatic environment and transforming these compounds after absorption Bitušík P. *et al.,* (2019).

Therefore, macrophytes are increasingly used in phytoremediation processes of contaminated water bodies, as well as in engineered systems known as constructed wetlands, for the treatment and purification of domestic, agricultural, mining and industrial wastewaters Bitušík P. *et al.,* (2019).An artificially constructed wetland is an environmentally friendly technology in which aquatic plants or a combination of plants and sediments are applied to remove nutrients (nitrogen and phosphorus), oil hydrocarbons, heavy metals, pharmaceuticals and other contaminants from water Bitušík P. *et al.,* (2019). The most frequently used macrophyte species for this purpose are emergent species, namely representatives of Typha, Phragmites, Scirpus, Iris and other genera Bitušík P. *et al.,* (2019). While emergent vegetation absorb nutrients and polluting substances mainly from sediments, submerged and floating macrophytes, such as Myriophyllum spp., Elodea spp., Potamogeton spp., Azolla spp., duckweeds (Lemna spp., Spirodela spp.), Eichhornia crassipes, Pistia stratiotes can effectively absorb contaminants from water Bitušík P. *et al.,* (2019). Aquatic macrophytes are considered more suitable for wastewater treatment than land plants because of their faster growth, greater biomass production, higher ability to absorb pollutants and better cleaning efficiency due to direct contact with contaminated water Białowiec-A *et al.,* (2019).

Aquatic macrophytes are widely used as biological indicators for assessing water quality Białowiec-A *et al.,* (2019). Macrophytes can be used in three ways to assess environmental factors and environmental impact, namely, as indicators, monitors and test-systems. In accordance with the European Water Framework Directive (WFD) 2000/60/EC, macrophytes are an obligatory element in monitoring the ecological quality of rivers Białowiec-A *et al.*, (2019) It has been shown that macrophytes can be distinguished in terms of their requirements for nutrient concentration in water, and this can be used in the assessment of freshwater quality Białowiec-A *et al.*, (2019). Macrophytes are sensitive indicators of eutrophication of calm and running waters; in addition, these plants are also recognized as indicators of acidification, water flow and morphological degradation Białowiec-A *et al.*, (2019).

Along with the important role of aquatic macrophytes in maintaining the biodiversity, structure and function of aquatic ecosystems, many of these species can be harmful if present in excess in an aquatic ecosystem. This applies in particular to aquatic weeds, that is, species that have spread outside their original geographical area Białowiec-A *et al.*, (2019). For some of them, the new natural environment turns out to be very favorable, which allows them to spread and propagate excessively, competing with local species for habitat and resources. Some environmental factors causing stress in freshwater ecosystems (such as eutrophication) can lead to reduced growth of inidgenous macrophyte species and contribute to the spread of invasive alien macrophytes Białowiec-A *et al.*, (2019) Owing to their excessive growth and rapid colonization rates, invasive macrophytes can establish abundant populations that adversely affect the dynamics of aquatic communities and threaten native biodiversity through various physical, chemical and biological impacts Białowiec-A *et al.*, (2019) In many European countries, including Ukraine, the distribution of species such as Eichhornia crassipes, Elodea nuttallii, Myriophyllum aquaticum, Myriophyllum heterophyllum and Pistia stratiotes, which possess a high invasive potential, is of particular concern (Bes M., Corbera J. *et al.*, 2018).

Roles of Aquatic Macrophytes:

As Primary Producers:

Macrophytes as primary producers are vital constituent of any aquatic habitat. As green plants, they play significant role in conversion of light energy into chemical energy in aquatic ecosystem. By the process of photosynthesis, they not only produce organic matter but also provide oxygen for respiration and decomposition of organic material [16,17].

As Biological Indicators of Water Quality:

A proportion of aquatic floras are required for the wellbeing of any aquatic habitat. In aquatic environment, water body fitness is represented by the density and abundance of macrophytes. Their absence or high diversity, both is an indicator of water quality status. Their absence represents the occurrence of factors that inhibit plant growth like water salinization, land cover changes, presence of inhospitable bottom sediments while their excessive growth may be an indicator of high eutrophication status that causes high nutrient threatening aquatic life [18,19]. The algal blooms produce a negative effect on different aquatic flora and fauna, birds and human beings as they gradually deplete oxygen level from the water body and produce *cyanotoxins*. The *allelochemicals* secreted by the macrophytes are natural algaecides [21].

In bioremediation:

Constant increase in industrial activity is polluting the aquatic status. Heavy metal removal experiments using various macrophytes displayed that different aquatic flora act as natural bio filters that carry out purification of water. Macrophytes are having various capacities to absorb and excessive nutrients and toxic metals from the water. They also slow down the flow of water to allow sedimentation of suspended particles. Various reviews have been observed to identify the potential of macrophytes and utilize them as bioremediators in control of heavy metal pollution in Lake Habitat [22-24]. Efforts have been done to identify and utilize the specific nutrient uptake capacity of various plants for phytoremediation [25-26].

In Fish Farming:

The macrophytes are used in fish farming in the form of food, breeding ground or sheltering station. Macrophytes having high nutritional status have been cncluded as an inexpensive alternative to costly fish feed in order to reduce the cost of fish production. This will not only allure fish farmers towards aquaculture but also meet the demand of high quality and easily digestible animal protein for growing population [30]. Comparative analysis of different macrophytes such as *Azolla*, *Lemna*, Ipomoea, *Nelumbo*, *Wolffia*, etc. has established their nutritional value as fish feed [31-32]. Herbivorous fishes prefer those macrophytes as feed that are fleshy and have high energy and protein content and avoid those that have chemical deterrents and calcareous or encrusting material [33]. Macrophyte complexity provides protection to larvae, juvenile and minute species against predation. They are also used for laying eggs by fishes like *Heterotis niloticus*, *Clarias* and *Tilapia zilli* [34]. Macrophytes when evaluated for ecological intensification of small scale fish farming on multi-parameter matrix *Azolla filiculoides* showed the best overall score [35]..

As Medicine:

Medicinal characteristics of macrophytes have been well documented. The ethnomedicinally important aquatic macrophytes used by the rural people have been explored at different locations. They are used for various ailments like skin diseases, throat disorders, inflammation, muscular pain, jaundice, dysentery, chest pain, small pox, yellow fever, flu, improving immunity, etc. [10,11,13]. The macrophytes used as nesting material at Alwara Lake had anti-viral, anti-fungal, anti-bacterial and anti-oxidant properties [36].

Macrophytes in Nest Building:

The diversity of macrophytes affects the variaty of nesting bird species. Many macrophytes are used by the birds as sheltering material. The quality of nest is determined by the material used in building nest. The large biomass of plants helps in faster building of nests and provides camouflage to their chicks from intruders in their territory. Whiskered tern builds large nests on large floating plants for its stability and security [37]. The review on Saras crane showed that the bird uses locally available macrophytes as the must available for nest building [36,38].

As Food and Fodder:

Vast values of aquatic plants have being used as food due to their nutritional cntents. The *Oryza sativa* forms a staple diet for more than 50% of world's population [39]. In India, the seeds of Euryale ferox and Echinochloa colona are eaten for their nutritional contents [40-41]. *Nelumbo nucifera*, *Alternanthera sessilis*, Ipomoea *aquatica*, *Nymphaea pubescens*, *Neptunia oleracea*, *Ceratopteris thalictriodes*, etc. are reported to be consumed as food in different parts of the world. Macrophytes like, *Ceratophyllum demersum*, *Eragrostis unioloides*, *Fimbristylis miliacea*, *Hygroryza aristata*, Ipomoea *aquatica*, *Kyllinga brevifolia*, *Leersia hexandra*, etc. have been mentioned for use as livestock fodder [13,42,43].

As Fertilizer:

Macrophytes have been used as biofertilizer, hence increases soil fertility. A literature study compiled the work on application of various macrophytes on different plants as biofertilizers [44]. Baweja *et al*. [45 A study showed that application of decaying macrophyes as fertilizer on maize crop not only increased its productivity but also provided resistance against phyto-pathogens [46].

Macrophytes and Species Richness:

Macrophytes give food, habitat, egg laying area, refuge, etc, for various invertebrates, fishes and other animals. Thus they support and nurture the biodiversity [47-48].

Miscellaneous Uses:

A strong study of some papers shows the miscellaneous uses of aquatic macrophyte. These are based on survey, questionnaire and conversation with the inhabitants living in location of wetlands or other aquatic habitats. Miscellaneous uses include the use of macrophytes for water gardening (Eg. *Nymphaea spp., Nymphoides spp., Eichhornia spp., Pistia stratiotes*, etc.); religious offerings (Eg., *Nelumbo nucifera, Nymphaea pubescens, Nymphaea lotus, Nymphaea stellata, Utricularia aurea*); weaving (Eg., *Cyperus spp., Typha angustifolia*); fencing (Eg., *Ipomoea carnea*); firewood (Eg., *Ipomoea fistulosa*); vegetables (eg., *Monochoria hastata, Ipomoea aquatic*a) and adorns (*Nymphaea spp*.) [42,43,49,50].

Conclusions

On the basis of above reviews, it can be concluded that documentation of macrophytes in various station is crucial for the identification of any pecies as well as for the conservation of ecologically significance and role of plants as change in physico-chemical properties of water may result in high loss of aquatic diversity. This is inresisitance as macrophytes are not only the source of livelihood for local people living near of aquatic habitat but give different other ecological habitat services necessary for ecological balance. The review conducted on macrophytes showed that vast part of our biodiversity having vital status is still unexplored. Efforts must be carry out to maintain the knowledge about the importance of locally available plants from indigenous local people as this knowledge is orally transmitted and may get diminished along with time. Therefore proper monitoring and adequate management is required to maintain proper abundance, availability and density and sustainable utilization of these importance aquatic resources.

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