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Aquatic Weeds: A Growing Threat to Water Security and Ecosystem Health

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Aquatic weeds constitute a major constraint to effective water resource utilization, ecological stability and agricultural productivity. These weeds are broadly categorized into surface (free-floating and rooted floating), submerged, emergent, marginal (shoreline), dispersed (including algae), and ditch weeds, each differing in morphology, habitat preference, and ecological behaviour. Their rapid proliferation disrupts aquatic ecosystems by reducing biodiversity, deteriorating water quality, obstructing navigation, lowering reservoir storage capacity, and significantly decreasing water flow in irrigation canals. In India, invasive species such as *Eichhornia crassipes*, *Salvinia molesta*, *Hydrilla verticillata*, *Alternanthera philoxeroides*, and *Pistia stratiotes* have emerged as major threats, infesting substantial portions of utilizable water resources and severely affecting paddy cultivation, fisheries, and irrigation systems. Management strategies for aquatic weeds include mechanical, chemical, and biological approaches. Mechanical methods such as dredging, mowing, chaining, netting, cutting, and harvesting provide immediate physical removal but often require repeated interventions. Chemical control through foliar sprays and granular herbicides ensures rapid suppression when properly applied, with systemic herbicides like glyphosate demonstrating high weed control efficiency. Botanical extracts rich in allelochemicals also show potential as eco-friendly alternatives. Biological control, involving insects, pathogens, and herbivorous fish, offers sustainable long-term suppression by exploiting natural ecological interactions. Integrating these approaches provides a comprehensive and environmentally responsible framework for effective aquatic weed management.

Keywords: Aquatic Weeds; Invasive Aquatic Plants; Integrated Management; Biological Control; Water Quality Management

Introduction

Aquatic weeds, plants that grow in ponds, lakes, canals, and other water bodies may seem harmless at first glance, but their unchecked growth can create serious problems. Dense infestations block sunlight, reduce oxygen levels, and disrupt the natural balance of aquatic ecosystems. In addition, invasive aquatic weeds can outcompete native plants, degrade water quality, and hinder fishing, boating, and other water uses. Effective monitoring, timely removal, and sustainable management practices are therefore essential to protect water resources, support agriculture, and maintain healthy aquatic ecosystems.

Types of aquatic weeds

A. Surface weeds: Free-floating weeds are plants whose leaves float on the water surface either singly or in clusters. These weeds can be classified into two types: those that are

entirely free-floating and those that have roots anchored at the mud bottom of the water body. The leaves of free-floating weeds are buoyant and rise and fall with changes in water level, such as during tides or fluctuations in water depth. This adaptation allows them to thrive in varying aquatic environments and can sometimes lead to rapid colonization of water surfaces.

B. Submerged weeds: Submerged aquatic weeds are complex plants that grow mostly underwater, with their flowering parts above the water surface while their foliage remains submerged. They possess true roots, stems, and leaves, making them vascular plants. However, they represent a major challenge globally as the most serious aquatic weed problem, these weeds proliferate rapidly, forming dense mats underwater that outcompete native vegetation and disrupt aquatic ecosystems.

C. Emerged weeds: These plants, rooted in bottom mud, exhibit aerial stems and leaves that extend either at or above the water surface. Their leaves can be broad, akin to many terrestrial plants, or grass-like in some species. Unlike floating weeds, their leaves do not fluctuate with water levels. These plants pose challenges in irrigation and drainage systems, often clogging canals and reducing water flow.

D. Marginal weeds (Shoreline weeds): Most of these plants are emerged weeds that thrive in moist shoreline areas with water depths ranging from 60 to 90 cm. These weeds exhibit variations in size, shape, and preferred habitat, making them adaptable to a range of environmental conditions. Typically growing in shallow waters near the periphery of water bodies, these emerged weeds play a crucial role in stabilizing shorelines, preventing erosion, and providing habitat for various aquatic organisms.

E. Dispersed weeds: Weeds that grow and spread throughout the water, including both unicellular (phytoplankton) and multicellular (scum algae) types, are classified as dispersed weeds. Algae, which belong to this category, lack roots, leaves, or flowers typical of vascular plants, they reproduce vegetatively and through pores, allowing them to rapidly colonize aquatic environments. Filamentous algae, for example, form strands that can attach to rocks or float in mats, contributing to the overall biomass of dispersed weeds.

F. Ditch weeds: "Ditch weeds" refers to plants that commonly grow in and around ditches, which are narrow channels or waterways used for drainage or irrigation purposes. These weeds can vary widely in species and characteristics but are typically adapted to moist or wet environments. Ditch weeds often include both terrestrial plants that grow along the edges of ditches and aquatic plants that thrive in the water itself.

		
Eichhornia crassipes **Surface weed**	***Cerstophyllum demersum*** **Submerged weed**	***Syngonium podophyllum*** **Emerged weed**
		
Scirpus spp. **Marginal weed**	***Chlorophyta spp.*** **Dispersed weed**	***Typha latifolia*** **Ditch weed**

Problems of aquatic weeds

Problems of aquatic weeds in India

- Major five primary aquatic weeds of the world and qualify the status of worst weeds in India

1. *Eichhornia crassipes*
2. *Salvinia molesta*
3. *Hydrilla verticillata*
4. *Alternanthera philoxeroides*
5. *Pistia stratiotes*

- In India 20-25 % of the total utilizable water is currently infested with water hyacinth (*Eichhornia crassipes*)
- By the end of 21th century, *A. philoxeroides* had become a growing menace in water bodies in India

Aquatic weed problems in lakes and ponds

- commercial navigation Impair
- Degrade and deteriorate water quality
- Difficult to catch the fish
- Reduce species diversity
- Habitat for insect-borne disease vectors
- Alter animal community interactions
- Reduce water storage capacity in reservoirs, tanks, ponds

Weed problems in rivers and irrigating canals

- In India many rivers, irrigation canals, lakes, ponds etc. are choked by the explosive growth of aquatic weeds
- *A. philoxeroides* has become one of the problematic weeds in nearby area of low lands areas
- The flow of water in canals is reduced drastically, 40 to 90 % by submersed weeds
- Aquatic weeds are great problem in canal systems which have already reduced the designed flow by 40-50 %

Aquatic weed problem in paddy and crop fields

- Vast areas of low land paddy in the north-eastern parts of India, West Bengal and Kerala states have been badly infested with aquatic weeds
- In the north-east, *E. crassipes, Chara spp. Nittela spp.* and algal scams are nuisance, in the coastal Kerala, *Salvinia sp.,* particularly *S. molesta* plays havoc
- Cultivation of water chestnut has also been abandoned in eastern part of India because of heavy growth of water hyacinth and other aquatic weeds in water bodies

Management of aquatic weeds

A. Mechanical method

In cases where herbicide use is impractical due to water being utilized for livestock, drinking, or fish culture, employing simple implements or machines for aquatic weed control presents a viable alternative. These implements, such as weed cutters, harvesters, mechanical dredgers, or rakes, are designed to manually remove or cut weeds, aiding in the clearance of water bodies and preventing clogging. While these methods are free from pollution, their implementation can be costlier than herbicide-based approaches.

1. Dredging

Dredging is one of the oldest and traditional way of cleaning weeds from drains and ditches. weeds are uprooted along with roots either manually or mechanically.

2. Mowing

Mowing is a common method used to control weeds in ditch banks and small patches of shoreline emerged weeds. This technique involves cutting the weeds to reduce their height and density, making it easier to manage their growth and prevent them from spreading further. However, the effects of mowing are typically short-lived, as the weeds can quickly

regrow if not managed consistently. Despite its temporary nature, mowing remains a practical and cost-effective approach for controlling weeds in specific areas.

3. Netting:

In this method small weight floating weeds such as water lettuce, walfia and duck weed can be removed by manually with a 3 cm mesh coir rope net.

4. Chaining:

A heavy chain is attached between tractor working on both banks of the ditch as these move the chain drags over the weeds.

• Examples: Hydrilla, Arrowheads

5. Cutting:

Using a mechanical device for cutting weeds without collecting them offers advantages in terms of speed and efficiency. These devices can swiftly cover large areas, making the process faster and more cost-effective compared to manual methods. However, a notable disadvantage is the potential for immediate regrowth, as the cut weeds may quickly recover if their roots remain intact.

6. Harvesting (cut and remove)

Combining mechanical cutting with plant removal in weed control offers the advantage of removing plant biomass, which can prevent rapid regrowth and contribute to long-term weed management. However, this approach is slower and more expensive compared to simply cutting weeds, as it involves the additional step of physically removing the cut plants.

B. Chemical method

Direct sprays on foliage from boats effectively kill floating and emerged weeds, while granular formulations treat submersed weeds and algae in shallow waters. Ensuring good dispersion of chemicals is crucial for successful control, maximizing effectiveness, minimizing resistance development, and promoting sustainable weed and algae management practices. Proper application techniques, regular monitoring, and adjusting strategies as needed are essential for achieving optimal results in weed and algae control, maintaining ecological balance in aquatic ecosystems, and preserving water quality for long-term environmental health. Soni *et al*. (2021) reported that application of glyphosate @ 2 L ha^{-1} recorded higher weed control efficiency (63.80 %) of different weed species at 5 and 20 days after spraying when compared to other treatments because glyphosate is a non-selective systemic herbicide it translocate throughout the plant and kill effectively then other herbicides. Ashwini *et al.* (2022) conducted an experiment and reported among all the treatment Root extract @ 80 g L^{-1}, Stem extract @ 80 g L^{-1}, Leaf extract @ 80 g L^{-1}, Whole plant extract @ 80 g L^{-1} shows highest reduction in fresh weight compare to other treatment due to *Alternanthera philoxeroides* contains 56 different allele chemicals among due to presence of water soluble phenolics namely 4 hydroxy-3-methoxy-benzoicacid and m-coumaric acid these allelochemicals in A. philoxeroides would have played an important role in inhibiting the growth of water hyacinth.

C. Biological method

Aquatic biological weed control refers to the use of living organisms, such as insects, fish, bacteria, or pathogens, to manage and control the growth of weeds. This method relies on the natural ecological interactions within aquatic ecosystems to suppress or limit the proliferation of specific weed species. Jimenez and Balandra in 2007 reported that pre releasing of *N. eichhorniae* species and after 4 months post releasing of plant pathogens like *Alternaria alternata*, *Fusarium oxysporum* it results 60 to 70 per cent reduction in infestation due to these insects creates wounds on the plant and these pathogens easily penetrates into plants, spread throughout the plant and cause the wilting of water hyacinth. Pathak and Kannan in 2011 reported that *Fusarium oxysporum* causes the highest infection rate (68.0 %) in water hyacinth with pin prick among other pathogens, because it's direct infection of the stem, leading to wilting of the water hyacinth plant. Effendi and his coworkers reported in 2017 that the treatment with 200 g $fish^{-1}$ treatment showed the highest biomass reduction percentage (88.9%) compared to the treatment with 100 g $fish^{-1}$ treatment. This is due to the

high daily feed intake and feeding rate of the 200 g fish, resulting in a reduction in the biomass of water hyacinth.

Conclusion

Aquatic weeds represent a multifaceted challenge affecting water conservation, irrigation efficiency, biodiversity, fisheries, and overall ecosystem health. Their diverse growth habits from floating and submerged to emergent and dispersed forms require targeted and scientifically informed management strategies. Invasive species have intensified the problem in India, where significant portions of water bodies are already compromised. No single method alone ensures sustainable control. Mechanical techniques provide rapid but temporary relief, chemical measures offer effective short-term suppression when judiciously used, and biological agents contribute to long-term ecological balance. Therefore, an integrated weed management approach that combines mechanical removal, selective chemical application, and biological control agents is essential. Such a strategy not only enhances weed suppression efficiency but also safeguards water quality, reduces environmental risks, and promotes sustainable utilization of aquatic resources for future generations.

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