A REVIEW ON AQUATIC WEEDS AND THEIR MANAGEMENT

Abstract

When aquatic weeds grow too much, they pose a threat to fish farming. An essential component of pond management is weed control. Among the 160 aquatic weeds in India, the following are of important: *Salvinia molesta, Ceratophyllum demersum*, Chara spp., Hydrilla verticillata, *Eichhornia crrassipes*, *Typha angustata, Nelumbo nucifera,* Nitelias, *Ipomoea aquatica*, *Alternanthera philoxeroides*, *Vallisneria spiralis*. Aquatic weeds are rapidly expanding in several irrigation and hydropower projects across the nation, including the Kakki and Idikki reservoirs in Kerala, the Tungabhadra project in Karnataka, and the Nagarjuna Sagar project in Andhra Pradesh. Weeds significantly increase evapotranspiration rates compared to open surface rates, which results in significant water loss. Eutrophication caused by water hyacinth renders water unsuitable and reduces water flow, in addition to various health-related issues. Biological, chemical, and physical strategies can all be used to control aquatic weeds. Aquatic weeds can be stopped from spreading or eliminated using a number of common control methods. Physical remedies work best for small-scale infestations, but they are expensive and prone to regrowth when used on big water bodies. Aquatic weeds have long been subject to chemical treatment, however this practise is not common in India. Herbicide control of tiny infestations has frequently been quite successful, but it significantly depends on trained operators who keep a close eye out for the appearance of regrowth or seedlings over a lengthy period of time. The amount of nutrients released into water in recent decades has significantly increased from home and industrial sources as well as from land where fertilisers are applied or where clearing has increased run-off. *Neochetina spp.* and *Cyrtobagaus salvinae,* exotic weevils, have been used successfully to manage water hyacinth and water fern in several parts of India, but suitable bio- agents are not yet

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available for several additional aquatic weeds. With varied degrees of success, some submerged weed, particularly Hydrilla species, have been controlled using some kinds of herbivorous fish, including *Tilapia spp*. and *Ctenopharyndon idella*. This essay discusses the issues with aquatic weeds in India and the attempts taken thus far to manage them using a variety of techniques.

Keywords: Aquatic weeds, Effects of Aquatic weeds, Fish production, Pond Management, Techniques for control of weeds.

I. INTRODUCTION

Aquatic weeds are undesired plants that grow out of control. The principal producers in the aquatic ecosystem are aquatic plants. They assist fish by giving them food, oxygen, protection, and other things. In actuality, fish ponds often enjoy having some aquatic vegetation present. Delay in controlling their excessive growth leads to decrease in the productivity of the water body by lowering the nutrients or by limiting sunlight entry via shading, which may result in either hyper saturation or oxygen depletion. Aquatic weeds provide predatory fish with cover while also contributing to the overpopulation of weed fish due to their prolific breeding and voracious feeding habits. Food supply is restricted by a number of factors. As a result, gases like H2S and CH4 that are harmful to fish are produced. However, a few aquatic weeds are necessary since many fish use them as natural food sources. They provide beneficial fertilisers in the pond when they decay. In India, there have been reports of around 140 plant species acting as aquatic weeds in and around different types of water bodies. According to the report given by (Philipose, 1968) the states like a Bihar, Assam, Tripura, Manipur West Bengal, and Odisha showed the presence of weed infestation ranging from 40-70%, whereas in other states which indicated a range of 20-50%.

A broad diversity of aquatic plants surround ponds used for fish breeding. These plants come in a variety of sizes, from tiny plankton algae that float in the water suspended to larger plants with roots in the pond floor. For fish to flourish, specific types of aquatic vegetation are required. Aquatic weeds, on the other hand, are plants that prevent the reproduction of commercial fish. Ponds are regularly supplemented with large amounts of commercial feed and inorganic fertilisers to support intensive fish production. When nutrients are introduced to the water through feeds and fertilisers, a good habitat for the growth of aquatic weeds is frequently generated. Submerged aquatic weeds are especially undesirable because fish harvesting seines will ride up over them and let fish escape. Because of the weight of the weeds piling up in the seine, it may be hard to harvest ponds with significant weed infestations. Additionally, culling out fish is time-consuming and stressful for the fish. (Marley et al. 2017).

II. TYPES OF AQUATIC WEEDS

1. **Floating Weeds:** Floating weeds are seed-bearing plants which float free on the water's surface, never becoming rooted in the soil, and are propagated by sexual and asexual means. Duckweed *(Lemna minor* and *Spirodela polyrhiza)* and watermeal *(Wolffia* spp.) are examples of common floating weeds (Marley et al. 2017) as shown in table No.1 and fig No. 1 to 5)

   They float on the water's surface rather of being anchored to the pond's bottom. e.g. *Azolla, Pistia, Wolfia, Lemna* etc. (Abhishek, 2020). Floating weeds have their foliage above surface of water with rooted hanging free underneath (Sanyal and Tanmay, 2017).

Figure 1: Duck¬Weed (Lemna Minor)

Figure 2: Spirodela Polyrhiza (Common Duck Weed)

Figure 3: Wolffiaglobose (Watermeal)

Figure 4: Azolla

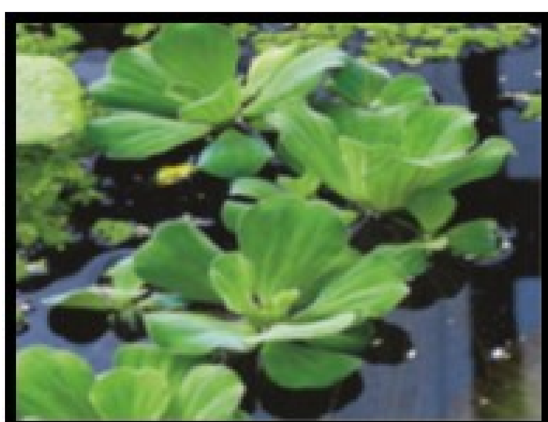


Figure 5: Pistia

2. **Emergent Weeds:** Emergent weeds, rooted in the bottom but having their foliage and flowers above the water surface (Sanyal and Tanmay, 2017).e. g. Nymphaea, Myriophyllum, Vallisneria etc. (Abhishek, 2020 Emersed weeds have roots that reach to the water's surface, but their stems, leaves, and flowers are above it. They typically appear in shallow water up to 10 feet deep along the shoreline. Common emersed weeds are waterlily (Nymphaea spp.) and alligator weed (Altemanthera philoxeroides) (Marley et al. 2017) as shown in table No1 and fig No.6 to 8)

Figure 6: Nym Phaea (Water Lilly)

Figure 7: Myriophyllum (Alligator Weed)

Figure 8: Altemanthera Philoxeroides

3. **Submerged Weeds:** Submerged weeds may or may not be rooted (Sanyal and Tanmay, 2017). Aquatic weeds that are submerged spread up and out of the water. The majority of weeds that are submerged have blooms and seed heads that rise above the water's surface. Examples of common submersed weeds are as follows: hydrilla (*Hydrilla verticillata*) and Brazilian elodea (*Egeria densa*) (Marley et al. 2017).

They are classified into two groups: i.e., Completely submerged weeds within the water but may be rooted in the bottom soil. e.g. *Hydrilla, Najas* etc. and Free floating submerged weed floats freely under the water e.g. *Ceratophyllum, Utricularia* etc. (Abhishek, 2020) as shown in table no. 1 and fig. no 9 to 13.

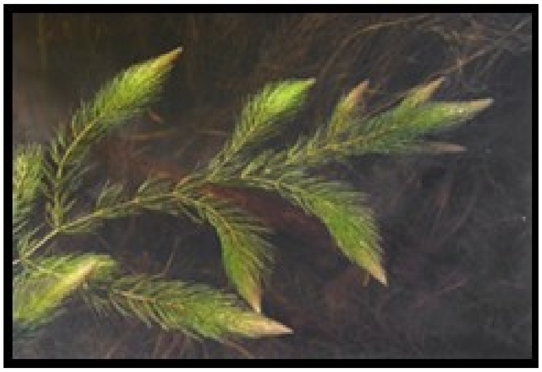


Figure 9: Ceratophyllum

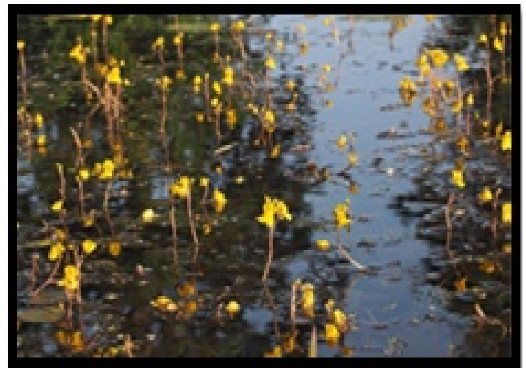


Figure 10: Utricularia

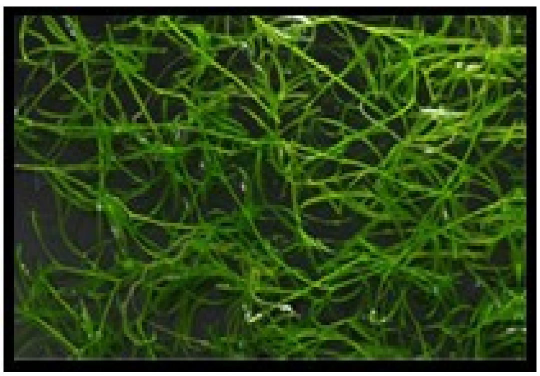


Figure 11: Najas

Figure 12: Hydrilla (Hydrilla Verticillate)

Figure 13: Brazilian Elodea (Egeria Densa)

4. **Marginal Weeds:** Marginal weeds are those weeds which weeds grow on the margins or on the shore line of the water body. Generally, these weeds are rooted in water logged area. e.g. Typha, Nymphaea, Marsilia, Ipomoea etc. as shown in table no. 1 and fig no 14 to 17.

Figure 14: Typha

Figure 15: Nymphaea

Figure 16: Nymphaea

Figure 17: Ipomoea

III. EFFECTS OF AQUATIC WEEDS

1. **Impact of Weed to Other Species Population on Same Ecosystem:** Submerged macrophyte modify food web interaction and stability of late littoral ecosystem (Sanyal and Tanmay, 2017). Quantitative relationships between epiphyte and macroinvertebrate were investigated using units of collonisable Typha and Phragmites plant surface on eutrophic lakes, but no direct relationships between total macroinvertebrate abundance and epiphyte on mass on the plant surface were found**.** (Sanyal and Tanmay, 2017). In a natural ecosystem, biodiversity can take several forms, including genetic diversity, species variety, and ecological diversity. Although the amount of the impact is rarely measured, many environmental weeds have the potential to have an influence at one or more of these levels (Adair and Gropves, 1998).

   Growth of water hyacinth has been prolific in many lake resulting in breeding vector and causing endemic disease**.** Aquatic plants are more prevalent in warm and marshy areas, which are a natural component of the environment and are used by many different creatures as food or hiding places. This overabundance of aquatic plants, however, may lead bats to interfere with people's activities, either by their mere abundance or by this (Sanyal and Tanmay, 2017).

- **Effects of Aquatic Weeds in India:** India is most concerned about the following aquatic weeds out of around 160: *Salvinia molesta, Vallisneria spiralis, Typha angustata, Hydrilla verticillata, Chara species, Nitella species, Eichhornia crassipes, Nymphaea stellata, Ipomoea species,* and others are mentioned. The five important aquatic weeds in the world- *Eichhornia crassipes, Salvinia molesta, Hydrilla verticillata, Alternanthera philoxeroides,* and *Pistia stratiotes* also rank as the worst weeds in India. But according to estimates, water hyacinth (*Eichhornia crassipes*) is currently present in 20–25% of all India's potable water, compared to 40% in Assam, West Bengal, Orissa, and Bihar (Gopal and Sharma, 1981). By the end of 20th century, *A. philoxeroides* had become a growing menace in water bodies in India, (Sushilkumar et al. 2009).

- **Aquatic Weed Problems in Lakes and Reservoirs:** Commercial navigation, water quality, hydropower production, flood frequency, duration, and intensity, species diversity, extinction rates for rare, threatened, and endangered species, safe swimming, recreational navigation, animal community interactions, sediment chemistry, and hydropower generation are just a few of the issues that aquatic weeds may adversely affect. Aquatic weeds have been identified as an increasing ecological threat (Malhotra and Ahmed, 1996). Thirunavukkarsu and Kayarkanni (1996) described about how aquatic weeds affect the ecosystem in India. The Kolleru lake in the West Godavari have been affected due to overgrowth of aquatic weeds such as *E. crassipes, Ipomoea aquatic, Typha Vallisneria*, *Nymphaea* and *Ulothrix spp.*

- **Effects of Aquatic Weeds in Fish Ponds and Lakes of India:** Commercial navigation, water quality, hydropower production, flood frequency, duration, and intensity, species diversity, extinction rates for rare, threatened, and endangered species, hydropower generation, sediment chemistry, safe swimming, recreational navigation, and animal community interactions are just a few of the issues that are adversely affected by aquatic weeds.

  About 40% of India's 8 lakh ha of freshwater that can be used for pisciculture are now unsuitable for fish production due to the invasion of aquatic weeds. Water hyacinth has prevailing over most of the fisheries ponds in and around Bangalore and the surrounding districts. Eichhornia, Azolla, Nymphaea, Nelumbo, Nymphoides, Hydrilla, Vallisneria, Potamogeton, Najas, Ceratophyllum, Typha, and Utricularia species are troublesome weeds in fishery lakes and tanks in Andhra Pradesh, Assam, Haryana, Himachal Pradesh, Jammu & Kashmir, Maharashtra, Tamil Nadu, and Uttar Pradesh in India. Some of the well-known fishery lakes, such as the Barwar, Ramgarh, and Guiar lakes in Uttar Pradesh, the Ansupa lake in Orissa, the Ootucmund lake in Tamil Nadu, the Kollern lake in Andhra Pradesh, the Loktak lake in Manipur, and the renowned Dal, Nigeen, and Walur lakes in Jammu & Kashmir, have been significantly overtaken by aquatic weeds. Natural and artificial water bodies in Assam have been affected by aquatic weeds, making them unsuitable for fish farming and other economic uses.

  The National Bank for Agriculture and Rural Development (NABARD) has recognised water hyacinth as a key problem in the beel fishing situation in Assam. Fish productivity in beels was found to be significantly lower as a result of water hyacinth invasion. A particular phytoplankton species will frequently grow swiftly to produce thick masses when the environmental conditions and nutrient supply are ideal. Such thick growths, sometimes known as "water blooms," give water bodies colour depending on the type of bloom-forming algae that is present like green, reddish brown, yellow green, and blue-green. Chlorophyceae (Chlorella vulgaris, *Pandorina* morum, Volvox aureus), Bacillariophyceae (Melosira granulata, Synedra ulna), Dinophyceae (Peridinium inconspicuum), and Euglenineae (Euglena spp., Trachelomonas spp.) are the principal culprits for transient blooms. The Myxophyceae (Microcystis spp., Anabaena spp., Raphidiopsis spp., and Oscillatoria chlorina) make up the majority of persistent blooms. Blooms are also produced by the widespread filamentous algae Spirogyra, Pithophora, and Oedogonium.

Aquatic weeds pose a serious threat to pisciculture and drinking water supplies in Nagpur, Maharashtra. Water hyacinth and *P. striata* have recently caused problems in Pune and Kolhapur. In Orissa's coastal regions, aquatic weeds seriously harm the fisheries and rice farming industries. Submerged, free-floating stratiotes, and newly emerging weeds are all examples of invasive species. Blue-green algae, in particular Microsystis spp., frequently cause severe fish mortality in nutrient-rich fish ponds. Aquatic weeds have caused a decline in fish productivity in several ponds, lakes, and reservoirs throughout Uttar Pradesh. For example, the substantial water hyacinth cover on the lake's water surface virtually reduced the yearly fish production potential of the 300 ha Kitham Lake in Agra. As a result of aquatic weeds including Hydrilla, Potamogeton, Vallisneria, Nelumbo, Nymphaea, Typha, Saccharum, and Brachiaria species, fishing ponds in the Tarai region of Uttar Pradesh and Uttarakhand, which includes Pilibheet, Barielly, Rampur, Udhamsing Nagar, Nanital, etc., were also affected.

- **Effect of Aquatic Weeds on Environment:** Aquatic weeds create the ideal environment for mosquito development. Mosquitoes that spread diseases including malaria, yellow fever, river blindness, and encephalitis find refuge and safety in the aquatic weed's roots and leafy growth. By finding refuge and food in the root zones, snails can proliferate and have a profound impact on the life cycles of parasitic worms like liver and blood flukes. Schistosomiasis and fuscioliasis spread as a result of the floating weed carrying the snails to other locations. Locals who reside close by worry about mosquito problems.

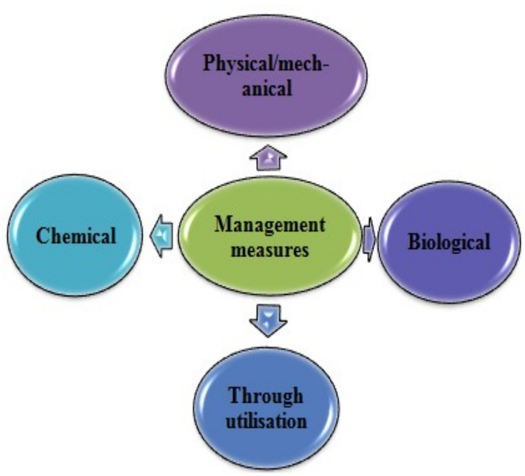
The presence of aquatic weeds that are both floating and submerged has a significant impact on fish output. When weed growth is sparse and covers the entire water body, it can be fatal for fish growth. However, isolated weed beds may be tolerated because they offer fish refuge and shade. Fish can die from oxygen deprivation and suffocate. Numerous fish species fall extinct when aquatic weeds that are both floating and submerged become so abundant. For instance, the production of fish in Punjab's Harike Lake is declining, which is of concern to all.

Huge volumes of biological matter decomposing leads to conditions where carbon dioxide and carbon monoxide are created and discharged into the environment. Compared to other vegetation on land, the duration of degradation is significantly shorter. The process of decomposition releases unpleasant odours that are bad for public health. In these conditions, parasites like mosquitoes thrive and threaten the lives of nearby residents.

Aquatic weed growth has a negative impact on water bodies that are used for enjoyment and aesthetic purposes. They interfere with other water activities as well as boat movement. Silica and other insoluble salts are produced during the decomposition of weed material and settle to the bottom of the water body. In rivers, canals, and drainage ditches, dense weed growth slows water flow, allowing silt to settle out and be deposited on the water body's bed. The longevity of lakes, dams, tanks, etc. is ultimately impacted by this rise in silt deposition, which necessitates additional spending for frequent desilting through dredging.

Aquatic weeds have an effect on water quality as well. Because of their high organic loading and disagreeable flavours and aromas, these weeds require more biological oxygen. They increase the water's organic matter content when used as curing and mixing water, which might have an effect on how long concrete constructions last. Because of how organic material reacts with cement, weakening the connection and potentially trapping a lot of air in concrete, this is the case. Aquatic weeds prevent water from flowing freely, which can increase seepage and raise water tables in the area. It might cause water logging. Because of this, the soil could become salty or acidic, which will also promote the growth of many other land weeds.

Submerged and floating weeds spread quickly. Eichhornia crassipes, one of these species, demands special consideration. From a couple, these plants can multiply by up to 4,000 in a single season. A canal or drain surface can typically be covered and choked by just a few sprouting or introduced plants in a single growing season. The floating weeds tangle together to form thick mats that travel downstream. These moving carpets frequently pack up against bridges and other buildings, putting a tonne of strain on them that can occasionally seriously damage them. Near Taran-Taaran in India, Kasur Nala served as an example of this kind of devastation. Over time if left unchecked the weed mats become so dense that people and animals can walk on them, although at the risk of injury or drowning.



IV. MANAGEMENT MEASURES TO CONTROL AQUATIC WEEDS

1. **Physical/Mechanical Method:** Aquatic weeds like water hyacinth can be removed by machines like JCB (Abhishek, 2020). In comparison to other strategies, this one requires more time and effort (Hill et al. 2017). As reported by (Thomaz et al. 2006) change in the level of water and nutritional composition in the water body may have an impact on the growth of floating and submerged aquatic weeds. As reported by (Cilliers et al. 2003) installing barriers like booms and cables in the water channels, manually removing weeds with rakes and fine-mesh nets, and mechanically removing weeds with tractors and excavators are some of the main human and mechanical techniques used to manage aquatic weeds. Modern technology has led to the development of equipment with simple handling, such as autonomous rotary-wing unmanned air vehicles (Goktogan et al. 2010). Aquatic weeds like *Hydrilla verticillata* and *Egeria spp.* that are submerged and floating should be removed manually and mechanically can result in canopy fragmentation, which will spread later and boost weed population (Dayan et al. 2005). For canals and huge reservoirs, various kinds of aquatic weed cutters and harvesters have been created. In fish ponds, using these devices is not viable. Early physical weed removal using rake or sieving can solve some weed issues. (Marley et al. 2017). There are several techniques like netting, barriers, chaining and water weed cutters to control weeds in aquatic situations. At the Central Institute of Fisheries Technology (CIFT), a portable mechanical gadget was developed which can clear both floating and submerged weeds at the rate of 1-1.5 ha area per day. Harvested weeds can be utilised as feed, manure, energy source etc. (Sushilkumar et al. 2009).

2. **Biological Method:** As a biological control method herbivorous fishes *Osphronemus gorannmi*, *Ctenopharyngodon idella* (Grass carp), *Puntius javonicus* (Tawes), *Tilapia mossambica*, and *Chanos chanos* (Milk fish) have been used for the controlling of aquatic weeds. It has been discovered that some birds can reduce water weeds. Swans and ducks, for instance, eat algae like wolffia, lemna, and marginal grasses (Abhishek, 2020). Natural biological regulatory agents cannot be found in the current habitats since aquatic weeds make up 99% of the ecosystem's arrivals. (Lovell et al. 2006). Sousa et al. 2011 suggested in their report that proper controlling agents should be selected for certain weeds by considering their negative impacts on ecosystem. In some places, this strategy is thought to be insufficient and too slow to yield immediate results (Coetzee et al. 2007). For Echinochloa polystachya and Paspalum repens, fungi such as Fusarium spp., *Cercospora pistiae*, Phaeoramularia spp., and Phoma spp., insect species such as Agasicles hygrophila and *Vogtia malloi,* and Bagous species are used (Dissanayaka et al. 2023).

   Grass carp can be used to successfully and cheaply reduce pond weeds. The weeds filamentous algae and duckweed, which have delicate, succulent foliage, are effectively controlled by grass carp, but waterlily and cattail, which have hard, woody flora, are not. The use of grass carp is governed by numerous state legislation. To learn more about the laws governing the usage of grass carp in your state, speak with a representative of the Department of Natural Resources (Marley et al. 2017). Certain aquatic weeds can be controlled in streams with various uses using a long-term, ecologically safe, and economically viable technique called biological management. The most effective control for aquatic invasive weeds that occupy sizable portions of water bodies in monotypic stands is biological. How frequently biological weed-control chemicals have been released has been quantified (Julien, 1989). According to his research, when 13 chemicals for traditional weed management were released in the first decade of the 20th century, the number of releases per decade increased practically exponentially. From 29% of all releases up until 1980 to 25% of all releases up until 1985, the efficacy rate decreased (Sushil kumar et al. 2009).

- **Use of Insects:** The world's most prominent aquatic weed is still the water hyacinth (*Eichhornia crassipes).* It is a big problem in South-East Asia and the Indian Subcontinent, and it is rapidly getting worse in Africa and Papua New Guinea. Successful biological control can significantly reduce this weed cover in 3 to 10 years after the installation of an agent, and it has generated remarkable control in a number of countries. In 1984, research into the usage of the curculionid Neochetina bruchi for water hyacinth control was conducted in Karnataka (Sanyal and Tanmay, 2017).

- **Use of Snails:** For the control of aquatic weed *Anachaares alensa* Snails (*Pomade canaliculata Lamer)* was used in Brazil and Marisa cornuarietis in Florida.Aquatic weeds like *Potamogeton illinoensis*, *Najas guadalupesis*, and *Ceratophyllum demersum* have also been successfully managed. The snail's root-trimming activity greatly slowed down the growth and flowering of *Eichhornia crassipes*, but only somewhat so for *Alternanthera philoxeroides* and *Pistia stratoites*. It was once believed that the water plant-eating snail Marisa cornuarietis could reduce weeds. However, its usefulness was constrained by its ability to devour early rice seedlings and poor tolerance for water temperatures below 10°C. However, if it has the ability to destroy the bilharzia snail vector's breeding grounds, it could be introduced in areas where rice isn't the primary crop. Another option for weed control is a South American snail called *Pomacea australis*. (Sanyal and Tanmay, 2017).

3. Chemical Methods

- **Chemical Control of Floating Weeds**
  - Paraquat @ 0.02 a/hac. (*Pistia, Lemna).*
  - Kerosene and Diesel @ 775-1100lit/hac. (*Pistoia, Lemma).*
  - 2,4-D @ 4.5-6.5kg/hac. (Water hyacinth).

- **Chemical Control of Marginal Weeds**
  - Copper sulphate with mud on the bottom soil @ 175kg/ hac. (*Nymphaea)*.
  - 2,4-D @ 5.0kg/hac, 2,2-dichloropropionic sodium @ 10- 12kg/hac, Amatol @ 8.0kg/hac. (*Typha, Colocation, Grasses)*.

- **Chemical Control of Emergent Weeds**
  - 2,4-D @ 1.5kg/hac. (Water lilies, Lotus).

- **Chemical Control of Submerged Weeds**
  - Copper sulphate or Copper sulphate with ammonium sulphate @ 50-300ppm.
  - Sodium arsenite @ 5-6ppm.
  - Ammonia @ 18ppm. (*Hydrilla, Najas, Vallisneria)*. (Abhishek, 2020)

By selecting the appropriate herbicides for aquatic weeds and using them at the right time with the proper dose, aquatic weeds can be effectively controlled without harming the ecosystems. These herbicides could include substances that are harmful to aquatic life and terrestrial biological control agents. The toxicity of diquat, glyphosate, and glyphosate trimesium chemicals (which is used for controlling *Eichhornia crassipes*) on aquatic insects such as *Eccritotarsus catarinensis* and Neochetina eichhorniae had been proven by previous literature (Hill et al. 2012, Dissanayaka et al. 2023)**.** The first step in chemical weed management is precise weed identification. Assistance with weed identification is offered through county Extension and Department of Natural Resources offices. Herbicide that is approved for commercial fish ponds may be chosen once the weed has been identified. Before applying an herbicide to a pond, the user must read and completely comprehend the label. Commercial fish pond herbicides are discussed in SRAC-361, Aquatic Weed Management Herbicides. (Marley et al. 2017).

Water hyacinth has been combated using a variety of pesticides, with varied degrees of success. The best herbicide for controlling water hyacinth is 2,4-D (2,4-dichlorophen oxyacetic acid). Patnaik et al.1976 reported that, 0.1 kg/ha of 'Gramoxone' (paraquat) can completely control the smaller floating weeds like Spirodela, Lemina, and Azolla. While Singh (1962) claimed that 2,4-D sodium salt was used to control Nelumbo and Euryale, Srinivasan and Chacko (1952) stated that 2,4-D ethyl ester was used to control Nymphaea. By using copper sulphate pellets, (Mitra and Banerjee 1966) had great success suppressing Nymphaea and Nymphoides. Tap grass (Vallisneria), water plantain (Ottelia), bushy pond weed (Najas), coon tail (Ceratophyllum), bladder wort (Utricularia), Hydrilla, and Nechamandra are the main submerged weeds that infest fish ponds. Sodium arsenate at 46 ppm was discovered to be efficient against Hydrilla and Najas without killing fish by Philipose (1963). As recommended (Mitra, 1977), a localised application of copper sulphate pelleted with mud at the rate of 35 kg/ha was used to control rooted submerged weeds such as Hydrilla, Vallisneria, Najas, and Nechamandra. Spraying with 2,4-D amines and esters at rates between 3.4 and 13.5 kg/ha was successful in controlling a variety of grasses and sedges. To eradicate Typha angustata at the pre-flowering stage, Panchal and Sastry (1976) discovered the use of diuron at a rate of 4 kg/ha coupled with 1 l/ha paraquat, and 2,4-D (sodium salt) at a rate of 8 kg/ha to manage Ipomoea aquatica.

4. Through Utilisation

Control Through Utilization: According to Abhishek (2020) Aquatic weeds are having economic value and they are used for various purposes. As the cost of aquatic weed removal by manual, mechanical and chemical methods is high and this cost can be reduced by using the weeds for the following purposes

- Manufacture of paper
- Leaf protein.
- Feed for animals/fishes/birds
- Fertilizer

Fu et al. (2020) reported that because of the presence of allopathic traits in aquatic weeds and having high potentiality as biofertiliser in aquatic weeds have an impact on the socioeconomic livelihood in many parts of the world. Tate et al. (1988) reported that aquatic weeds can be used as mulching material for supplying plant nutrients and organic matter, retaining soil moisture, and increasing soil microbial population. Similarly, Nawaj et al. (2021) reported that mulching material is readily being utilised to produce low-cost bags, paper plates, paper boards, and decorative paper thanks to its increased cellulose, hemicellulose, and low lignin content. Because of the presence of high nutritional value, particularly due to its favourable amino acids and increased protein content, Azolla spp. is regarded as a feed supplement for livestock, poultry, and aquaculture cultivation (Brouwer et al. 2018, Das et al. 2018). Aimvijarn et al. (2018) reported that because of the Free radical scavenging pigments in *Nymphaea pubescens* extract by having a medicinal value, so that it is used for the treatment melanoma skin cancers. Jafari et al. (2010) reported that *Eichhornia crassipes* being an ornamental plant also known as phytoremediation plant which is a source of biomass energy, a source of raw materials for animal feed, construction, handicraft, paper, and board making. Wasagu, at al. (2014) reported that *Pistia stratiotes* oil extract is an excellent medicine, especially for worm infections, asthma, and skin disease, while leaves and roots are excellent sources of antioxidants. Chen et al. (2019) reported that, every part of *Nelumbo nucifera*, including leaves, rhizomes, seeds, and flowers, have been utilised for the human diet, Ayurvedic medicine, pharmaceuticals, and also landscaping. Due to scarce resources, controlling aquatic weeds is especially challenging in underdeveloped nations like Sri Lanka. As a result, several water weed species have multiplied at an alarming rate, disrupting Sri Lanka's agriculture and natural environment. The goal of this project is to assess the possibility of using aquatic weeds as a starting point for the creation of compost in order to meet the demands of sustainable plant nutrient management in the local environment. This will increase the efficiency of aquatic weed management at the level of agriculture and ecosystems. (Dissanayaka et al. 2023).

V. THE ROLES OF AQUATIC PLANTS IN PHYTOREMEDIATION OF WASTEWATER

Aquatic plants are essential in biological wastewater treatment systems because they can be used for phytoremediation through rhizofiltration, phytoextraction, phytovolatilization, phytodegradation or phytotransformation techniques. The eradication of pollutants depends upon duration of exposure, concentration of pollutants, environmental factors (pH, temperature) and plant characteristics (species, root system etc.) (Irshad et al. 2013). However, it is worthy to note that different species of aquatic plants have been utilized in the phytoremediation process of wastewater with notable successes (Richard et al. 2002).

VI. CONCLUSION

Indigenous aquatic plants are necessary as they are part of ecosystem, even though the invasive species are causing a threat to environment and preventing the people from using the water ways which are affected by them. Majority of the aquatic weeds were introduced purposefully into the local water bodies. Aquatic weeds can be controlled using a variety of methods, including cultural, mechanical, biological, and chemical control, if it has been identified that a pond is affected with aquatic weeds. Owners of the ponds should first identify the invasive species to prevent harm to the local fish and plants. Then, they should select a product that is labelled for both the circumstance and that plant. One of the most frequent threats to the world's economy, ecology, and environment is the impact that invasive aquatic weeds have on aquatic ecosystems. Because of their rapid development and wide range of adaptation mechanisms, the bulk of water bodies are challenging to utilise and maintain. Composting is one of the most sustainable and eco-friendly techniques to use nutrients from aquatic weeds in crop cultivation. Because of their short life cycles, high biomass yield, higher plant nutrient levels, tendencies of allopathy, and phytoremediation skills all support their suitability as composting materials. After examining the ecology and physical traits of a few aquatic weeds, it is possible to improve the majority of aquatic ecosystems while protecting them from soil and water contamination by employing the proper composting procedures and parameters.

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