



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 6, June 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512



9940 572 462



6381 907 438



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Treatment of Lake Water Using Submerged Aquatic Plants

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Abstract: Increasing urbanization, industrialization and over population are the factors mainly responsible for adding hazardous components in water, which mainly constitutes heavy metals and chemicals etc. Water bodies are the main targets for disposing the pollutants directly or indirectly. This is a review paper illustrating the role of plants to assist the treatment of Lake (wastewater). The prevailing purification technologies used to remove the contaminants are too costly and sometimes non-eco friendly also. Therefore, the research is oriented towards low cost and eco-friendly technology for waste water purification, which will be beneficial for community. The paper discusses the potential of different process and utilization of terrestrial and aquatic plants (Hydrilla) in purifying water and wastewater from different sources.

KEYWORDS: Wastewater, Submerged, Treatment, Phytoremediation, Water pollution, Heavy metals.

I. INTRODUCTION

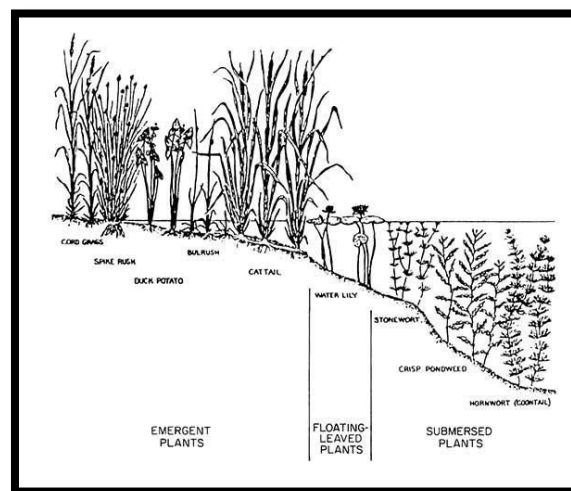
Earth is covered by almost 70% water. Fresh-water content of this total available water of the earth is only 3% which comprises of icecaps, glaciers, groundwater and surface water. Only 0.3% of this surface water is available for human use like agriculture, household and drinking, industry, etc. in the form of lakes, swamps and rivers. Modern technology, global industrialization and unhygienic lifestyle have lead to a serious problem of pollution in freshwater resources like lakes, rivers and swamps. Industrial effluents contribute to the inorganic pollution due to addition of waste chemicals. Anthropological influences like domestic liquid discharge, agricultural wastes, organic industrial wastes, etc. provides adequate nutrients in dissolved state for growth of pathogenic bacteria, and algae and also which interferes in beneficiary use of these natural supplies of freshwater. Rivers, lakes and other freshwater bodies encounter a serious environmental problem of eutrophication due to excess deposition of phosphorus deduced from various human activities. Pharmaceutical industry effluents add up to the existing contamination of freshwater bodies which can cause acute water pollution and other environmental hazards.

Aquatic plants have been used to recover and recycle these waste waters and use them for agricultural and industrial purpose if not for household and domestic use. Low cost, easy maintenance and the ability to assimilate nutrients and sediment the inorganic chemicals makes the aquatic plant system a promising domestic prospect for waste water management. Though there are ponds built with aquatic plant system for treatment of municipal and industrial waste water, the main challenge lies in availability of large lands, authenticity of removal of pathogenic bacteria by the aquatic plants and the choice of aquatic plants. Water hyacinth and dry hyacinth are already used for this purpose in the tropical areas. Macrophytes plays prominent role in recycling or removal of heavy metal contaminants and microbes. Surface floating plants uptake heavy metal through their roots whereas leaves as well as roots of submerged plants participate in this phenomenon. The emergent plants or macrophytes influence metal storage indirectly by modifying the substratum through oxygenation, buffering pH and adding organic matter. It has been reported earlier that almost 78% to 91% removal of BOD, reduction of nitrogen from 30.8 to 9.8 mg/l and phosphate from 14.9 to 9.6 mg/l were observed using emergent macrophytes *Typhalatiofolia* and *Phragmites*. It is reported that *Hydrilla* sp. has better removal efficiency when compared to *Salvinia* sp. and is an excellent biosorbent for treating waste water contaminated with low concentration of cadmium. There are many other potential aquatic plants which can be used in this respect

but lack of investigation and reports in their support have not allowed doing so. Hydrilla is a perennial submerged plant that has been used as an animal feed, decorate aquariums and has been reported as an efficient agent for removal of dissolved nitrogen and phosphorus.

Aquatic plant system has been accounted as one of the processes for wastewater recovery and recycling. The main purposes of using this system have focused on waste stabilization and nutrient removal. The principal removal mechanisms are physical sedimentation and bacterial metabolic activity as in the conventional activated sludge and trickling filter (USEPA, 1991). Plant assimilation of nutrients and its subsequent harvesting are another mechanism for pollutant removal. Low cost and easy maintenance make the aquatic plant system attractive to use. Thus, constructed ponds with aquatic plants are increasingly applied as a viable treatment for municipal wastewater. However, there are some constraints with using aquatic plants such as the requirement for large area of land, the reliability for pathogen destruction, and the types and end-uses of aquatic plants. Submerged Aquatic Plants are oxygenating plants. Plants like hydrilla increase the oxygen content of water and remove carbon dioxide from it. Plants also give enough oxygen for aquatic animals. This leaves have no pores and stomata that's why these plants absorb more carbon dioxide from water and in simple word it will create the process of Rhizofiltration. We all know so many toxic metals and other components are present in lake water so due to the process of Rhizofiltration, this plants easily remove toxic metals and unwanted components from water. We also know about it many peoples are washing their clothes, vehicles, buffalos, cows, etc and so many peoples are bath in lakes and because of bad human activities like release wastewater into lake, release industrial waste water etc. such activities dirt the lake water. So by using submerged aquatic plants we want to remove toxic substances from water and we will try to make water fresh for use.

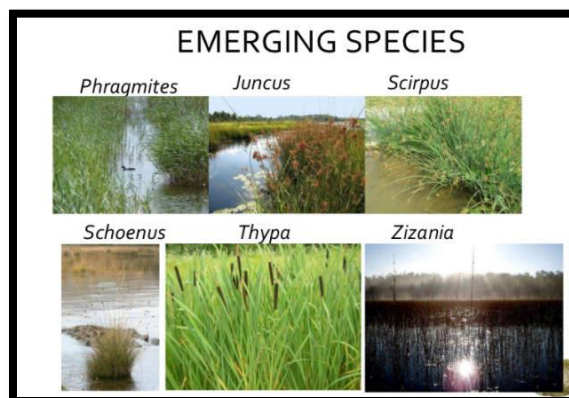
Types of Aquatic Plants-



(Fig.1: Diagram showing emerging, floating and submerged Aquatic plants)

1. Emerging plants:

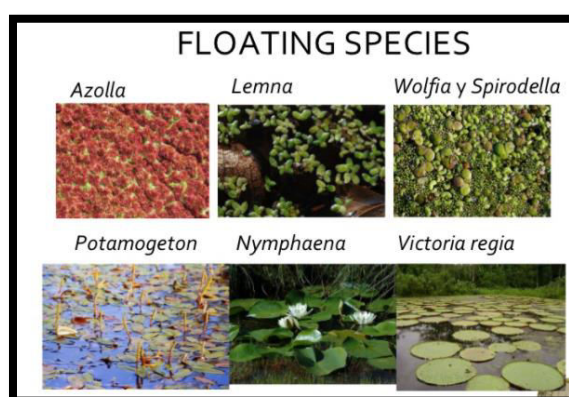
Those whose roots grow in wetland soil, but their stem and leaves emerge over water surface making photosynthesis, flowering, fructification and seed spreading in open air.



(Fig.2: Emerging Species)

2. Floating plants:

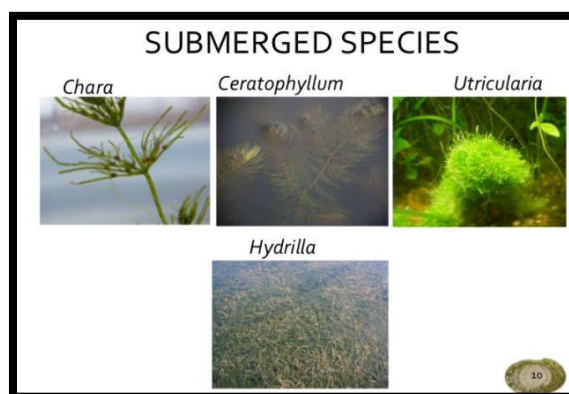
Those floating over water surface whose roots don't reach wetland bottom e.g duckweeds (Lemna, Wolffia, Spatodella, etc.), fern (Azolla sp.), water Hyacinth (Eichhornia crassipes), water Lilly (Victoria regia) etc.



(Fig.3: Floating Species)

3. Submerged plants:

Plants whose stems and leaves grow submerged in water and their roots are anchored in soil beneath water. This type of plants are commonly used in fishbowls.



(Fig.4: Submerged Species)

II. COMMON SUBMERGED AQUATIC PLANTS

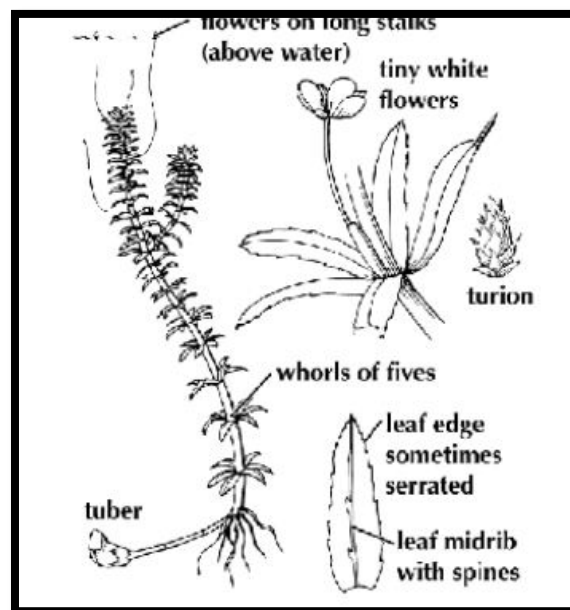
Muskgrass (*Chara spp.*) is actually a form of erect algae. It is a great plant for ponds with excessive nutrients because it uses up a large amount of nutrients and provides food and hiding for fish and other organisms. It can look like several other aquatic plants, but a way to tell it apart is to break the thin straw-like stem. Since it is a single celled stem, if you break it, the entire stem will turn flaccid. Other plants will just break or bend, not turn flaccid. Also has a strong garlic smell to it. As with many plants, it is good in moderation. The pond above is a bit over grown.

Pondweed (*Potamogeton*) is a thin leafed aquatic plant that is native to many areas. This plant can serve as a food source and hiding place for organisms in your pond and produce oxygen. Since it is native, it is not as invasive as non native plants, but it must be kept in moderation. This picture is of young pondweed before it puts out its surface leaves. Some consider pondweed as a floating plant due to these surface leaves.

Eurasian Watermilfoil (*Myriophyllum spicatum*) is not native to the US and is an extremely invasive species. There are strict regulations for boats in lakes that contain eurasian watermilfoil because small pieces that break off can stick to boats and trailers and then re-root in other bodies of water. The leaves are feather-like and are limp when out of water. The leaves are arranged in circles of 3 to 5 around a long, spaghetti stem. The plants can grow over 10' tall. The tops of the stems often are reddish in color.

Bladderwort (*Utricularia purpurea*) is an aquatic plant that can live in ponds with limited nutrients available. It is actually a carnivorous plant. It can look like an unorganized mess in your pond, but it eventually comes together to form the "starfish" shape and then shoots up the yellow flowers. Black bladders hang below that open and catch small organisms like zooplankton. Bladderwort can be a pain if it takes over your pond and since it isn't as dependent on nutrients in the pond, it can spread rapidly.

Hydrilla (*Hydrilla verticillata*) is an undesirable aquatic plant with long, branching stems. Hydrilla often fragments and form large floating mats. It produces tiny white flowers in early fall. It can be differentiated from Elodea or Egeria with its sharp toothed leaf margins. Hydrilla feels brittle to the touch. Hydrilla can grow in shallow or deep water and can quickly spread throughout a body of water. – photo courtesy of The Lake Doctors, Inc.



(Fig.5: Hydrilla Submerged Aquatic Plants)

Common Waterweed (*Egeria densa*) is branched and has a long, narrow stem with dense leaves found in whorls of 4. The leaves can be oblong or linear and are very fine toothed. It produces flowers that are white with yellow anthers. As



with many aquatic weeds, it needs to be controlled to prevent overtaking your pond. – photo courtesy of The Lake Doctors, Inc.

Elodea (*Elodea canadensis*) is commonly confused for hydrilla or egeria, but is much smaller in size. The leaves are bright green, in whorls of 3, and elliptic to oblong. Small white flowers are produced from mid summer to fall. Needs to be kept in check to limit spreading. – photo courtesy of The Lake Doctors, Inc.

Coontail (*Ceratophyllum demersum*) is a submersed aquatic plant, but does not have any root structure. The feathery, fan shaped leaves are arranged in whorls with small teeth and resembles a raccoon tail. Coontail can grow very tall (15') and occur in deep water areas. Controlling the spread of coontail can be difficult since it is free floating. – photo courtesy of The Lake Doctors, Inc.

Wetlands:

The importance of wetlands has changed over time. Wetlands serve as transition zones between aquatic and terrestrial environments and provide a dynamic link between the two. Moving along a gradient, water picks up chemicals and sediments which, as they move through the wetland, are transformed and transported to the surrounding landscape.

Wetlands are effective nutrient sinks and absorbers of organic and inorganic pollutants. This absorptive capacity of a natural wetland is the mechanism employed in a constructed wetland for the purpose of treating wastewater from businesses and municipalities.

The biotechnological solution to wastewater involves installing artificial wetlands to act as natural filters. By locating constructed wetlands between the wastewater source and aquatic resources (rivers, lakes, lagoons), these systems require no maintenance, consume no electricity, and cost less than one quarter that of a traditional waste treatment system. Such constructed wetlands employ different species of plants that commonly abound in natural wetlands: cattails, waterlilies and rushes.

III. PROBLEMS OF AQUATIC WEEDS IN INDIA

Out of about 160 aquatic weeds, the following are of primary concern to India: (1) *Eichhornia crassipes* (2) *Salvinia molesta* (3) *Nymphaea stellata* (4) *Nelumbo nucifera* (5) *Hydrilla verticillata* (6) *Vallisneria spiralis* (7) *Typha angustata* (8) *Chara* spp. (9) *Nitella* spp. (10) *Ipomoea* spp. Among these, *Eichhornia crassipes*, *Salvinia molesta*, *Hydrilla verticillata*, *Alternanthera philoxeroides* and *Pistia stratiotes* are five primary aquatic weeds of the world and qualify the status of worst weeds in India too. It is, however, estimated that 20-25% of the total utilisable water in India is currently infested with water hyacinth (*Eichhornia crassipes*), while in the state of Assam, West Bengal, Orissa and Bihar, it was 40% (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).

(a) Aquatic weed problems in lakes and reservoirs Aquatic weeds may cause following problems: impair commercial navigation; degrade and deteriorate water quality; disrupt hydropower generation; increase flood frequency, duration and intensity; reduce species diversity; increase extinction rate of rare, threatened and endangered species; habitat for insect-borne disease vectors; alter animal community interactions; recreational navigation impairment; interfere with safe swimming; change sediment chemistry; interfere with fishing; reduce water storage capacity in reservoirs, tanks, ponds; impede flow and amount of water in canals and drainage systems; reduce fish production, interfere with navigation and aesthetic value; promote habitat for mosquitoes. Malhotra and Ahmed (1996) has categorized aquatic weeds as a growing ecological menace. Thirunavukkarasu and Kayarkanni (1996) discussed the environmental impacts of aquatic weeds in India. The famous Kollerulake in the West Godavari has succumbed to invasion of *E. crassipes*, *Ipomoea* aquatic, *Typha*, *Vallisneria*, *Nymphaea* and *Ulothrix* spp.

In Punjab, floating, emerged and submerged aquatic weeds are major problem in many, reservoirs and wet lands. In Punjab, three wetlands namely Harike, Kanjli, Kehhopur-Mianilake and MandBharthala in Roper have been threatened by aquatic weeds like water hyacinth, *Potamogeton pectinatus*, *Hydrilla verticillata* etc. (Ladhar 1996). *Typha* spp. (Kumar and Singh 1996d) and water hyacinth have been a big problem in reservoirs and ponds of Punjab (Sharma and Chandi 1996).



In Gorakhpur (Uttar Pradesh), about 22 sq km Ramgarh lake was filled with dense growth of Hydrilla, Najas, Potamogeton, Ceratophyllum and Chara spp. Of these, Hydrilla and Najas spp. infest the lake round the year while others invade it seasonally. The Gujar lake (110 ha) in Varanasi (Uttar Pradesh) has been invaded by aquatic weeds.

In West Bengal, *E. crassipes* is the foremost aquatic weed. In the southern part of West Bengal, Typha is a noxious weed. Aquatic weeds have played havoc in West Bengal in fishery waters, potable waters and in lowland paddy fields. In Palta and Baranagar water bodies, Eichhornia and Lemna spp., along with some molluscs, blocked the water pipes.

(b) Aquatic weeds problems in fish ponds and lakes of India Most of the freshwater fishes rely on aquatic plants at some point during their lives and prefer specific habitats based on their growth stage. Young fish use aquatic vegetation as a food source, both by directly consuming plants and by foraging for the microfauna associated with the plants, and as cover to hide from predators. Mature fish moves to more open waters to increase foraging success and consume other fish to supplement their diets. Nesting, growth and foraging success of plant-loving fish are influenced by plant composition and density. Of the 8 lakh ha of freshwater available in India for pisciculture, about 40% is rendered unsuitable for fish production because of invasion by aquatic weeds. Most of the fishery tanks and ponds in and around Bangalore and other cities have been badly invaded by water hyacinth. Some of the weeds like Eichhornia, Azolla, Nymphaea, Nelumbo, Nymphoides, Hydrilla, Vallisneria, Potamogeton, Najas, Ceratophyllum, Typha and Utricularia spp. are problematic weeds in fishery lakes and tanks of Andhra Pradesh, Assam, Haryana, Himachal Pradesh, Jammu & Kashmir, Maharashtra, Tamil Nadu and Uttar Pradesh in India. Some of the well-known fishery lakes like Barwar, Ramgarh and Gujjar lake in Uttar Pradesh, Ansupa lake in Orissa, Ootucmund lake in Tamil Nadu, Kollern lake in Andhra Pradesh, Loktak lake in Manipur and the world famous Dal, Nigeen and Walur lakes in Jammu & Kashmir have been largely invaded by the aquatic weeds. Large number of water bodies, both natural and man made in Assam are infested with aquatic macrophytes, making them unfit for fish culture and other economic uses.

IV. PROPOSED METHODOLOGY

WASTEWATER TREATMENT WITH AQUATIC PLANTS:

Treatment systems using aquatic plants consist of shallow reservoirs containing floating or submerged aquatic plants. The best studied wastewater systems are those utilizing duckweed (*Lemna minor*). Generally, treatment systems break into two types based on the dominant plant types. The first type uses floating plants which are distinguished by their ability to meet their need for carbon dioxide and oxygen directly from the atmosphere. Such plants derive their mineral needs from the water.

The second type of treatment system consists of submerged plants, which are distinguished by their ability to absorb oxygen, carbon dioxide, and minerals directly from the water column. Submerged plants are easily inhibited by high turbidity because their photosynthetic parts are under water.

Treatment using Submerged plants:

Whole plant body growing entirely below and up to the water's surface. Flowers or inflorescence generally extend above the water. These plants produce dissolved oxygen via photosynthesis. They are really adapted to deep-water zones. *Azolla Carolinian* is a species of *Azolla*. It is a freshwater aquatic fern, with scale-like frond 5 to 10 mm long with green to reddish colour. It is common in many parts of the world especially in tropical environment like North America. It is capable of fixing nitrogen from the air by means of symbiotic cyanobacteria which make it grows successfully in aquatic environments having or lacking of nitrogen. Perhaps, it also may be a good mechanism to help *Azolla* increase rapidly in polluted water. Research found that *Azolla Carolinian* could remove lead and cadmium from wastewater up to 90% and 22%, respectively. *Azolla Pinnata* is known as feathered mosquito fern or water velvet. It grows in slow motion water bodies as swift currents and waves might destroy the plant. The frond has varieties of colours like, green, blue green and dark red and a round shape. *Azolla Pinnata* like other *Azolla* species removed 70-94% of cadmium and mercury from industrial effluent and the concentration of both heavy metals ranged between 310 to 740 mg Kg⁻¹ dry weight²⁴. *Azolla Filiculoides* is another common species of *Azolla* in Western Europe, eastern, central and southern Africa, tropical Asia, North America, Australia and New Zealand. It is a small, green to reddish-brown with 25-35 mm long. The length of individual leaf is around 1—1.5 mm, and it grows sexually through spores. Generally it is a plant of slow moving water like ponds and lakes. *Hydrilla verticillata* is a leafy-stemmed submerged



belong to the Hydrilla's family which is native to the warmer areas of Asia. It has received lots of worldwide recognition as one of the most noxious weeds among submerged plants species²⁶. It is rapid growth and very it is very efficient at reproducing itself via fragmentation, subterranean turions, axillary turions, seeds, stolons, and rhizomes. It is easy adaptable to adverse conditions such as low light intensity, high conductivity waters. The potential of Hydrillaverticillata with another submerged aquatic species have assessed to remediate a few metals (Arsenic, Alumnium and Zinc) through exposition to mine waste for two weeks under hydroponic conditions. Results from the present study suggested that Hydrillaverticillata could be used as a good accumulator to accumulate arsenic and zinc (92.5%, 93.7%), respectively. Excess amount of nutrients like phosphorus and nitrogen cause several problems for some ecosystems such as lakes and ponds as well as other aquatic organisms. Eutrophication is an ecological trouble that causes water as a result of excess nutrients that provoke excessive growth of other aquatic plants. Hydrillaverticillata was conducted in an ex-situ experiment as a bio filter to improve the quality of lake water. Results indicated that Hydrillaverticillata can be used a better bio filter for phosphorus. In addition, a great decreasing in some physical and chemical parameters such as total suspended solid (TSS, 60%), biological oxygen demand (BOD, 37.5%), chemical oxygen demand (COD, 37.5%), nitrate (33.41%) and phosphorus (46.01).

V. CONCLUSION

- Aquatic plants have different route to uptake heavy metals, for instance in the case of free floating and emergent plants, is through the roots, however, the upper inside of plants might able to remove metals, but there is no enough data, which needs to study further in the future. Whereas in submerged both roots and leaves take part in removing heavy metals and nutrients. These bunches of aquatic plants could be applied as an effective, economical and ecological alternative to accelerate the removal and degradation of agro-industrial wastewater polluted with metals, nutrients and other common pollutants.
- Above results indicated that submerged aquatic plant HydrillaverticillataCasp had an efficient applicability to reduce significant amount of nutrients from domestic wastewater. The method proved to be a cheap, low cost, eco-friendly and pollution free techniques for wastewater treatment.

ACKNOWLEDGMENTS

The authors are grateful to the PRIYADARSHINI J.L COLLEGE OF ENGINEERING for providing guidances and resources to carry out this work.

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