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A Review on potential of Freshwater macrophytes for Phytoremediation of wastewater

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Abstract

Uncontaminated water is a basic need of every human being apart from food and shelter. Various freshwater bodies and underground water are the main source of clean water. Due to presence of various organic and inorganic pollutants the quality of water is deteriorating gradually. Before discharge into the environment wastewater must be treated properly. The conventional water treatment techniques are high in cost, required continuous power supply and not always effectively remove pollutants. Phytoremediation utilizing aquatic macrophytes is the most desirable method among various strategies developed till date.Phytoremediation is a promising cost-effective green technology for treating different wastewaters by the application of plants. Aquatic macrophytes have the unique ability to absorb excess contaminants present in various wastewater in their body tissue.

Uncontaminated water is a basic need of every human being apart from food and shelter. Various freshwater bodies and underground water are the main source of clean water. Due to presence of various organic and inorganic pollutants the quality of water is deteriorating gradually. Water pollution has become one of the serious ecological issues in the world over the last few years. It is caused by large scale disposal of wastewater into various water sources has been considered to be as one of the major problems of the world. Aquatic ecosystems of freshwater act as a vital source of drinking water for most of the municipal corporations are getting degraded due to discharge of untreated wastewater. Wastewater containing large amount of pollutants concentration is heavily toxic for water ecosystem and human health. Reclamation of wastewater has been the only option left to meet the increasing demand of water in growing industrial and agricultural sectors[2].

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At present, the use of treated wastewater is an extended practice over the world, especially in arid and semiarid nations[22]. Peoples of water scarce countries are looking for alternatives like reuse of water for cultivation, agriculture irrigation, industry, and watering urban green areas. Reuse of wastewater has been considered as a viable option to overcoming water scarcity in many parts of the world. Therefore, discharge of ineffectively treated wastewater to the environment could pose serious environmental and human health issues.

Elimination of noxious pollutants is very much important to curtail the threat to human health and its ecosystem. The proper treatment of wastewater, is a method of environmental management that aims to avoid any water pollutant by reducing the organic load and recovery of nutrients[18]. Conventional wastewater treatment technologies are uneconomical, complicated operational system and time consuming. These treatment technologies require high capital investment and in the end, generate the problem of sludge disposal[2,12]. To overcome these issues one need to opt for alternative technique for treatment of wastewater which should be suitable and sustainable. Among various strategies developed so far the technique of phytoremediation using aquatic macrophytes is most preferable[4] technology to remove pollutants from wastewater. Phytoremediation has been described as an advanced bioremediation method utilizes plants and associated microorganism to clean-up environmental pollutants. The present study illustrates an eco-friendly practice of phytoremediation for elimination of pollutants on a long-term basis. Besides, this review study précises the potential application of freshwater macrophytes in phytoremediation for the treatment of wastewater.

Literature was gathered through online web-based search engines in google and google scholar site using keywords wastewater, aquatic macrophytes, phytoremediation back searches through references. Only the research article published in last 10 years (2011 onwards) on hydrophytes involving in phytoremediation of wastewater were selected for the review. Various articles published in Egyptian Journal of Aquatic Research, Ain Shams Engineering Journal, Sustainability, International Journal of Life Science for Scientific Research, Current World Environment, journal of applied Research in Water and Waste Water, International Journal of Water Resources and Environmental engineering etc. were reviewed for the for the possible uses of aquatic plants for this purpose. The key objective of this review paper is to study current progresses and research in wastewater phytoremediation processes, the limitations, and the potential areas of phytoremediation method that may require further attention was identified. So far, more than 25 aquatic macrophytes were discussed in this paper. The adequate information provided in the article will help researchers on selection of appropriate aquatic macrophytes for phytoremediation studies different wastewater.

Aquatic macrophytes for water and wastewater treatment:

The aquatic macrophytes are low-cost and ingenious clean-up technique for phyto-

remediation of a huge contaminated area. Aquatic macrophytes act as a natural absorber for contaminants and heavy metals. Various kinds of aquatic plants are used to reclaim industrial, textile, municipal, agricultural and domestic effluents, the selection of plant species depends on various factors, including the type of toxins and the amount of pollution. Basically, three types of aquatic macrophytes are used for the treatment of wastewater. The potential of various macrophytes in removal of various heavy metals are summarized in table-1.

Floating Macrophytes :

These aquatic plants are with submerged roots and floating leaves. Free-floating aquatic plants are the most dominant macrophytes in the wetlands. These floating macrophytes are highly suitable to eliminate the contamination from the aquatic ecosystem due to their high productivity, high nutritive value and easy harvesting process. Water hyacinth (*Eichhornia crassipes*), water ferns (*Salvinia minima*), duckweeds (*Lemna minor*, *Spirodela intermedia*), water lettuce

Table-1. The potential of various macrophytes in removal of heavy metals

Macrophyte	Common name	Wastewater type	Metals/ Pollutants	Reference
Alternanthera sp.	Joyweed	Domestic WW	BOD, COD, TSS, Cu, TKN, TP	Mustafa and Hayder. 2021
Ceratophyllum demersum	Hornwort	Fish pond	N, P, As, Cd, Cr, Pb	Abdallah. 2012; Matache *et al.* 2013; El-Khatib *et al.* 2014
Eichhornia crassipes	Water hyacinth	Industrial WW	Pb, Hg, Cu, Cr, Ni, Zn, BOD, COD, Oil & Grease	Saha et al. 2017
Hydrilla verticillata	Hornwort	Secondary domestic wastewater	BOD, COD, TSS, TP, Pb	Patel and Kanungo. 2012; Abu Bakar *et al.* 2013
Ipomeo aquatica	Water spinach	Industrial WW	COD, TDS, Nitrate, NH3-N, Phosphorous, Ni, Pb, Cd	Sa'at and Zaman. 2017; Hanafiah *et al*., 2020.
Lemna minor	Duckweed	Textile, distillery, institutional WW	Chloride, P, N, sulphate, BOD, COD, TDS, Cu, Cd, PbCr, As, Ni	Priyanka Saha *et al*. 2015; Bokhari *et al*. 2016;Amare *et al*. 2018
Mentha aquatica	Water mint	Polluted River water	Pb, Cd, Fecal pathogen	Dahija et al. 2019
Myriophyllum aquaticum	Parrot feathers	River water	(BOT) waste water (Chloride,	Mustafa and Hayder. 2020

Myriophyllum spicatum	Parrot feathers	Polluted rural river water	COD, TN, TP, NH4-NPb, Cd, Fe, Cu	Milojković *et al.* 2016; Saleh *et al.* 2019
Nasturtium officinale	Water cress	Industrial WW	N, BOD, COD,NH4+	Musavi *et al.* 2016
Phragmites australis	Common reed	Iron mine Water	Fe, Cu, Cd, Pb, Zn	Ganjali *et al.* 2014; Ha and Anh. 2017
Pistia stratiotes	Water lettuce	Industrial WW	Cr, Zn, Fe, Mn, Cu, Nitrite	Suggu Sri Gowri Reddy *et al*. 2015; Lu *et al*. 2018
Polygonum hydropiperoides	Smart weed	Fish pond	N, P, Cu, Pb, Zn	Martins *et al.* 2010; Rudin *et al.* 2017
Potamogeton crispus	Pondweed	Industrial	Cu, Fe, Mn, Ni, Zn	Borisova *et al.* 2014
Potamogeton pectinatus	American Pondweed	Industrial	Cd, Cu, Cr, Zn	Ali *et al*. 2020
Salvinia herzogii *Salvinia minima*	Water fern Water spangles	Municipal WW Sewage WW	Cd, Cr TSS, NH3, COD, As, Cd, Cr, Ni,	Ali *et al*. 2020 Aziz *et al*. 2020
Salvinia natans	Water moss	Raw wastewater	BOD, COD, NH4-N	Laabassi and Boudehane. 2019
Scirpus grossus	Bulrush	Industrial WW	Cd, Fe, Al.	Kutty and Al-Mahaqeri 2016
Spartina alterniflflora	Cordgrass	Municipal WW	Cu, Cr, Zn, Ni, Mn, Cd, Pb, As.	Ali et al. 2020
Spirodela intermedia	Duckweed	Industrial WW	Fe, Zn, Mn, Cu, Cr, Pb	Rai. 2019
Typha angustifolia L	Narrowleaf cattail	Textile WW	BOD, COD, color, TDS	Chandanshive *et al*. 2017; Al-Baldawi. 2017
Typha latifolia	Common cattail	Municipal WW	Zn, Mn, Ni, Fe, Pb, Cu	Mustafa and Hayder. 2021
Typha orientalis	Cumbungi	Municipal WW	BOD, Na, TOC, turbidity, nitrate	Oladejo *et al.* 2015; Di *et al*. 2020
Vallisneria spiralis	Tape grass	Dye containing WW	Ar, colour	Giri 2019; Ahila *et al.* 2021
Vetiveria zizanioides	Khus grass	Fish pond wastewater	NH_3, NO_2, NH_4, PO_4	Effendi *et al.* 2020

(*Pistia stratoites*), water cress (*Nasturtium offcinale*) are some of the well-known free-floating hydrophytes for their capability to remove metals from the polluted ecosystem[2].

Submerged Macrophytes :

These hydrophytes are remain completely submerged in water and root in soil, which play a vital role in the water bodies. The entire submerged macrophyte plays a significant and promising role to remove the pollutants from the aquatic ecosystem. Some of the famous submerged plants such as parrot feather (*Myriophyllum spicatum*), coontail or hornwort (*Ceratophyllum demersum*), pondweed (*Potamogeton Crispus*), American pondweed (*Potamogeton pectinatus*), *Mentha Aquatica*, *Vallisneria spiralis* and water mint are well known for their ability to gather Cr, Cd, Cu, Fe, Ni, Hg, Pb and Zn.

Emergent Macrophytes :

They grow in shallow waters where the water table is 0.5 m beneath the Soil. The leaves and stems of these kind of macrophytes are often spread outside the water and the root system is completely under water, fixed to soil or attached to sediments. Emergent macrophytes have an effective capacity to store the nutrients over a long period than floating macrophytes[27]. The well-known emergent macrophytes used for effectively removal of heavy metals like Cd, Fe, Pb, Cr, Zn, Ni, Cu are Cattail (*Typha latifolia*), bulrush (*Scirpus* spp.), common reed (*Phragmites*) and smartweed (*Polygonum hydropiperoides*)[15,25].

Water is a vital natural resource and is essential for the subsistence of all forms of life. The constant contamination of water would cause threat to the existence of living beings. Phytoremediation using aquatic macrophytes is a promising technology applied for the removal of pollutants from aquatic ecosystem. It could be an important technique for the reclamation of wastewater because they are highly capable to absorb and degrade pollutants from polluted water. Phytoremediation techniques not only eliminate the heavy metals abut also removes the organic pollutants like nitrites and phosphates as well form wastewater. Therefore, it regain the quality of polluted water before into the environment. This review reveals numerous features of aquatic macrophytes application in the phytoremediation of various aquatic pollutants. The review also covers the importance of free-floating aquatic macrophytes because of their outstanding hyper accumulator aptitude. *Salvinia molesta* and *Pistia stratiotes* are the two most widely used aquatic macrophytes for the treatment of agricultural, domestic and industrial wastewater. The large application of these plants is due to their obtainability, pliability in a noxious environment, bioaccumulation capacities, invasive mechanism and biomass abilities. On the basis of present review, the benefits of using aquatic macrophytes to removepollutants are vast, because this skill does not only eliminate the contaminants but is low-cost budget friendly,aesthetically pleasing and sustainable tothe environment.

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