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Review Article

ROLE OF AQUATIC PLANTS IN IMPROVING WATER QUALITY

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ABSTRACT

Water is among the greatest resources that support life throughout the globe. Pollution of water by different pollutants like, organic contaminants (pesticides, detergents, antimicrobials, solvents and cleaning fluids, hormones and sterols) and inorganic contaminants (metals, ions excess nutrients, radionuclides) outcome is widespread in environment. Increasing these eco-awareness are gained much attention of researches to extend its energetically in the area of Phytoremediation. It is among the most valuable efforts that have being made towards the sustainability. A successful plant phyto-extractor must to tolerate contaminants, accumulate them to a substation level, and translocate them to green shoot. As a matter of fact, the majority aquatic plants are naturally occurring and easily adapted for their surroundings environment. Aquatic plants have a remarkable capability to remove excessive nutrients load form the water otherwise cause eutrophication of the water body. They have also been used to mitigate heavy metals, toxic organics, suspended solids and bacteria from agricultural outcome, landfill, acid-mine drainage and urban storm water runoff. In addition, the aquatic plants, indirectly helping some materials to sediment and suspend them through slowing the water current and thus affecting metal retention in water bodies. An effort has been made in this review article to shed light and to cover the most studied different aquatic plants (free-floating, submerged and emergent) for enhancing the quality of wastewater.

Keywords: Phytoremediation, Submerged, Emergent, Free Floating Plants.

INTRODUCTION

Contamination of environment by different pollutants arises as a result of increasing urbanization, industrialization, and over population growth as well as ever enhancing demand for clean water for everyone's daily use. Water bodies are the main and the final destination for capturing these pollutants. They receive industrial waste, residential waste, surface runoff etc. and causing serious effects on human, animal and plant organisms. Coagulation, precipitation, ion exchange, reverse osmosis, electrolysis, precipitation and sedimentation are the most usable treatments in practice for sanitation of water and up taking these contaminants[1]. The majorities of these controvental methods in practice consumes huge economic resources, and are producing lots non-eco-friendly wastes as well as highly power consuming.

In the early seventeenth, several researchers carried out series investigations to enhance the quality of water using natural means to overcome this trouble[2-5]. Since then extensive research is being proceed worldwide by numerous investigators to study the performance of many species of aquatic plants in removal, nutrients and metals in different aquatic water bodies. Among different varieties of plant, the concept of using aquatic plants are experimentally acknowledged to mitigate a considerable amount of pollutants like, organic contaminants, metals form aquatic environment through absorption, and/or adsorption to incorporate them directly into their plant tissues[6]. Eventually, they produce great amount of biomass, which can be used for many constructive purpose.

From the ecological point of view, eliminating or decreasing pollutants to the level that cause no side influences on organisms and environments are the priority goals. Classical methods of reducing metals form the wastewater is being to use them with sewage and then proceed for primary, secondary and tertiary treatment. Both secondary and tertiary processes of water treatment need chemicals and energy as well as high input of technology[7,8]. Therefore, These un-environmentally treatment processes are in need of replacement by another purification method. An eco-friendly, positive impact on the environment and cost effective method accepted over classical methods for water purification for natural and artificial wetlands[9]. This review paper showed the potential of common aquatic plants from sub-merged,

emergent and free floating for remediation of pollutants from aquatic eco-system.

Phytoremediation process is taking a major role in dealing with this eco-problem in an environmentally way via spending enormous efforts towards sustainability. Photosynthetic activity and growth rate of plants are the most two factors that have roles in the economic success of phytoremediation[10]. Aquatic macrophytes communities are among the most important ecological components of ponds, lakes and quiescent water. They play a various role in the structure and implementation of theses habitats. For instance, they provide food and shelter for many aquatic organisms (fish and invertebrates), increase dissolved oxygen indirectly via oxygenate the water and limit erosion[11]. They also, acting as reservoirs for nutrients and trace elements[12].

The ability of aquatic plants to remove accumulates and decomposition high amount of metals by roots and green parts is being the target of many phytoaccumulation researches, usually with a view to application in phytoremediation namely, phytoextraction, phytodegradation, rhizo filtration, phyto stabilization, and phytovolatilization[13-15]. Both aquatic plants and organisms are capable of removing different varieties of pollutants such as heavy metals and other contaminants. Generally, aquatic plants are widely distributed in water bodies around of our planet. As it well known, water body well off with nutrients in particular, ponds and lakes by natural process or by human activities such as urban and agricultural effluents which makes the supportive medium for aquatic macrophytes and other aquatic organisms.

Studies have clearly shown that aquatic plants are very much appropriate for the treatment of wastewater as they have incredible capacity of absorbing nutrients and other pollutants from water[16-19]. Furthermore, the main way of up-taking heavy metals in aquatic plants is through the roots and leaves in the case of submerged plants; while in emergent and surface floating plants participate in removing metals and nutrients. Generally, the aquatic macrophytes in eutrophic water bodies can be classified into:

1) **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[20]. *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[21]. Perhaps, it also may be a good mechanism to help *Azolla*to increase rapidly in polluted water. Research found that *Azolla* Carolinian could remove lead and cadmium form wastewater up to 90% and 22%, respectively[22]. *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 verities of colours like, green, blue green and dark reed and a round shape[23]. *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 weight[24]. *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 leave 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[25].

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 species[26]. 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[27-29]. The potential of *Hydrilla verticillata* with another submerged aquatic species have assessed to remediate a few metals (Arsenic, Almnium and Zinc) through exposition to mine waste for two weeks under hydroponic conditions. Results from the present study suggested that *Hydrilla verticillata* could be used as a good accumulator to accumulate arsenic and zinc (92.5%, 93.7%), respectively[30]. Excess amount of nutrients like phosphors 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[31]. Results indicated that *Hydrilla verticillata* 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).

2) Free floating to partly submerged plants: The entire green part (fronds) freely moves above water and flexible enough to resist tearing by wave action, but the root is under the surface water, but not attached to the soil[32]. They reproduce very quickly, in particular in an environment rich in nutrients. Some of them they are totally rootless or have a single root or several roots. *Saliviniacucullata* is a free floating aquatic plants belongs to the *Salviniaceae* family, it handles easily and native to tropical and subtropical region in the world[33]. The nutrient enriched water is one of the most attractive environments for this species to grow easily and rapidly. Also, it spreads via fragmentation. As a result of grows quickly, it produces thick mats, which create obstacles for irrigation and transpiration of other aquatic organisms. However, the roots of *Salviniacucullata* are not very long, but they are very effective in removing metals such as, lead and cadmium parallel to the leaves through bounding them to the root cells and partially transport them to the leaves[34].

Siprodelapolyrrhiza known-as giant duckweed is a free-floating aquatic plant belonging to the family *Lemnaceae*, which find around the world on the surface of fresh and

brackish waters[35]. It is a tiny plant lacks of actual leaves and stems, it consists of an oval leaf like body called a thallus with up to 12 distinct veins. It grows very quickly by asexual budding, and seeds. Due to high protein content, it has being served as a food source for ducks, geese, and some fishes. Form the ecological view; it uses to reduce nutrients from wastewater, which makes among the most standardized test organism in aquatic ecotoxicology[36,37]. A recent study[38] pointed out that *Spirodela Polyrrhiza* could be used in a large scale as a good hyper-accumulator to remove heavy metals from polluted water. They reduced up to 95%, 79%, and 66% Copper and Zinc, respectively, followed by 53% for Chromium, 45% for Mercury, 26% for Cobalt, 20% for manganese and 7% for Nickel. They also were very effective on other physicochemical endpoints like pH, BOD, COD, Nitrate, Phosphate, sulphate, TDS, TSS and Turbidity as they reduced them by 12%, 37%, 49%, 100%, 36%, 16%, 53%, 85% and 52%, respectively. *Eichhorniacrassipes* is a perennial free- floating aquatic plant belonging to the family Pontederiaceae[39]. It consists of long pendant roots, rhizomes, stolons, leaves and fruit clusters. Sometimes might be high up to 1m with around 6 to 10 lily like flowers. It is one of the of the world's worst aquatic weeds which can be found in rivers, dams, lakes and irrigation channels. The plant has been shown to cleaning up municipal and agricultural due to due to its rapid growth and large biogas production in polluted wastewater and the capacity to absorb heavy metals[40-42]. *Eichhorniacrassipes* is capable of reducing BOD, COD and turbidity as the root can fractionate and dissolve organic matter, furthermore, the root hairs have great roles to attract opposite charges of colloidal particles such as suspended solids and cause them to adhere on the roots where they are slowly digested and assimilated by the plant and micro-organisms as they have electrical charges on them[43-46].

3) Floating (stems and leaves): Roots attached at the shoreline. Due to large cover area by these plants they produce a wide shade, they might affect on the temperature of water. They also may have side effects on the rest of other organisms. *Nymphaeaodorata* is a free floating perennial aquatic plants belonging to the family *Nymphaeaceae* and can be found in quiet waters, like ponds and marshes[45]. The plant has continuously growing horizontal stems, called rhizomes, which spread out laterally and produce flowers on top of, and slightly above, the water. Flowers are fragrant and can be white or pink with yellow centers[45]. Both roots and fronds of *Nymphaeaodorata* parallel to other species of aquatic plants were examined over two seasons in mesocosm wetland systems to remediate water from a coal pile runoff basin. Results revealed that *Nymphaeaodorata* could help remediate acidic, metal-contaminated runoff from a coal storage pile, however both roots and shoots concentrations of most elements differed[46].

4) **Emergent woody and herbaceous:** The structures of this group are woody, having strong and resistance tissues, long life and very effective for treating municipal wastewater. Due to have more supportive tissues in terms of size and weight than floating aquatic plants, they may have greater potential to uptake and store nutrients over a long time. Plants from emergent herbaceous, stand upright above water surface, but roots are in the soil. They have full structure (roots, stems and leaves), they also have being used in constructed wetland to treat animal waste[47]. *Typhalatiofolia* is a species belongs to the Typhaceae's family which as about 30 species and common in North America and some places around the world. It is a unisexual plant that grows alongside the freshwater of lakes and rivers. It has long and thin flowers like sausages. On a stick, the brown part "Sausage" contains seed with fluffy part "parachutes". Research showed that *Typhalatifolia* is among the emergent macrophytes that are capable of improving the quality of water through removing up to 71%, 30.8mg/l and14.9mg/l of BOD, Nitrogen, Phosphate, respectively[47].

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.

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