International Journal of Innovative Research in Science and Engineering
Vol. No.3, Issue 01, January 2017
www.ijirse.com
ISSN (O) 2454-9665
ISSN (P) 2454-0663

EFFECTIVENESS OF WATER HYACINTH AND WATER LETTUCE FOR THE TREATMENT OF GREYWATER - A REVIEW

O.S. Nayanathara[1], A. G. Bindu[2]

[1]*P. G. Student, Department of Civil Engineering, Govt. Engineering College Thrissur, India*

[2]*Assistant Professor, Department of Civil Engineering, Govt. Engineering College Thrissur, India*

ABSTRACT

Greywater constitutes around 65% of the total domestic wastewater. Developing a cost-effective technology for the treatment of greywater is needed to meet the future water demand. Phytoremediation has emerged as a powerful and attractive tool for the treatment of wastewater which mainly utilizes plants to detoxify pollutants. Water hyacinth and water lettuce are two obnoxious weeds that can be grown hydroponically. They are capable of removing nutrients from wastewater. The aim of this review is to summarize the effectiveness of water hyacinth and water lettuce for the treatment of greywater.

Keywords: Greywater, Hydroponics, Phytoremediation, Water hyacinth, Water lettuce

I. INTRODUCTION

Water shortage in India will be a key issue for its sustainable development in the future. Conventional groundwater and surface water sources are becoming increasingly vulnerable to industrial and natural pollution. India is facing a water crisis and by 2025 it is estimated that India's population will be suffering from severe water scarcity. International Water Management Institute (IWMI) predicts that by 2025, one in three Indians will live in conditions of absolute water scarcity. Excessive use of natural water resources due to rapid urbanization has necessitated search for alternative sources of water for non-potable purposes. Greywater is one such source of water if properly treated can be utilized for non- potable purposes.

Greywater is all wastewater that is discharged from a house, excluding blackwater (toilet water). Greywater constitutes around 65% of the total domestic wastewater. This includes water from showers, bathtubs, sinks, kitchen, dishwashers, laundry tubs, and washing machines.

Kitchen grey water is high in nutrients and suspended solids. Dishwasher greywater may be very alkaline (due to builders) and show high suspended solids and salt concentrations. Bathroom greywater is regarded as the least contaminated greywater source within a household. It contains soaps, shampoos, toothpaste, and other body care products. Bathroom greywater also contains shaving waste, skin, hair, body-fats, lint, and traces of urine and faeces. Greywater originating from shower and bath may thus be contaminated with pathogenic microorganisms in small concentrations. Laundry greywater contains high concentrations of chemicals from soap powders (such as sodium, phosphorous, surfactants, and nitrogen) as well as bleaches and suspended solids.

ISSN (O) 2454-9665
ISSN (P) 2454-0663

Recycle of greywater will protect aquatic ecosystems by decreasing the diversions of freshwater, reducing the quantity of nutrients and other toxic contaminants entering waterways. It will reduce the need for water control structures. There are some other benefits of using greywater. It reduces the total wastewater treatment cost as it lessens the organic and hydraulic loads of waste water treatment plant. Reclaiming nutrients in greywater improves the soil quality. Greywater application in excess of plant needs is also a good way to recharge groundwater. Highly treated greywater can be reused for aquifer recovery and storage [1].

When properly managed, greywater can be used for the purpose of landscaping, gardening, irrigations, plant growths and toilet flushing [2]

Treatment of greywater can be categorized into three groups: physical, chemical and biological. The physical treatments include coarse sand and soil filtration and membrane filtration, followed mostly by a disinfection step. Very few chemical processes were reported for greywater treatments and reuses. The chemical processes applied for greywater treatments include coagulation, photo-catalytic oxidation, ion exchange and granular activated carbon. Biological methods include Constructed Wetland (CW), Membrane Bioreactors (MBR), Rotating Biological Contactors (RBC), and Sequencing Batch Reactors (SBR) [3].

Biological methods are found to be most effective for the treatment of greywater. But the main problem associated with these methods is their cost. Presence of phosphorous, potassium and nitrogen makes greywater a source of pollution for lakes, rivers and ground water. But these are excellent nutrient sources for vegetation when this particular form of wastewater is made available for irrigation.

Hydroponics exploits this feature of greywater. Here plants are grown in a soilless media to remove pollutants from the environment. They offer advantages like environmental friendliness, cost effectiveness and the possibility of harvesting the plants which can be used for some other purposes. Recently hydroponics has become an increasingly recognized pathway for contaminant removal from water and is an aesthetically pleasing, solar-driven, passive technique useful for remediation of shallow plumes with low to moderate levels of contamination.

Li et al., [3] reviewed the technological aspects for greywater treatment and reuse. The literature review shows that all types of grey water have good biodegradability. The bathroom and the laundry grey water are deficient in both nitrogen and phosphorous. The kitchen greywater has a balanced COD: N: P ratio. The review also reveals that physical processes alone are not sufficient to guarantee an adequate reduction of the organics, nutrients and surfactants. The chemical processes can efficiently remove the suspended solids, organic materials and surfactants in the low strength grey water. The combination of aerobic biological process with physical filtration and disinfection is considered to be the most economical and feasible solution for grey water recycling.

Eichornia crassipes (water hyacinth) and *Pistia stratiotes* (water lettuce) are two obnoxious weeds that can be grown hydroponically. They are suitable for removing excess nutrients present in wastewater. Microorganisms attached to their root surface can oxidise the biodegradable matters present in wastewater.

ISSN (O) 2454-9665
ISSN (P) 2454-0663

II. EICHORNIA CRASSIPES (WATER HYACINTH)

The water hyacinth is an invasive plant that is native of the Amazon and whose capacity for growth and propagation causes major conservation problems. It is a species of great ornamental value used in gardening because of the beauty of its foliage and flowers but is on the (International Union For Conservation Of Nature) IUCN's list of the 100 most dangerous invasive species. Most of the problems associated with *E. crassipes* are due to its rapid growth rate, its ability to successfully compete with other aquatic plants, and its ease of propagation. These characteristics give rise to enormous amounts of biomass that cover the water surface of a great variety of habitats often interfering with the use and management of water resources. It is said that it grows double in 5 to 15 days. Only ten plants in just eight months can produce population of 655,330 individuals [4].

Some of the principal problems are its interference with navigation, water flow, and the recreational use of aquatic systems, as well as the risk it poses of mechanical damage to hydroelectric systems. The impact of *E. crassipes* on the physico-chemical characteristics of the water in general are declines biological oxygen demand (organic load), and nutrient levels. This makes them suitable for the treatment of wastewater. Optimal water pH for growth of this aquatic plant is neutral but it can tolerate pH values from 4 to 10 [4].

Water hyacinth has been seen as an invasive species all over the globe and considerable amount of resources have been spent for their control. However, they have certain qualities which can be utilized to produce biofuels (both bioethanol to power vehicles and motors, biogas to generate electricity) as the plants are low in lignin content and have rapid growth rate [5]. Figure 1.1 shows the image of *E. crassipes.*

Fig 1.1 Water hyacinth

III. PISTIA STRATIOTES (WATER LETTUCE)

Pistia stratiotes, also known as ‘Jal kumbhi’, water cabbage, water lettuce, Nile cabbage, or shellflower is a free floating aquatic plant of streams, lakes and ponds. As a floating weed it forms dense mats on surface of water bodies, disrupting aquatic flora and fauna underneath and thus adversely affects the water ecosystem and hinders water flow, fishing, swimming, boating, water sports and navigation. Lettuce doubles its biomass in just over 5 days; triples it in 10 days, quadruples in 20 days and has its original biomass multiplied by a factor of 9 in less than one month. This evolution indicates that 25 days is the maximum period to allow the plant in the system [4].

However water lettuce is capable to remove nutrients and heavy metals from the sewage sludge and drainage ditches. The physicochemical parameters reduce progressively from the influent to effluent ponds like turbidity, phosphates, total iron, sulfates and suspended solids. Hence it is the most suitable plant for waste phytoremediation in tropical areas.

Water lettuce contain alkaloids, glycosides, flavonoids, and steroids, vitamin A, B and C, proteins, essential amino acids, and minerals. Its leaves are used in traditional medicine for treatment of ringworm, syphilis, skin infections, boils, wounds, fever, tuberculosis and dysentery in many countries of the world. Figure 1.2 shows the image of *Pistia stratiotes*.

Fig 1.2 Water lettuce

IV. MECHANISM OF PURIFICATION IN HYDROPONICS

A hydroponic root mat consists of emergent wetland vegetation growing on a mat or structure floating on the surface of a pond-like water body. The plant stems remain above the water level, while their roots grow down through the buoyant structure and into the water column. In this way, the plants grow in a hydroponic manner, taking their nutrition directly from the water column in the absence of soil. Beneath the floating mat, a hanging network of roots, rhizomes and attached biofilms is formed. This hanging root-biofilm network provides a biologically active surface area for biochemical processes as well as physical processes such as filtering and entrapment. Thus, a general hydroponic root mat design objective is to maximize the contact between the root-biofilm network and the polluted water passing through the system.

The coverage of pond surface provided by the floating mat minimises light penetration into the water column, thereby limiting the potential for algae growth. This will also have an impact on the composition of the biofilm community that develops within the network of roots under the floating mat. With the exception of the edges of the floating mats where there will be some light penetration, biofilms will be composed predominantly of non-photosynthetic bacterial communities. This will have an effect on the physico-chemical conditions that develop in the water column (e.g. dissolved oxygen and pH) and some of biogeochemical processes affecting treatment within the hydroponic root mat (e.g. the role played by algae in nutrient and element cycling). Figure 1.3 shows the schematic diagram of hydroponic root mat [6].

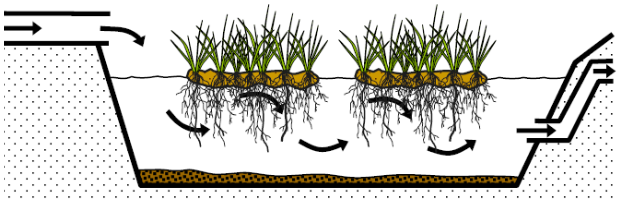

Fig 1.3 Schematic diagram of hydroponic root mat

V ROLE OF WATER HYACINTH AND WATER LETTUCE IN TREATMENT OF WASTEWATER

Qin et al, [7] conducted experiments to explore the potential of the alien plants water hyacinth (*Eichornia crassipes*) and water lettuce (*Pistia stratiotes*) as phytoremediation aquatic macrophytes for nutrients (nitrogen and phosphorus) removal and algal interception from open pond contaminated with domestic sewage. Water hyacinth, which exhibited hyperactive accumulating capacity for nitrogen (58.64% of total reductions), was more suitable than water lettuce for the intensive purification of domestic sewage with high nitrogen concentrations. This result may be attributed to the larger total root surface, active absorption area and leaf area and higher root activity, root biomass and net photosynthetic rate of water hyacinth than those of water lettuce.

Akinbile and Yusoff, [8] analyzed water hyacinth (*Eichornia crassipes*) and water lettuce (*Pistia stratiotes*) to determine their effectiveness in aquaculture wastewater treatment in Malaysia. Wastewater from fish farm in Semanggol Perak, Malaysia was sampled and the parameters determined included, the pH, turbidity, dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), phosphate (PO_4^{3-}), nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3), and total kjedahl nitrogen (TKN). Also, hydroponics system was set up and was added with fresh plants weights of 150 ± 20 grams *Eichornia crassipes* and 50 ± 10 grams *Pistia stratiotes* during the 30 days experiment. Considerable percentage reduction was observed in all the parameters treated with the phytoremediators. Percentage reduction of turbidity for *Eichornia crassipes* were 85.26% and 87.05% while *Pistia stratiotes* were 92.70% and 93.69% respectively. Similar reductions were observed in COD, TKN, NO_3^-, NH_3, and PO_4^{3-}. The capability of these plants in removing nutrients was established from the study.

Sivasankari and Ravindran, [9] conducted experiments on water hyacinth and water lettuce and showed that these two macrophytes can be readily degraded under anaerobic condition to yield significant quantities of hydrogen. Anaerobic digestion provides a feasible technology to harness the chemical energy stored in these weeds. Water hyacinth and water lettuce were evaluated in this study as substrates for biohydrogen production. The result showed that aquatic plants are a promising biomass for biohydrogen production. Biohydrogen will play a major role in future because it can utilize renewable sources of energy.

Awuah et al., [10] performed a bench-scale continuous-flow wastewater treatment system comprising three parallel lines using duckweed (*Spirodela polyrhiza*), water lettuce (*Pistia stratiotes*), and algae (natural colonization) as treatment agents to determine environmental conditions, fecal coliform profiles and general treatment performance. Each line consisted of four ponds connected in series fed by diluted sewage. Influent and effluent parameters measured included environmental conditions, turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate, nitrite, ammonia, total phosphorus. BOD removal was highest in the duckweed system, followed by pistia and algae at 95%, 93%, and 25%, respectively. COD removals were 65% and 59%, respectively, for duckweed and pistia, while COD increased in algal ponds by 56%. Nitrate removals were 72%, 70%, and 36%, respectively for duckweed, pistia, and algal ponds. Total phosphorus removals were 33% and 9% for pistia and duckweed systems, while an increase of 19% was observed in the algal treatment system. Ammonia removals were 95% in both pistia and duckweed and 93% in algal systems. Removals of total dissolved solids (TDS) were 70% for pistia, 15% for duckweed, and 9% for algae.

Dixit et al., [11] studied the effect of sewage effluent on growth of five aquatic species *Eichornia crassipes*, *Alternanthera philoxeroides*, *Egeria densa*, *Najas flexilis* and *Potamogeton crispus,* grown in plastic pools in well water, with or without the addition of 25% of sewage effluent. Of the five test plants, *E. crassipes* showed the maximum growth response to the sewage effluent, with *A. philoxeroides* second. The water hyacinth dominated others covering 71% of the water surface and removed 6.9 g of N, 2.9 g of P and 8.7 g of K from the sewage pools.

VI. CONCLUSION

Greywater if properly treated can be used for non-potable uses which in turn reduces the total water consumption. Phytoremediation is found to be one of the cost effective method for the treatment of greywater. *Eichornia crassipes* and *Pistia stratiotes* are two plant species that are found to be effective for the removal of BOD, COD, nitrogen and phosphorous. They are capable of taking up nutrients for their growth thereby reducing their concentration. Microorganisms attached to their roots are capable of oxidizing the organic matters present in wastewater. Many studies are reported on the use of water hyacinth and water lettuce in phytoremediation to remove different contaminants. Hence these plants can be used effectively for the treatment of greywater provided their growth is properly controlled.

REFERENCES

[1.] Shaikh, Sameer S. K. and Younus S. K. (2015), ‘A sustainable solution for water crisis in Pusad city Maharashtra’, *International Journal on recent and innovation trends in computing and communication*, 3(2), pp. 167-170.

[2.] Chintanwar Y. D., Batra P., Kumar V., Gour R., Chorey S., Yeole N. and Kumar R. (2016), ‘Grey water treatment and management : the potential of greywater systems to aid sustainable water management’, *Journal of Research in Engineering and Applied Sciences*, 1(3), pp.141-147.

[3.] Li F., Wichmann K. and Otterpohl R. (2009), ‘Review of technological approaches for greywater treatment and reuse’, *Science of the total environment*, 407(1), pp. 3439-3449.

[4.] Gupta P., Roy S. and Mahindrakar A. B. (2012),‘Treatment of Water Using Water Hyacinth, Water Lettuce and Vetiver Grass - A Review’, *Resources and Environment*, 2(5), pp. 202-215.

[5.] Bhattacharya A and Kumar P (2010), 'Water hyacinth as a potential biofuel crop', *Electronic journal of Environmental, Agriculture and Food Chemistry,* 9(1), pp. 112-122.

[6.] Headley T. R. and Tanner C. C. (2012), 'Floating treatment wetlands: an innovative option for storm water quality application', *Journal of Environmental Science and technology,* 42(21), pp. 261-310.

[7.] Qin H., Zhang Z., Liu M., Liu H., Wang Y., Wen X., Zhang Y. and Yan S. (2016), 'Site test of phytoremediation of an open pond contaminated withdomestic sewage using water hyacinth and water lettuce', *Ecological Engineering*, 95(1), pp. 753-762.

[8.] Akinbile C. O. and Yusoff M. S. (2012), 'Assessing water hyacinth (*Eichhornia crassipes*) and lettuce (*Pistia stratiotes*) effectiveness in Aquaculture wastewater treatment', *International Journal of Phytoremediation*, 14(1), pp. 201-211.

[9.] Sivasankari B and Ravindran D. (2016), 'A study on chemical analysis of water hyacinth (*Eichornia crassipes*) and water lettuce (*Pistia stratiotes*), *International Journal of Innovative Research in Science and Technology*, 5(10), pp. 17566-17570.

[10.] Awuah E., Peprah O. M., Lubberding H.J.and Gijzen H. J. (2004), 'Comparative performance studies of water lettuce, duck weed and algal based stabilization ponds using low strength sewage', *Journal of toxicology and Environmental health,*67(1), p. 1727-1739.

[11.] Dixit A., Dixit S. and Goswamy D. S. (2011), 'Process and plants for wastewater remediation – a review', *Science reviews and chemical communication*, 1(1), 71-77.