GREY WATER TREATMENT BY WATER HYACINTH-A REVIEW

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Abstract - Aquatic plants for the treatment of domestic wastewater have been used by several researchers. All techniques are reported to be cost effective compared to other methods. Various contaminants like total suspended solids, dissolved solids, hardness, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, nitrogen, phosphorous, heavy metals, and other contaminants have been minimized using aquatic plants like water hyacinth, hydrilla etc. In this paper role of all plant species, origin and their occurrence, ecological factors and their efficiency in reduction of different water contaminants have been presented.

Key Words: **Domestic Wastewater, Water Hyacinth, Aquatic Plants, Hydrilla**

1. INTRODUCTION

Aquatic plant system has been accounted as one of the processes for wastewater recovery, reuse and recycling. The main purposes for using this system have focused on waste stabilization and nutrient removal. The removal mechanism are physical sedimentation and bacterial metabolic activity as in the conventional activated sludge and trickling filter (USEPA, 1991). Plant assimilation of nutrients and their subsequent harvesting are another mechanism for pollutant removal. Minimum 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 domestic 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.

Water hyacinth (*Eichhornia crassipes*) treatment systems are generally known in tropical area. The system with WH can operate at higher loading rates. Their end-use products can be utilized for organic fertilizer. Dry WH petioles can be woven into baskets and purse (Polprasert, 1996).

The degree of purification of wastewater within a hyacinth lagoon depends not only on the capacity of the plants to assimilate nutrients, but also on their potential to alter the wastewater environment to enhance removal of organic matter through biochemical processes. Water hyacinth lagoons function as horizontal trickling filters in which submersed plant roots provide physical support for a thick bacterial biofilm, which actively degrades organic matter (Stowell *et al*. 1981). They are considered to combine the physical process of filtration with fixed–film and suspended growth biological conversion processes. The micro-organisms degrade organic matter, producing metabolites, which they and the plants utilize along with nitrogen, phosphorus and other minerals as a food source. The system differs from other more conventional fixed-film systems in that the attachment medium is biologically active.

2. LITERATURE REVIEW

Thongchai Kanabkaew (2004)__investigates that the enhanced removal efficiency of unconventional plants for aquatic treatment system as post treatment. Lotus (Nelumbo nucifera) and hydrilla (Hydrilla verticillata) were planted with one control unit. Influents and effluents were analysed for pH, SS, BOD5, TKN, NH3 -N, NO2 - -N, NO3 - -N, TP and Coliform bacteria twice a week. The results showed that ponds with aquatic plants were superior to those who don't have aquatic plants. The system with lotus showed the good removal efficiency for wastewater treatment. For the system with hydrilla verticillata, it was found that pH and SS of the effluent were high. It might not be best to use hydrilla for effluent polishing.

Rajendra B. Magar (2017) defines that the roots of Water hyacinths (WH) naturally absorb pollutants including lead, mercury, and strontium90, as well as some organic compounds which are carcinogenic and have concentrations of approximately 10,000 time that is present as in generically found water. This study attempts to evaluate the effect of WH in two different type of sewer or drainage line, one from water closet and another from bath or shower room. Further, the reading for various parameters like Potential of hydrogen (pH), Turbidity, Chemical oxygen demand (COD), chloride and colour has been periodically taken every 24 hrs for 5 days. The effect of WH has resulted in significant decrease in turbidity and due to which the reduction of flocs and reduction in organic matters in water have been observed.

R. Sooknaah (2000) Presence of aquatic plants in natural or constructed wetlands not only reduces the concentration of problematic nutrients from the wastewater, but also alters the physico-chemical environment of the water, rhizosphere and underlying sediment (Reddy & Patrick, 1984). In addition to plant assimilation of nutrients, changes in the environment of the water also help in reducing the pollutant level of the wastewater through biochemical processes brought about by micro-organisms. This paper gives a review of the biochemical and physico-chemical processes occurring in a floating aquatic plant system.

3. MATERIALS AND METHODS

The domestic wastewater before discharging to vicinity Rivers', can be stopped through constructing check dam in drain and can be diverted to the Floating rafts bed tank for its pollutants remediation.

The flowing volume of wastewater can be measure by V-Notch. The Floating rafts bed tank having size of approximate 20m long, 2m width and 1m depth or an appropriate size shallow rectangular tank/basin with a high length to width ration will be designed and constructed with bricks and cemented concrete lining to protect any leaching towards underground. The design will take care to reduce the potential for short circuiting and to simple harvesting operations. The domestic wastewater will be directly diverted to Floating rafts bed tank at different hydraulic retention time (HRT) such as 1, 2 ,5 ,10 and 15 days for remediation of wastewater pollutants through plant roots (rhizosphere) system (Canna and Water lily). The Floating rafts will be made-up with bamboo/PVC pipe and proper netting will be done for support of plants and to form bio-film to support the maximum attached microbial population. The desired number of Floating rafts will be made with suitable size of approximate 1.4m x 2.1m (2/3) in rectangular shape for the Floating rafts bed tank.

A comparative study may be carried out at different HRT for optimization of pollutants removal efficiency/reclamation of wastewater and preparing the engineering design of large scale system for remediation/restoration of domestic and other industrial wastewater. Biological stability of Floating rafts bed is the prime requirement for successful wastewater treatment. The plants belonging to Typha species, Reeds (Phagmites), Canna and other aquatic plants may be selected for up-take of pollutants by their roots considering existing climatic condition. Maintenance of the Floating rafts bed tank may include harvesting of plants at various interval of time and removal of detritus accumulation.

Phyto-remediation: Phyto-remediation of industrial/domestic polluted water is generally believed to occur through one or more of the following mechanisms or processes: phyto-extraction, phyto-stabilization, phyto-degradation, phyto-volatilization, rhizo-filtration and rhizo-degradation (Oh *et al*., 2013a; Li *et al*., 2009). Phyto-remediation is applicable to a broad range of contaminants/pollutants, including heavy metals and radionuclides, as well as organic compounds like chlorinated solvents, polycy-clicaromatic hydrocarbons(PAHs),pesticides/insecticides, explosives, and surfactants (Oh *et al*., 2013a) (Li *et al*., 2009).

Research on floating rafts mechanism in polluted water restoration: Use of floating rafts for treatment of polluted wastewater is a complicated physical, chemical and biological process. In the floating rafts technique generally aquatic plants' developed roots are utilize to contact wastewater, forming a concentrated natural filtering layer of roots (rhizosphere), as well as absorbing, adsorption, transforming and degrading (rhizodegradation) the water pollutants. Plant's roots can also release large amount of enzyme and organic acid to enhance the decomposition and degradation of the macromolecular or toxic pollutants/substances in wastewater and improve the bioavailability of nitrogen and phosphorus to the plant roots. Plant's roots also provide microorganism with oxygen source and attachment place (root surface) and enhance their metabolism to cut down water pollutants content. Through shifting the plants out (old stem can removed) and separating them from floating platform, we will achive the purpose of purifying water quality.

Absorption of nitrogen and phosphorus: Aquatic plant's such as Canna, Water lily etc. have an enormous potential on removing of nitrogen and phosphorus elements in eutrophic water (Wang *et al*., 2012, Xu, 2010). Aquatic plants make the rapid accumulation of biomass (bimegnigication) come true in the way of more vegetative reproduction and removal of more pollutants from wastewater. As indispensable nutrient, elements in plants growing process, the inorganic form of N and P in water could be absorbed directly by aquatic plants through their roots' absorption (rhizoaccumulation), and then plant protein or organic component were synthesized to facilitate plant's growth and development. Therefore, plants had a strong capacity of fixing N and P as well as other nutrients/pollutants (Xuand Lu, 2011). When aquatic plants were shifted out of water of floating platform where they established, the nitrogen and phosphorus absorbed by different parts of plant such as stem, leaves and root were brought out of water too. In the research conducted on Floating rafts purification in intensive aquaculture pond, water spinach floating beds were observed highest direct absorption rates of Total Nitrogen (TN) and Total Phosphorus (TP) on the 100 days as 52.35 and 5.39 kg hm-2 a-1respectively (Chen *et al*., 2010).

Degradation of organic matters (OMs): Floating rafts not only can remove nitrogen and phosphorus elements effectively, but it is also effective in removing organic matters (Luo *et al*., 2011; Bu *et al*., 2010). Canna and Calamus floating bed's removal rates of COD and Mn were 42.3% and 36.3% respectively in 5 days (Bu *et al*., 2010). However, the main ways of removing organic matters by Floating rafts were the degradation of roots secretion as well as absorption and utilization of microbes. Aquatic plants constantly secreted great deal of macromolecular organics to the environment in the process of growth, such as enzyme, saccharide, organic acid etc. (Liu *et al*., 2009). Those secretions not only decomposed organic matters effectively, but it also provided root's microbes with many nutrient substances. Moreover, the oxygen produced by floating plant's photosynthesis was released to water through plant's roots (Cheng *et al*., 2003), then many anoxic and aerobic areas were formed around its rhizosphere to intensify both aerobic microbe's and anaerobic microbe's growth and reproduction, to pro-mote microbe's constant absorption and utilization of organic pollutants in water and to raise its degradation efficiency of organic matters, thus achieving the pro-pose of removing organic matters. For example, samphire's removal of humic like proteinoid, DOC and other organic matters were implemented by its rhizo-sphere's activity (Huang *et al*., 2013)

Temperature: Among, factors affecting the efficiency of floating raft treatment, temperature are most important which play a vital role in plant's growth and reproduction. Temperature is positively correlated with plant's purifying capacity, when the temperature is high, floating bed plant's growth and their metabolism is vigorous and plant's purifying effect of water pollutants is obviously improved and as the plant become more healthy, they accumulates more pollutants in their tissues. It was observed that, when the water temperature was increased from 2°C to 29°C, canna's removal rates of TN (Total Nitrogen) and TP (Total Phosphorus) were distinctly increased by 57% and 63%, respectively as compare to at 2°C. When the temperature was raised beyond 10°C, canna removal rate of TP and TN inform wastewater obviously in-creases; and when the temperature was lower than 10°C, canna's growth rate was at a standstill (Zhen *et al*., 2008; Luo *et al*., 2010). In another researchit was ob-served that cress floating bed's and water cress floating bed's removal rates of TN and TP from eutrophic water at22°C were clearly higher than that of at 10°C and 35°C (Hu *et al*., 2010); *Eichhorniacrassipes* floating bed's removal rates of TN and TP from eutrophic water at 25°C was higher than that of 15°C and 35°C temperature.

It was also observed that, plant's removal rates of TN and TP were not proportional to the temperature, but the temperature was very important factor that affect to the floating bed plant's biomass and more the plant biomass, more will be accumulation of pollutants (Liu *et al*., 2013). As discussed in above paragraph, plant's growth rate was different at different temperatures and the growth of plants were very good at the optimum temperature condition and its purifying effect for polluted water was obvious mare as compare to very high or low temperature conditions where plant's growth was restrained, thereby plant's purifying effect of polluted wastewater was influenced greatly by temperature.

Processing time/hydraulic retention time (HRT): Floating rafts plant's pollutants removal efficiency are proportionally related to processing time or hydraulic retention time such as more the pollution level of wastewater, more processing time will required. For example, yellow flag, canna and siberian iris floating bed's purifying capacity for nitrogen and phosphorus in polluted water increased with the growth of time of plants (Chen *et al*., 2011). Lycopus, wood betony, rumex japonicas and garden sorrel floating bed's purifying effects of N and P in sewage increased with the growth of time, moreover, in the initial 30 days plant's removal efficiency were obvious, while after 30 days plants removal rates of contaminants ware declined (Xu, 2010). With the growth in the processing time (such as 24, 48, 72 and 96 hours), watermifoil'sand water caltrop's enrichments of Cd^{2+} increased proportionally. (Zhen *et al*., 2008). Study conducted by Luo and friends have found that with the growth of processing time, the removal rate of water pollutants had the tendency to firstly increase and then decrease (Luo *et al*., 2010). Ajayi and Ogunbayo used water hyacinth in 2012 to purify sewage and found that the content of BOD, Fe and Cu in water firstly increases and two weeks later gradually decreases.

Resource utilization of aquatic plants: Aquatic plants are supposed to be growing rapidly and they also have capacity to gain large biomass in less time. Nutrients such as Nitrogen and Phosphorus etc. which were absorbed by plants can be transformed into proteins, amino acids and other nutrient materials and have certain economic value also (Zhou *et al*., 2006). As the aquatic plants have certain age limit and hence they require pruning on time otherwise plants will de-cay in wastewater, and as a result of that, this not only leads to production of secondary pollution but also leads to wastes of valuable resources (Chen *et al*., 2010). At present, aquatic plants are used in the form of phyto-extraction, exploitation for medical purpose, forage production for animals (Fan *et al*., 2011) and edible vegetables for human being etc., (Li *et al*., 2008). However, the performance of aquatic plant for excess removal of pollutants from wastewater is yet one of the important limiting factors of their ecological restoration in the aquatic environment/condition, and new methods and modification in this technique ac-cording to level of pollutants to enhance the performance of floating raft will be a future research direction.

Engineering application: Since long ago, Floating rafts technique is used as an aquatic plants based treatment method for wastewater and eutrophic water. There are many engineering techniques at both domestic and international level having gotten good purifying effect, but they also simultaneously having many problems also such as high installation cost, production of secondary pollutants, management of generated sew-age sludge etc. However, Floating raft is plant based method of purification, its purifying capacity also de-pends upon certain climatic factors such as humidity, temperature, wind velocity, mean sea level etc. Nevertheless, once the growth of plant reached to the saturation stage, removal of these plants again will be time consuming and require labour cost (Guo and Zhang, 2010) Plants used in the Floating rafts require daily care as they are vulnerable to the certain pest and disease with reference to the environmental condition and if the management of plants fail to form systematic specification; Floating rafts working life become short, usually < 6 years (Guo and Zhang, 2010); still there are no technology and management standards to reference in engineering application of floating raft technique. However, Floating rafts technique has excellent merits and above problems/demerits are hindering Floating rafts technology's application and promotion. There-fore, the use of Floating raft technique in combination with technology at broad and field level needs further systematically research.

4. CONCLUSION

It has been observed that phytoremediation of wastewater using the floating and submerged plant system is a predominant method which is economic to construct, requires little maintenance and increase the biodiversity. Many researchers have used water hyacinth, water lettuce and hydrilla for the removal of water contaminants but their treatment capabilities depend on different factors like climate, contaminants of different concentrations, temperature, etc. The removal efficiency of contaminants like TSS, TDS, BOD, COD, hardness, heavy metals, etc. varies from plant to plant. Plant growth rate and hydraulic retention time can influence the reduction in contaminants. Therefore, an available knowledge and techniques for removal of water contaminants and advancement in wastewater treatment can be integrated to assess and control water pollution.

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