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ORIGINAL ARTICLE

Floating wetlands- a new Sustainable Lake Cleaning Technology

Nafath-ul-Arab[1], Adnan Abubak[1], M.H.Balkhi[1], Asim Iqbal Bazaz[2], Zarka Yousuf[2], Zaib Hafeez [2], Bisma S Khan[2], Anees bin Mansoor [3], Nakeer Razak[3], Irfan Ahmad[3*]

[1] Division of Aquatic Environmental Management; [2] Division of Fisheries Resource Management;
[3] Division of Fish Genetics & Biotechnology. Faculty of Fisheries, SKUAST-K, Rangil, Nagabal. Jammu and Kashmir, India-06

** Corresponding Author: ahmadirfan@skuastkashmir.ac.in*

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ABSTRACT

Floating Treatment Wetlands or islands are an innovative variant of a constructed treatment wetland that allows water treatment in water bodies that are too deep for plants to grow. FTWs can be used in deep eutrophic lakes, storm water ponds of urban and rural areas that otherwise have the tendency to stagnate and accumulate toxins. Floating Wetlands are micro ecosystems where plants and bacteria form a symbiotic relationship supported by a unique material, which facilitates microbiological and plant processing of nutrients. Not only do the plants take up nutrients and contaminants themselves, the plant roots and floating island material provide extensive surface area for formation of biofilm—the slimy layer of algae, bacteria and other microbes that adhere to all the surface area. Although FTWs are effective in both tropical as well as temperate climates, low temperature in temperate climates can reduce the performance.

Keywords: Floating treatment wetland, Artificial wetland, Buoyant, Eutrophic, Biofilms

INTRODUCTION

Floating Islands also known as Floating Wetlands or Floating Treatment Wetlands are islands that float on water. FTWs, or islands, are an innovative variant of a constructed treatment wetland that allows water treatment in water bodies that are too deep for plants to grow. Floating wetlands do

occur naturally, where under certain conditions a 40–60 cm deep floating organic mat can break away from the bottom sediment and float, supporting plant growth (Headley & Tanner, 2006). Artificial wetland islands can be constructed from various materials to mimic the same effect and allow aquatic emergent plants to grow as a floating mat without risk of inundation regardless of changes in water level (McAndrew, Ahn & Spooner, 2016). In India floating treatment wetland technology has been implemented at many lakes in Hyderabad, Bengaluru, Delhi, Indore and Maharashtra. The largest floating wetlands in India are at Neknampur Lake in Hyderabad. Bengaluru is the largest city in terms of implementation of floating treatment wetlands.

HISTORY

The history of FTWs dates back to 1250 – 1600 C.E, when the empires of Aztecs and Incas called them "Chinampa" which is referred to as "FLOATING GARDENS". During late 1980s the idea of constructing a floating platform on which plants could be grown to improve water quality originated in China, Japan and Taiwan**.** In 1998**,** a floating island made from lightweight concrete was first used in Kasumigaura Lake, Japan to create fish and water bird habitat while improving water quality and landscape.

STRUCTURE OF FLOATING TREATMENT WETLANDS

The structure of FWs is strikingly similar to other traditional wetlands except that, in FWs, plants are supported by artificial buoyant materials. These floating materials keep the plants crown elevated above the water level thus letting them establish their roots in the deeper zones. 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 are formed. Buoyancy in FWs is maintained either by using low density plant holding material or by using plants with aerenchymatous abilities (Fink and Mitsch, 2007). The structure of floating treatment wetlands consists of a holding frame and a variety of low density materials such as polyester sheets, PVC pipes, and bamboo containing meshes etc. These floating structures have many holes for holding the vegetation. Usually native plants are preferred as vegetation in floating treatment wetlands which have the natural ability of entrapping gases which allows them to float on the water surface. The other components such as anchor, the root system and the island matrix are also a part of the structure of floating treatment wetlands and are taken into consideration before designing floating treatment wetlands.

PLANTS USED IN FLOATING TREATMENT WETLANDS

In FTWs, plants perform several functions necessary for the wastewater treatment. Usually native emergent aquatic plants are selected and planted for their benefits to local biodiversity, their intricate and deep growing root systems and beauty. Common plants which have been used in FTWs are- Cattails, Citronella, Fountain grass, Vetiver etc. (Brix, 2003).

WHERE FTWS ARE USED?

There are many freshwater bodies in which floating wetlands can be deployed in order to improve the quality of water. FTWs have limited remediation benefits on larger lakes (Lewtas *et al*. 2016). FTWs can be used in deep eutrophic lakes, storm water ponds of urban and rural areas that otherwise have the tendency to stagnate and accumulate toxins. They can also be used in waste

water lagoons which are greatly benefited by the biological treatment of FTWs. In landfill leachate and tailing ponds, the by-products of tailings can be effectively separated by FTWs. FTWs can also be used at sites of oil spills in the breakdown of petroleum hydrocarbons.

WORKING OF FTWS

Floating Wetlands are micro ecosystems where plants and bacteria form a symbiotic relationship supported by a unique material, which facilitates microbiological and plant processing of nutrients. Not only do the plants take up nutrients and contaminants themselves, the plant roots and floating island material provide extensive surface area for formation of biofilm—the slimy layer of algae, bacteria and other microbes that adhere to all the surface area. Research suggests the plants only account for a small fraction of the overall treatment; it is the biofilm that coats roots and the island surface where the majority of nutrient uptake and degradation occurs in the FTW system (Tanner & Headley 2011; Winston *et al*., 2013). The greater the surface area, the greater the biofilm development and treatment potential. The biofilm layer facilitates adsorption and breakdown of nutrients, toxins and contaminants by the microbe community and promotes growth of invertebrates that provide food for fish and other aquatic insects. Some nutrients and heavy metals get absorbed in the plant biomass but the majority of nitrogen, phosphorus and organic nutrients are converted by bacteria to chemical forms that escape as gases, or metabolites that are removed from the nutrient cycle. Bacteria also bind suspended particles together so they become heavy enough to sink, in a process called flocculation. The potential mechanisms that provide treatment in floating wetlands are known but the precise contributions are uncertain. The biofilm formed in FTWs acts as a filtration media. The beneficial bacteria eat up the organic matter and passes on cleaned water. The formation of biofilm stimulates the breakdown, absorption and removal of nutrients and contaminants. The plants of the FTWs accumulate and stabilize the nutrients and contaminants from the water and sediments incorporating them into their biomass. The nutrients after accumulation and stabilization are converted into gases like nitrogen and released through volatilization (IISD, 2019).

FACTORS AFFECTING THE PERFORMANCE OF FTWS

There are many factors that affect the performance of Floating Wetlands. Some of them are:

(1) Water Depth: With an increase in the depth of water there is an enhancement in the performance of FTWs due to the increased contact time of pollutants with roots and microbial biofilm (Tanner and Headley, 2011).
(2) Plants: Native plants are usually preferred in FTWs; the plant choice also depends on their ability to make dense root systems.
(3) Season and Temperature: Solar radiation and temperature also have a prominent effect on performance of FTWs (Nelson *et al*. 2009). During spring microbial proliferation and plant growth are enhanced which promote degradation of some pollutants such as nitrogen whereas during fall and winter reduced plant growth and bacterial metabolism results in less removal of contaminants.
(4) Aeration: Nutrient removal in FTWs can be maximized by improving the aeration of waste water. Aeration develops aerobic micro-zones which stimulate biofilm production (Hussain *et al*. 2018).
(5) Plant harvesting: Plant shoots should be harvested before the culmination of growing season to achieve maximum removal of nutrients.

BENEFITS AND LIMITATIONS OF FLOATING TREATMENT WETLANDS

The benefits of floating treatment wetlands are that:

(1) They attract birds and sustain insect populations.
(2) Plants used in FTWs provide aesthetic beauty.
(3) Provide cover for wildlife habitat.
(4) They require low to no maintenance.
(5) These islands shade and provide cover and allow fish to thrive.

The limitations of floating treatment wetlands are that:

(1) Anchoring the floating rafts often becomes a challenge.
(2) Plants used in FTWs need to be removed or harvested periodically.
(3) Block access or reduce available area for recreational use of the water body.
(4) Minimum water depth should always be maintained to avoid plant growth deep into the sediments.
(5) Invasive or undesirable plants may reduce the efficiency of FTWs.

POTENTIAL OF FTWS IN KASHMIR VALLEY

As of yet FTW technology has not been used to clean the eutrophic lakes of the Valley. However, our valley has a great potential for the use of this technology. Several emergent aquatic plants can be fixed on floating mats and they could help in controlling various pollution levels and in improving the water quality parameters. Common Plants which can be used in FTWs of Kashmir are: *Typha angustata* and *Phragmites communis.*

FTWS OF HAUZ KHAS LAKE/ CASE STUDY

Hauz Khas Lake, a water body located in South Delhi was built in 1295 by Sultan Alauddin Khilji. The lake covering an area of 58515 sq m dried up a few decades back because the storm water drains that fed it were diverted due to some construction work. A shrinking catchment area because of urban development further added to its miseries. In 2002, a New Delhi based NGO (INTACH) along with DDA, came up with a plan to revive the lake with treated sewage water (Roy, 2016). In 2017 to further rejuvenate, conserve and revive the Lake, the DDA selected Evolve Engineering, an organisation which specialises in innovative engineering solutions using constructed floating wetlands for lake restoration. About 500 floating Islands were placed in the lake. The plants were grown on a mat built from wire mesh, drainage pipes and used water bottles. The biochemical oxygen demand (BOD) amount of dissolved oxygen needed by aerobic biological organisms to break down organic materials has come down by two-thirds while dissolved oxygen, amount of oxygen present in the lake had gone by a third between June and October (The Hindu, 2018).

CONCLUSION

Floating wetlands are sustainable alternatives for the treatment of water containing various kinds of pollutants. Although its pollutants removal mechanism are similar to surface flow wetlands, its floating nature made it applicable for ponds, lakes and rivers for with fluctuating water level. Plant root systems play a crucial role in the removal of pollutants from the wastewater by their direct uptake, provide residency and nutrients for the development of microbial biofilm, and filtration of polluted water. The below floating mat portion of macrophytes is reported to accumulate more

nutrients as compared to the upper portion of plants. Although FTWs are effective in both tropical as well as temperate climates, low temperature in temperate climates can reduce the performance.

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