

Floating Raft Wastewater Treatment System: A Review

Praveen Solanki^{1*}, Maitreyie Narayan¹, Shiv Singh Meena² and R.K. Srivastava¹

¹Department of Environmental Science, ²Department of Soil Science,
G.B. Pant University of Agriculture and Technology, Pantnagar - 263 145, Uttarakhand, India.

<http://dx.doi.org/10.22207/JPAM.11.2.55>

(Received: 03 March 2017; accepted: 04 May 2017)

Recently more imbalances are observed in availability and quality of natural resources such as water, which is most precious as well as playing a vital role in the governance of entire natural as well as manmade ecosystem. Hence, the presence of water in good quality is extremely necessary for overall sustainable and eco-friendly development. The floating raft wastewater treatment system is most emerging sustainable and plant-based-eco-friendly method for wastewater treatment since it is totally plant based and there is no more initial requirement of inputs as well as there is no production of harmful by-products into the environment.

Keywords: Floating raft, Phytoremediation, Biofilms, Wastewater.

Floating raft wastewater treatment system (FRWTS) is a manmade ecosystem that mimics natural floating system/habitat. At the beginning of the 20th century, this system was used for birds' habitat and fish's spawning place as natural habitat. In the 1980s, German scholars designed the modern ecological floating bed and used it to purify polluted water for the first time (Nakamura and Shimatani 1997). Floating rafts is a new concept and promising wastewater remediation technology for improving surface water quality in wastewater body where we grow vegetation/plants on artificial floating platforms. This technology basically is an application of hydroponics using artificial floating platforms, where plants grew up and utilize nutrients and organic matter present in the wastewaters and the overall process will lead to treatment/phytoremediation of wastewater in eco-friendly manner. (Sun *et al.*, 2009).

Water is our most precious and basically required natural resource, which is a key component

for sustainable governance of all ecosystems and further responsible for the great abundance and diversity of life on the earth. However, drastically increasing pollution load in water and simultaneously decreasing in fresh water resources are two most emerging threat to the entire living ecosystem. Heavy metals and metalloids, such as Cd, Pb, Hg, As, Se, etc. are releasing into the environment by mining, industry and agricultural activities, which leads to threatening environmental and human health (Dixit *et al.*, 2015). Due to the acute toxicity of these contaminants, there is an urgent need to develop low-cost, effective and sustainable methods to remove them from the environment or to detoxify. Floating rafts is a plant-based approach, like phytoremediation, which is relatively inexpensive since they are performed in-situ and are natural-driven (Duan *et al.*, 2016). Since plants play a crucial role in this method as mention by Paulo *et al.*, (2014), can improve water quality by accumulate metals in their harvestable biomass (phytoextraction), to release certain metals in a volatile form (phytovolatilization), to degrade complex compounds into simpler compounds (phytodegradation), filtering the metals

* To whom all correspondence should be addressed.
E-mail: praveen.solanki746@gmail.com

(rhizofiltration) and so on (Fig. 1). FRWTS may represent a comparatively low cost and sustainable engineered best management practice (BMP) for reducing pollution load in wastewater (Wilson et al., 2006). Evaluating their effectiveness as a BMP is a subject of on-going research at GBPUA&T, Pantnagar, Uttarakhand.

Floating Raft

Bamboo/PVC pipe, coconut coir, and polyethylene mesh may use to develop low cost eco-friendly floating rafts (Fig. 2). Open textured coarse peat/soil or coconut coir materials that do not become too heavy or anaerobic once saturated are likely to be the most suitable growth media for plant establishment on floating raft. Floating rafts constructed using lengths of large diameter bamboo interwoven or other materials with mats of natural fiber (coconut coir). "The articulated nature of the bamboo means that it contains sealed chambers of air throughout the stem which is naturally buoyant" (Headley and Tanner, 2006).

Plant roots and rhizomes can spread and grow through the matrix (coconut coir/peat), with their roots extending down into the water below. The matrix would also be incorporate with various plant growth media and potentially also reactive/absorptive media (e.g., zeolites or P-absorbing materials) to enhance contaminants removal efficiency of the system.

Plants can grow on floating raft

Aquatic and some other plants which have bioremediation potential for removal of water pollutants and rapid accumulation of pollutants in their biomass are most suitable for this system. Therefore, plants species namely Pistia (*Pistia stratiotes*), Canna (*Canna indica*), American aloe (*Agave americana*) and Water lily (*Nymphaea L.*) etc. may use for lab and field level study for acclimatization/standardization before transferring these plants to field level study.

Development of biofilms

Submerged roots, stem and leaves are believed to play a key role in treatment processes within floating rafts by virtue of the contact that is afforded as the water passes directly through the network of hanging roots and other plant parts that develop beneath the floating mat. Submerged plant parts, viz. roots, stem etc. provide a living surface which lead to better development of biofilms, comprising different communities of attached-

micro-organisms, who are responsible for a number of treatment processes for wastewater remediation such as degradation of complex organic and inorganic molecules/pollutants in the simple form (Fig. 3) (Headley and Tanner, 2006).

The rhizospheric zone and associated biofilms are collectively acted as physical trapping for pollutants and particulates within the water column. There are many pollutants and metals, which are associated with specific microorganisms attached to the biofilm develops in submerged condition. The enhanced form submerged biofilm afforded by FRWTS, may make them particularly effective at removing pollutants with greater efficiency. Complexation of metals with root and submerged plant's biofilms, root exudates, humic compounds and other large molecular weight organics followed by deposition may play an important role in metal removal and their detoxification under this method (Headley and Tanner, 2006).

Working concept behind FRWTS

The following processes occur during phytoremediation:

1. Organic matter degradation by microorganisms such as bacteria and fungi on plant root surfaces (rhizosphere).
2. Plant uptake organic, inorganic substances such as nutrients, heavy metals etc. through phytoextraction.
3. The roots of floating plant promote flocculation and sedimentation of suspended materials and filter out sediment and associated pollutants through rhizofiltration.
4. Degradation of plant material and trapped organic matter releases soluble carbon which allows natural de-nitrification to occur in oxygen limited conditions.

Significance

Floating rafts have been used as a low-cost treatment to remove a wide range of contaminants from polluted waters such as municipal wastewater, effluents from industries, oil refineries waste and agricultural runoff and so on.

This paper mainly focused on the basic concept of Floating rafts, its scope, applications and different plant species for removal of different contaminants. Moreover, from the techno-commercial point of view, this paper would be phenomenal for adopting and accelerating concerted efforts of the various concerned organization at the national level, which would be

a complimentary efforts for the Namami Gange and Clean India campaign launched by Govt. of India.

Potential advantages of FRWTS

1. Provides design flexibility: Floating raft can be sized to fit into almost any pond, lake, and domestic wastewater drain.
2. It is eco-friendly- Natural air motion, will allow the raft to move here and there and this movement will add oxygen into the water body to enhance purification efficiency.
3. Enhances the pollutant removal effectiveness of existing wastewater ponds.

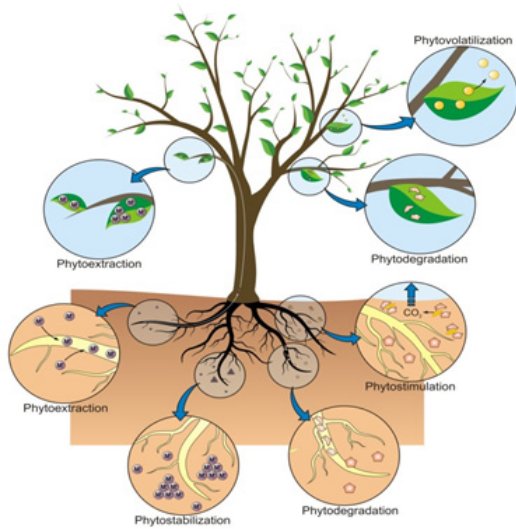


Fig. 1. Pictorial representation of phytoremediation process (Paulo et al., 2014)



Fig. 2. Pictorial representation of FRWTS at GBPUA&T, pantnagar

4. Provides a sustainable pollutant removal system and also provides the natural habitat for aquatic animals.
5. Offers resiliency: This system can tolerate storm-event driven water-level fluctuations as long as they are anchored to the bottom or tethered to the shoreline so they are not damaged or lost by flowing through the outlet structure of the pond and rivers.
6. Improves aesthetics: FRWTS can be used to enhance the visual appeal/interest of surface water features like ponds and lakes.
7. One of the key pathways for contaminant removal in floating raft wetland systems is believed to occur via the sequential processes of a release of extracellular enzymes, development of biofilms and promotion of flocculation of suspended matter at the surface of the submerged plant organs.
8. The inclusion of a floating raft wetland over the pond surface provides a barrier against light penetration into the water column, thereby limiting the potential for algae growth.
9. Floating raft wetlands may be perceived to enhance the aesthetic values of a wastewater treatment pond, depending on the shape, structure, and vegetation used.
10. This technique can be utilized profitably for the treatment of wastewater and its reuse by competent authorities of big and small cities as well as cities and towns located on the banks of holy rivers Ganga, Yamuna and others in the country.

Constraints

1. Initial concentrations of pollutants are likely to

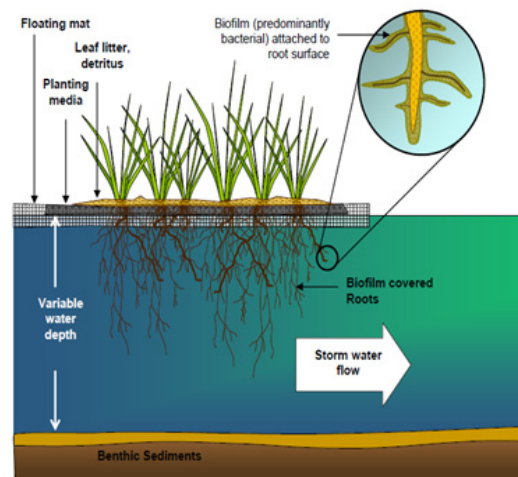


Fig. 3. Development of submerged biofilms (Headley and Tanner, 2006)

- decrease the purification efficiency of FRWTS.
- Hues generation of wastewater is another problem and leads to affect FRWTS's efficiency.

CONCLUSION

Floating raft technology is very easy to install in the village/urban/industrial wastewater pond or river perennially receiving wastewater for their reclamation. It is cost effective and eco-friendly in nature because does not require much maintenance and initial inputs. The output of flowers and value added products from selected plants may lead to additional income source from this wastewater treatment system.

REFERENCES

- Dixit, R., Wasiullah, A., Malaviya, D., Pandiyan, K., *et al.* Bioremediation of Heavy Metals from Soil and Aquatic Environment: An Overview of Principles and Criteria of Fundamental Processes. *Sustainability.*, 2015; **7**: 2189-2212.
- Duan, J., Feng, Y., Yu, Y., Shiyang, H., Xue, L. and Yang, L. Differences in the treatment efficiency of a cold-resistant floating bed plant receiving two types of low-pollution wastewater. *Envi. Moni. Asses.*, 2016; **188**(283): 1-11.
- Headley, T.R. and Tanner, C.C. Application of Floating Wetlands for Enhanced Stormwater Treatment: A Review. Auckland Regional Council Technical Publication No. November 2006 ISSN.
- Paulo, J.C., Favas, J.P., Mayank, V.R. and Manoj, S. Paul. Phytoremediation of Soils Contaminated with Metals and Metalloids at Mining Areas: Potential of Native Flora, Environmental Risk Assessment of Soil Contamination, Dr. Maria C. Hernandez Soriano (Ed.), 2014: Intech, Doi: 10.5772/57469.
- Sun, L., Liu, Y. and Jin, H. Nitrogen removal from polluted river by enhanced floating bed grown canna. *Ecological Engineering.*, 2009; **35**: 135-140.
- Wilson, A., Lennard, B. and Leonard, V. A comparison of three different hydroponic sub-systems (gravel bed, floating and nutrient film technique) in an Aquaponic test system. *Aqua. Int.*, 2006; **14**: 539-550.