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Floating Wetland For Wastewater Treatment In Rural And Urban Area

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Abstract

Floating wetlands are a contemporary, nature-based technology for water treatment and sewage treatment. They are floating platforms that accommodate aquatic plants whose roots dangle freely in the water column where biological, physical, and chemical processes clean polluted water. The plants and their microbial Biofilms trap nutrients, break down organic pollutants, and filter suspended solids. This process makes Floating Treatment Wetlands (FTWs) effective Ecologically friendly systems appropriate for decentralized wastewater treatment. The growing world-wide generation of wastewater through urbanization and industrialization threatens serious environmental impacts. Traditional wastewater treatment systems, as useful as they are, require high capital investment, high energy consumption, and regular maintenance. Floating wetlands bypass these limitations by offering a low-cost, low-maintenance, and adaptable solution that can be installed in ponds, lakes, canals, or drainage channels. Various studies have proven their functionality: The demonstrated FTWs are able to remove more than 70% of nutrients; The documented COD and TSS reductions in significant amounts; and showed increased pollution removal upon integrating FTWs with biochar. In addition to water treatment, floating wetlands enhance biodiversity, restore ecosystems, and enhance water bodies' aesthetic beauty. In summary, FTWs present a sustainable, cost-effective, and environmentally friendly approach to treating wastewater and sewage treatment. They integrate the natural cleansing potential of plants and microorganisms with inexpensive engineering design. Their application can enable urban and rural communities equally to attain cleaner water and healthier environments, thus making them a vital innovation in future water management plans.

Introduction

Water is a basic resource for all life processes. Maintaining the quality of this crucial resource is important for both human health and ecological sustainability. Presently, the rapid urbanization, industrial growth, and growing population are generating enormous amounts of wastewater. If not treated properly, this wastewater can contaminate rivers, lakes, and groundwater with consequent environmental degradation, eutrophication, and proliferation of waterborne diseases. Traditional methods of wastewater treatment-chemical treatment and activated sludge systems show efficiency in functioning but generally require high energy supplies, vast infrastructure, and significant expenses in operation. For small villages and developing regions, most such systems are either lacking or unsuitable, pointing out the need for low-cost, efficient, and sustainable alternatives. FTWs are an upcoming, innovative solution for the aforementioned problem. They are engineered systems that replicate natural wetland processes by supporting aquatic plants on buoyant platforms. The roots of these plants hang in the water, providing surface area for

microbial biofilms that break down organic pollutants and absorb nutrients. The integration of plant uptake with microbial degradation enables FTWs to remove a wide range of contaminants: organic matter, suspended solids, nitrogen, phosphorus, and sometimes emerging pollutants such as pharmaceuticals. The design of FTWs can be flexible; treatment efficiency can be enhanced by changing parameters like plant species, mat size, and hydraulic retention time in accordance with the source of wastewater. FTWs can be implemented in lakes, ponds, canals, retention basins, and urban drainage channels. This flexibility makes them very suitable for decentralized wastewater treatment, especially when and where conventional treatment plants would be inappropriate because of high costs or technical/structural conditions. Besides purifying the water, FTWs restore habitats of aquatic organisms, promote biodiversity, and therefore increase the scenic value of water bodies. Multifunctionality makes FTWs sustainable technologies that respond to both ecological and social demands. Various studies prove the efficiency of FTWs in wastewater treatment. For instance, according to Oliveira et al. (2021), FTWs are efficient for the removal of nutrients and organic matter from domestic wastewater. Similarly, Benvenuti et al. (2018) performed a real-scale study and recorded up to 78% reduction in chemical oxygen demand and significant removal of total suspended solids. Other research, including Tran et al. 2024, shows that FTW coupled with materials such as biochar can increase pollutant removal, and Arshad et al. (2017) corroborated that FTWs can be designed to treat municipal wastewater sustainably. This body of research proves not only that FTWs are effective in treating water but also that they are cost-effective and environmentally friendly. FTWs are envisioned to be one of the promising alternatives to conventional wastewater treatment methods as the demand for effective and sustainable solutions intensifies globally. The integration of biological, physical, and chemical processes, together with low-cost and low-maintenance design, makes these wetlands applicable for various uses: from small rural communities to urban stormwater management. As a means to integrate wastewater treatment with ecological restoration, FTWs allow a novel, practical, and sustainable way to address a host of water management related problems in the modern world.

1.1 Background

Water pollution is now a big problem for the environment and public health all over the world, especially in developing countries like India. The rapid growth of cities, industries, and populations has led to a huge increase in the amount of wastewater produced in both rural and urban areas. A lot of this wastewater is dumped directly into natural bodies of water without treatment, which pollutes them, harms ecosystems, and spreads diseases that are spread through water.

In rural areas, there aren't enough sewage systems and treatment plants, so people dump their wastewater directly into ponds, rivers, and farmland nearby. Urban areas also have problems like sewage treatment plants that are too full, high operating costs, and a lack of land. These problems show how badly we need wastewater treatment solutions that are long-lasting, cheap, and work well.

1.2 Concept

Floating wetlands, also known as Floating Treatment Wetlands (FTWs) or artificial floating islands, are an innovative and eco-friendly approach to wastewater treatment. These systems consist of buoyant platforms that support the growth of aquatic plants whose roots extend into the water column.

The plant roots, along with associated microbial communities, play a crucial role in removing pollutants such as suspended solids, nutrients (nitrogen and phosphorus), heavy metals, and organic matter through processes like sedimentation, filtration, adsorption, and microbial degradation.

1.3 Need for study

Conventional wastewater treatment methods require high capital investment, energy consumption, and skilled operation. In contrast, floating wetlands offer a nature-based solution that is cost-effective, easy to maintain, and adaptable to different environmental conditions.

In rural settings, floating wetlands can be installed in existing ponds or water bodies, eliminating the need for complex infrastructure. In urban areas, they can be integrated into lakes, stormwater drains, and retention basins to enhance water quality and aesthetic value.

1.4 Problem statement

Floating wetlands, also known as Floating Treatment Wetlands (FTWs) or artificial floating islands, are an innovative and eco-friendly approach to wastewater treatment. These systems consist of buoyant platforms that support the growth of aquatic plants whose roots extend into the water column.
The plant roots, along with associated microbial communities, play a crucial role in removing pollutants such as suspended solids, nutrients (nitrogen and phosphorus), heavy metals, and organic matter through processes like sedimentation, filtration, adsorption, and microbial degradation.

1.5 Research Gap

Although floating wetlands have shown promising results, there is limited awareness and implementation, particularly in rural areas. Additionally, variations in climatic conditions, plant species, and wastewater characteristics require further research to optimize system performance in different contexts.

Existing Research Gaps:

Floating Treatment Wetlands (FTWs) effectively remove pollutants like BOD, COD, TSS, nitrogen, and phosphorus through plant and microbial action, with removal efficiencies up to 50–80%. They are widely used in urban lakes, stormwater systems, and rural wastewater treatment, offering a low-cost and eco-friendly solution, though performance varies with conditions.

How This Study Contributes to the Field:

- Established FTWs as a sustainable and low-cost wastewater treatment method
- Demonstrated effective removal of BOD, COD, nutrients, and suspended solids
- Identified key factors like plant species, climate, and design parameters affecting performance
- Supported use of FTWs in both rural and urban environments

1.6 Objectives of the Study

- To study the design and working mechanism of floating wetlands
- To evaluate their efficiency in treating wastewater
- To compare their applicability in rural and urban areas

Primary Objectives:

- To evaluate the efficiency of floating wetlands in treating wastewater in rural and urban areas

Secondary Objectives:

- To study the design and working mechanism of FTWs
- To analyze removal of BOD, COD, TSS, and nutrients
- To compare performance in rural vs urban conditions
- To assess cost-effectiveness and sustainability

Material required

- Platform: PVC pipes, bamboo, or plastic bottles used to make the floating base.
- Supporting Mat: Coconut coir, thermocol sheet, or synthetic mesh to hold plants.
- Aquatic Plants: Canna indica, Typha latifolia, Eichhornia crassipes, or Phragmites australis etc.
- Anchoring Materials: Ropes, nets, and weights to keep the setup stable in water.
- Water Source: Domestic or municipal wastewater sample.
- Testing Equipment: Beakers, pH meter, turbidity meter, DO meter, reagents for BOD and COD tests.
- Safety Tools: Gloves, boots, and protective gear for handling wastewater.

- In short: Floating base mat, aquatic plants (water hyacinth, vetiver grass), inlet and outlet pipes, sample collection jars, testing kits for pH, BOD, COD, TSS, and nitrate levels.

Advantages:

• Low-cost and sustainable wastewater treatment option.
• Easy installation and minimal maintenance.
• Improves aesthetic value of water bodies.
• Supports biodiversity and aquatic habitat restoration.
• Effective in nutrient and heavy metal removal.
• Operates without electricity or complex infrastructure.

Disadvantages:

• Limited treatment capacity for large-scale sewage systems.
• Performance may vary with climatic conditions.
• Requires periodic plant harvesting.
• May not be suitable for highly polluted or industrial wastewater.
• Risk of plant decay or pest infestation if not maintained properly.

Mostly asked Question

1 What are Floating Wetlands?
-Floating wetlands consist of artificial platforms that float on the surface of water bodies. They support vegetation with roots extending into the water and provide a natural habitat for microorganisms that break down pollutants. The root zone would work as a biological filter to improve the quality of water.

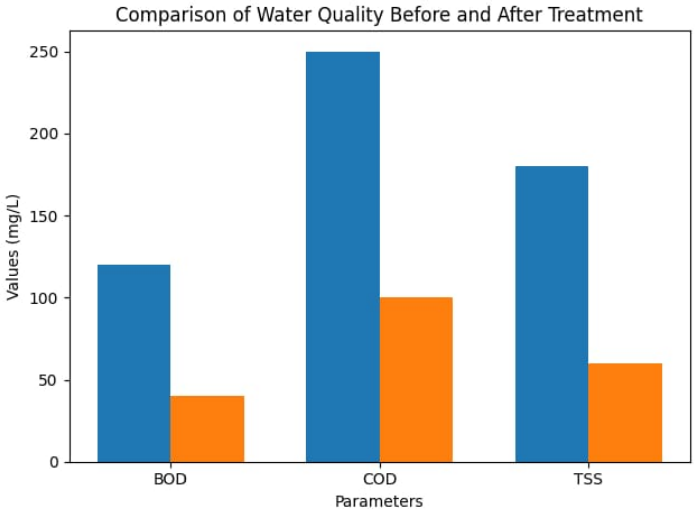
2 Need for Wastewater Treatment
-Wastewater contains organic matter and nutrients from domestic and industrial sources, besides harmful microorganisms, which cause water pollution and degrade the environment. Floating wetlands thus offer an efficient and sustainable alternative to conventional treatment systems.

3 Working Principle of Floating Wetlands
-It involves the ability of plant roots and biofilms to absorb and degrade pollutants. As water passes through the roots, contaminants like nitrogen, phosphorus, and heavy metals are removed by microbial processes, with a portion taken up by the plant.

4 Applications
-Floating wetlands find applications for lakes, ponds, sewage treatment plants, industrial effluents, and stormwater management systems. They also enhance the aesthetic value of water bodies while improving biodiversity.

Result Analysis

Parameter	Before Treatment	After Treatment	% Removal
BOD	120 mg/L	40 mg/L	66%
COD	250 mg/L	100 mg/L	60%
TSS	180 mg/L	60 mg/L	67%
pH	7.5	7.0	--



BLUE: Before Treatment
ORANGE: After Treatment

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CONCLUSIONS

Floating Treatment Wetlands are innovative, sustainable, and effective ways of treating wastewater and sewage. By incorporating the natural processes of aquatic plants into microbial activity, FTWs can efficiently remove organic matter, nutrients, suspended solids, and even certain emerging contaminants in wastewater. They can fit various water bodies, from ponds to lakes, canals, and urban drainage channels, suitable for decentralized treatment in small communities, urban areas, and regions with limited resources. Full-scale and pilot studies conducted have proven that they are capable of yielding high percentage reductions in pollutants and, therefore, can be considered as an economical and ecologically viable alternative to conventional wastewater treatment systems. Other important ecological benefits of FTWs include the restoration of habitats for aquatic organisms and submerged and emerged vegetation, promotion of biodiversity, and the increase in aesthetic values in water bodies. Overall, FTWs offer a practical, flexible, and sustainable solution to modern wastewater challenges. Their combination of efficiency, low maintenance, and ecological benefits places them as an important tool in reaching water sustainability, environmental protection, and public health goals. With continued research and

optimization, FTWs could become a standard solution for both domestic and municipal wastewater management worldwide.

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