WASTEWATER TREATMENT THROUGH CONSTRUCTED FLOATING WETLAND

By

FIBA M (2021-02-019)

SHAHLA SHERIN P P (2021-02-028)

ARATHI N (2021-02-041)

SHAHANA M (2020-02-037)

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the degree of

BACHELOR OF TECHNOLOGY IN AGRICULTURAL ENGINEERING

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

DEPARTMENT OF SOIL AND WATER CONSERVATION ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND FOOD TECHNOLOGY

Tavanur-679573, Malappuram

Kerala, India

2025

DECLARATION

We hereby declare that this project entitled **“WASTE WATER TREATMENT THROUGH CONSTRUCTED FLOATING WETLAND”** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of another university or society.

Place : Tavanur

Date : 31/05/2025

Fiba M

(2021-02-019)

Shahla Sherin P P

(2021-02-028)

Arathi N

(2021-02-041)

Shahana M

(2020-02-037)

CERTIFICATE

Certified that the project entitled **“Waste water treatment through constructed floating wetland”** is a record of project work done jointly by **Ms. Fiba M (2021-02-019), Ms. Shahla Sherin P P (2021-02-028), Ms. Arathi N (2021-02-041)** and **Ms. Shahana M (2020-02-037)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

Place :Tavanur

Date :31/05/2025

Guide

Dr. Jinu.

Asst. professor

Dept. of SWCE

KCAEFT Tavanur

Co-Guide

Dr. Anjaly C Sunny

Assistant professor(c)

Dept. of SWCE

KCAEFT, Tavanur

ACKNOWLEDGEMENT

It is our prerogative to express profound gratitude and respect to our guide, ***Dr.Jinu.A****, Asst. Professor, Department of Soil and Water and Conservation Engineering, KCAEFT, Tavanur for his inexplicable support and guidance throughout our endeavor.*

We are also indebted to ***Dr.Jayan P R****, Dean, Kelappaji College of Agricultural Engineering and Food Technology, Tavanur, for providing us with the necessary support and permissions to carry out our work with ease. We cannot suffice enough to thank our beloved teacher,* ***Dr. Anjaly C Sunny****, Asst. professor(C), Dept. of SWCE, KCAEFT for her sincere support, aid and continuous guidance throughout our journey till the end which were definitely a motivational thrust for us to achieve accomplishment.*

I take this opportunity to express our sincere gratitude to ***Dr. Anu Varughese****, Asst. Warden, LH, KCAEFT for providing permission and support to carry out our study in hostel premises.*

We also ***thank Dr. Abdul Hakkim V M****, Professor and Head, Department of SWCE and* ***Dr. Rema K P,*** *Professor and Head, Dept. of IDE, KCAEFT, Tavanur and all other teachers for their valuable advice and criticism during the study.*

Our following hearty gratitude to all the Technicians, especially in the workshop and laboratories and the Staffs and Labourers of KCAEFT, for their untiring effort and dedication for the fabrication of the unit and valuable help without whom our work would never have been completed.

We also wish to remember and gratify our Parents, who always bless us for our betterment and pray for our success.

Finally, we thank all those, who directly or indirectly helped us.

Fiba M

Shahla Sherin PP

Arathi N

Shahana M

DEDICATED TO OUR AGRICULTURAL ENGINEERING PROFESSION

CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

SYMBOLS AND ABBREVIATIONS

Asst.: Assistant

BOD: Biological Oxygen Demand

Ca: Calsium

COD: Chemical Oxygen Demand

CFW: Constructed floating wetland

Dept.: Department

E.g.: Example

EC: Electrical Conductivity

et al.: And others

Etc.: Etcetera

Fig.: Figure

GW: Grey water

h: Hour

HF: Horizontal Flow

HRT: Hydraulic Retention Time

IDEN: Irrigation and Drainage Engineering

i.e: That is

KCAET: Kelappaji College of Agricultural Engineering and Technology

LH: Ladies Hostel

L: liter

L/p/d: Liter per person per day

Lpcd: Liter Per Capital per Day

LWRCE: Land and Water Resources and Conservation Engineering

m: meter

Mg: Magnesium

mg/l: milligram per liter

mm: millimeter

N: Nitrogen

Na: Sodium

P: Phosphorous

PVC: Poly Vinyl Chloride

SFCW: Subsurface Flow Constructed Wetland

S: Sulfur

S/m: Siemen per meter

Sp.: species

TC: Total Carbon

TDS: Total Dissolved Solid

WHO: World Health Organisaton

%: Percentage

&: And

℃: Degree Celsius

/: Per

°: Degree

INTRODUCTION

CHAPTER I

INTRODUCTION

Water is one of nature's most precious gifts to humanity. It is the most essential component of life and is crucial for the sustenance of all living beings. Although water covers approximately 70% of the Earth's surface, it is often mistakenly considered an abundant and inexhaustible resource. In reality, freshwater is the type we rely on for drinking, bathing, and irrigation is extremely limited. Only about 3% of the world's total water is freshwater, and nearly two-thirds of that are locked away in glaciers or otherwise inaccessible (Baker, 1972).

The growing scarcity of water is primarily driven by rapid population growth, inefficient and improper water use, and the lack of effective recycling and reuse methods. Consequently, around 1.1 billion people globally lack access to safe drinking water, and about 2.7 billion experience water scarcity for at least one month each year. Additionally, inadequate sanitation affects approximately 2.4 billion people, exposing them to diseases such as cholera, typhoid, and other waterborne illnesses. Tragically, diarrheal diseases alone claim the lives of around two million people annually, most of whom are children.

Many of the natural water systems that support both ecosystems and human populations are under severe stress. Rivers, lakes, and aquifers are either drying up or becoming too polluted to use. Over half of the world's wetlands have already been lost. Agriculture is the largest consumer of water and is notorious for its inefficiency, leading to significant wastage. Furthermore, climate change is drastically altering global weather and water distribution patterns, intensifying droughts and water shortages in some areas while causing floods in others.

If current consumption patterns prevail unchecked, the situation will deteriorate further. By 2025, it is estimated that two-thirds of the global population could be living under water-stressed conditions, placing immense pressure on ecosystems and human communities alike.

Most developing countries are located in regions of the world that are either already facing water scarcity or are expected to experience it in the near future. This challenge is further compounded by the degradation of existing water sources due to pollution. In many cases, untreated sewage and industrial wastewater are directly discharged into rivers, lakes, and other surface water bodies, significantly impairing water quality. As a result, it becomes crucial to reduce reliance on both surface and groundwater across all sectors of water consumption. To ensure sustainable water management, efforts must be made to substitute freshwater with alternative sources and to enhance water use efficiency through the treatment and reuse of wastewater.

Wastewater refers to any water that has been negatively affected in quality due to human activities. It includes liquid waste from domestic households, commercial establishments such as offices and retail buildings, as well as discharges from industrial and agricultural operations. Wastewater, if properly treated, holds great potential as a supplementary water source, particularly in regions where freshwater availability is limited.

Among the alternative water sources commonly considered for reuse are rainwater and greywater. Rainwater harvesting, followed by appropriate treatment, is particularly valuable in areas that receive significant rainfall and can provide a reliable source of water for non-potable uses. On the other hand, greywater defined as the relatively clean wastewater generated from household activities such as bathing, laundry, and kitchen use has become an increasingly viable option, especially in developing countries experiencing rapid urbanization and industrial growth (Jamrah *et al*., 2006).

The potential for grey water reuse is considerable, given its substantial share in domestic wastewater generation. Research indicates that approximately 27% of grey water originates from kitchen sinks and dishwashers, 47% from wash basins, bathrooms, and showers, and 26% from laundry and washing machines (Jamrah *et al*., 2006; Al-Mughalles *et al*., 2012; Ghaitidak and Yadav, 2013).

1.1 BENEFITS OF GREY WATER RECYCLING

- Lower fresh water extraction from river and aquifers
- Reduce strain in septic tank or treatment systems
- Indoor usage E.g. toilet flushing

- Irrigation and plant growth
- Less energy and chemical use
- Highly effective purification
- Ground water recharge
- Maintain soil fertility
- Enhance water quality

Grey water can be treated through a variety of methods, including both chemical and physical processes. While chemical treatments are commonly used, there is an increasing emphasis on environmentally friendly alternatives that are both sustainable and cost-effective. One such approach involves the use of wetlands either naturally occurring or man-made—which serve as effective systems for water treatment by mimicking natural ecological processes.

Wetlands are areas where water either saturates the soil or remains at or near the soil surface for varying periods throughout the year. This consistent presence of water supports the growth of both aquatic and terrestrial plant species. One of the key features of wetlands is the presence of large aquatic plants, known as macrophytes, which play a vital role in the filtration and treatment processes. Wetlands are often referred to as "nature's kidneys" because of their ability to purify water and remove pollutants from the environment. These ecosystems are highly sensitive and are greatly influenced by hydrologic and soil conditions.

Examples of naturally occurring wetlands include marshes, bogs, and swamps. In these ecosystems, the interaction between water, soil, and vegetation facilitates the breakdown and transformation of chemicals, a process known as biogeochemical cycling. Wetlands significantly influence these cycles, contributing to the natural treatment and improvement of water quality. The application of constructed wetlands for greywater treatment represents a practical and ecologically sound method, especially for developing regions seeking sustainable water management solutions.

Some of the functions of wetlands are given below

- Wetlands can provide water quality improvements
- Recycling of nutrients and other materials

- Habitat fish and wild life
- Used for education and research purposes
- Support many of living organisms
- Flood storage and desynchronisation of storm rainfall and surface runoff etc

The treatment of wastewater using floating treatment wetlands (FTWs) is an emerging and suitable method that has gained attention in various parts of the world, especially in areas with limited space for traditional land-based treatment systems. A floating treatment wetland is defined as a vegetated buoyant platform that floats on the surface of water bodies such as ponds, lakes, or wastewater lagoons. Unlike constructed wetlands that are built on land, FTWs operate directly on the water surface and are specifically designed for pollution control and water quality enhancement.

Floating wetlands function by utilizing aquatic plants rooted in a floating mat, allowing their roots to extend below the surface into the water column. These roots act as natural biofilters by providing surfaces for microbial communities to grow. These microorganisms, along with the plants, play a crucial role in nutrient uptake, organic matter degradation, and the removal of pollutants. Commonly used plants in FTWs include emergent species such as cattails (*Typha spp*.), bulrushes (*Scirpus spp*.), and reeds (*Phragmites spp*.), which are known for their tolerance to waterlogged conditions and their ability to support microbial activity.

One of the key advantages of FTWs is their ability to improve water quality in existing water bodies without the need for land excavation or significant infrastructure. The roots of the floating plants oxygenate the surrounding water, creating favorable aerobic conditions for the breakdown of pollutants such as biochemical oxygen demand (BOD), nutrients like nitrogen and phosphorus, suspended solids, and some heavy metals. Moreover, FTWs provide habitat for aquatic life and can enhance the aesthetic appeal of treatment ponds and urban water features.

Floating treatment wetlands are increasingly being adopted for applications such as greywater treatment, stormwater management, and the polishing of treated effluents. Their modular and low-maintenance design makes them particularly suitable for decentralized water treatment systems. In this context, floating wetlands can serve as an alternative and sustainable water treatment option, with the potential to reuse treated water for non-potable purposes such as landscape irrigation, aquaculture, and environmental restoration.

In this project, we focus on grey water treatment by using constructed floating wetland and its use as an alternative water resource for irrigation purpose.

Objectives

1) To design and fabricate the floating wetland by using suitable substrate and plants

2) To evaluate the performance of constructed floating wetland.

REVIEW OF LITRATURE

CHAPTER 2

REVIEW OF LITRATURE

The increased urbanization and industrialization will lead to increased freshwater demand and hence enhanced ground water exploitation. But the available freshwater quantity is nearly constant. Hence in the near future, some sort of waste water treatment and reuse will be unavoidable. Wastewater treatment will have two major positive effects on environment. It will help to reduce the pollution of water bodies, bad odor, insects like mosquitoes and snails, and also reduce the demand of freshwater. For human, soil, crop and environmental risk-free wastewater reuse, some sort of treatment is necessary.

2.1 GREY WATER

Grey water is defined as the urban wastewater that includes water from baths, showers, hand basins, washing machines, dishwashers and kitchen sinks, but excludes streams from toilets. Grey water constitutes 50–80% of the total household wastewater. Grey water is generated as a result of the living habits of the people involved, the products used and the nature of the installation and, therefore, its characteristics are highly variable. (Li *et al*., 2009). Grey water is relatively low in pollution and therefore, after appropriate treatment, has great potential for reuse in non-potable water applications such as infiltration, irrigation, toilet flushing, washing water, etc. An average BOD/COD ratio of 0.45±0.13 gives an indication of the good aerobic biological treatability of grey water. A COD: N:P ratio of 100:20:1 is required for aerobic treatment and a ratio of 350:5:1 is required for anaerobic treatment. In grey water, this ratio is 100:3.5± 1.3:1.6±0.7, which indicates a nitrogen deficiency for aerobic treatment, but not for anaerobic treatment. Only about 3% of the nitrogen from household wastewater is discharged with grey water, as about 87% is in urine and 10% in faeces. Furthermore, a large fraction of the total nitrogen in grey water was organically bound, the fraction of ammonium– nitrogen was on average 0.34±0.13, which is significantly less than in sewage where most nitrogen is present as ammonium. (Li *et al*., 2009).

Grey water re-use for garden irrigation should be encouraged in urban and rural households. It utilizes a valuable on-site resource which is otherwise wasted, conserves precious drinking water and reduces the load on wastewater disposal systems (both on-site and centralized). If applied appropriately to gardens, grey water re-use presents minimal health risks and environmental pollution. It conserves fresh water which can remain in natural ecosystems.

An average urban house uses 820 litres of water per day for indoor and outdoor use. This encompasses toilet (140 litre), grey water (340 litre) and outdoor (340 litre) use. Grey water is generated in the bathroom (180 litre), laundry (110 litre) and kitchen (55 litre). Each house varies from these averages depending on appliances and habits, but the volumes indicate that a lot of grey water is generated that generally disappears down the plug-hole never to be seen or re-used again. The reuse of grey water for non-potable water applications is a potential solution for water deprived regions worldwide. Adequate treatment of grey water prior to reuse is important to reduce the risks of pathogen transmission and to improve the efficacy of subsequent disinfection. (Winward *et al*., 2008).

2.2 CONSTRUCTED WETLAND

Surve (2007) conducted treatment performance of recycled grey water collected from the bathroom outlets of men"s hostel KCAET, Tavanur, by subsurface flow constructed wetland (SFCW). It was evaluated removal efficiency of various parameters. The parameters analysed for the study were pH, BOD5, TSS, sulphate, phosphate etc. done for both influent and effluent. The yield and growth of vegetation irrigated by both recycled and untreated grey water were studied.

Nafla K and Navaneeth B S (2018) conducted a study at the Ladies' Hostel premises of KCAET, Tavanur, to evaluate the performance of a SFCW for treating grey water collected from bathroom outlets. The experimental setup involved pre-treatment units, a sedimentation tank, and a planted wetland system using Heliconia as the macrophyte. Various parameters such as pH, BOD_5, COD, TSS, TN, TP, TS, salinity, and oil and grease were analysed for both influent and effluent samples. The study aimed to assess the pollutant removal efficiency and found significant reductions in BOD_5 (up to 95.8%), COD, and TSS, indicating the effectiveness of SFCW as a low-cost and eco-friendly grey water treatment method suitable for reuse in irrigation.

Athira P. M., Chithra M. R., and Dibisha K. Das (2018) conducted a study at the Ladies' Hostel premises of KCAET, Tavanur, to compare the effectiveness of SFCW and coagulation methods in treating grey water from bathroom outlets. The SFCW system included a sedimentation tank, suitable filter media, and vegetation using Canna as the macrophyte, while the coagulation method involved a chemical treatment with alum. The influent and effluent samples were analysed for parameters such as pH, BOD_5, COD, TSS, TN, TP, oil and grease. Results showed that the SFCW achieved a BOD_5 removal efficiency of up to 97% and COD removal of about 50%, indicating its potential as a sustainable and eco-friendly method for grey water treatment suitable for reuse in irrigation. The study highlighted the advantages of SFCW in terms of simplicity, cost-effectiveness, and long-term performance.

2.3 FLOATING WETLAND

Floating rafts technology which is totally plants based (natural plant-based-eco-friendly) pollutants removal technique by the process called phytoremediation, maybe add into existing technologies and its application may leads to more pollutant reduction, not only because of its less installation cost, higher phytoremediation efficiency, no further production of any toxic pollutants, but also because, it can lead to further addition in ecological biodiversity as plants are used. Floating rafts technique is also known as Ecological Floating Island/Artificial Floating Island, because it utilizes the technical principle of soilless culture (which is known as hydroponics) on the artificial floating platform made up of bamboo/ PVC and plastic mess to batter supports plant growth. Vegetation is considered as a dominant feature of floating rafts and acts as an important biotic factor in the overall treatment process (Solanki *et al.*,2017).

Constructed floating wetland is an engineered system which makes use of the aquatic plants and natural processes to remove the contaminants from wastewater. The floating wetland system works on the principle of phytoremediation in which aquatic plants extract the contaminants through their roots from wastewater. This system works like natural method in which only a single plant can remove the multi-pollutants from wastewater. Many floating plants can be used in the wetland for removal of contaminants, but plant selection criteria depend on the climate conditions, nature of wastewater and nutrients to be removed. The main objectives of this study were to evaluate all environmental work that sustains a treatment system; to assess the environmental impacts of treatment systems, and to document the economic analysis of treatment system. (Arshad *et al.,*2017).

2.4 ROLE OF PLANTS

Plants play a crucial role in floating wetland wastewater treatment by supporting microbial activity, removing pollutants, and improving water quality. Their roots provide a habitat for beneficial bacteria that break down organic matter and absorb heavy metals and nutrients through phytoremediation processes like phyto-extraction and rhizo-filtration, also plants aid in nutrient removal by absorbing excess nitrogen and phosphorus, preventing eutrophication. Their root systems act as natural filters, trapping suspended solids and enhancing sedimentation. Some species also facilitate oxygen transfer, promoting aerobic microbial activity for pollutant breakdown. Plants enhance the efficiency of floating wetlands by contributing to biological, chemical, and physical treatment mechanisms, making them a sustainable and cost-effective wastewater treatment solution. (Sanjrani *et al*., 2020)

Kanabkaew *et al. (*2004) studied the feasibility of aquatic plants in domestic wastewater treatment. A pilot scale aquatic pond, with dimensions of 1.8 m in length, 0.6 m in width and 1.2 m in depth, was constructed at the Hat Yai Municipality Central Wastewater Treatment Plant, Thailand. Wastewater was introduced to the systems using peristaltic pumps to maintain a fixed flow rate at HRT of 5.4 and 10.5 days, respectively. Lotus (*Nelumbo nucifera*) and hydrilla (*Hydrilla verticillata*) were planted along with one control unit. Influent and effluent were analyzed 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 without plants. The system with lotus showed the best removal efficiency for wastewater treatment. For the system with hydrilla, it was found that pH and TSS of the effluent were high. It might not be suitable to use hydrilla for effluent polishing. This study could emphasize that lotus and hydrilla could provide an alternative aquatic plant system for wastewater treatment.

Barco *et al*. (2020) studied the feasibility of ornamental plants in floating wetland for treating domestic wastewater. Herbaceous ornamental plant species that could form an interesting opportunity to improve water quality and the aesthetic-ornamental value of urban water bodies. A pilot scale FTW was installed in Northern Italy to assess the growth performances of eleven wetland species having ornamental features*: Canna indica L., Pontederia cordata L., Thalia dealbata Fraser ex Roscoe, Acorus calamus L., Juncus effusus L., Iris laevigata L.,Mentha aquatica L., Oenanthe javanica (Blume) DC., Caltha palustris L., Sparganium erectum L.* and *Zantedeschia aetiopica (L.) Srengel.* For these species, a suitability index was elaborated that considers plant survivability, above-mat biomass production, nitrogen uptake, root length and root-shoot ratio. On this basis, the results obtained clearly indicated that *C. indica, P. cordata* and *T.dealbata* were the most suitable species for FTW due to their high vigor and colonization of the floating mats of above-mat dry biomass, root length, root-shoot ratio, survival, nitrogen uptake, respectively. On the contrary, *A. calamus, S. erectum* and *Zantedeschia aetiopica* did not present adequate features for use in FTWs.

Vlek *et al*. (2014) studied the contribution of plant uptake to the overall removal capacity of Floating Treatment Wetlands (FTWs). A batch mesocosm experiment was conducted using polyethylene tanks covered with floating Styrofoam mats. The study included control tanks with only Styrofoam cover and treatment tanks planted *with Iris pseudacorus* and *Typha angustifolia*. Nutrients were added weekly to maintain consistent nitrogen and phosphorus concentrations. The results showed that Typha had relatively low removal efficiency due to limited biomass increase, while Iris significantly enhanced nutrient removal. The removal rates in Iris-planted tanks were substantially higher than in control tanks, with plant uptake playing a major role in nitrogen and phosphorus removal. These findings suggest that FTWs with *Iris pseudacorus* can be effective in temperate climates for mitigating excessive algae growth in surface waters. Some of the plants are listed in table 2.1.

Table 2.1 Some of the Plants used in CFW

Family	Scientific name	Common name
Alismataceae	*Sagittaria lancifolia*	Bulltongue arrowhead
Araceae	*Pistia stratiotes*	Watter lettuce
Araceae	*Lemna valdiviana*	Duckweed
Araceae	*Spirodela sp.*	Duckweed
Ceratopphyllaceae	*Ceratophyllum demersum*	Hornwort
Cyperaceae	*Scirpus californicus*	Bulrushes
Cyperaceae	*Eleocharis sphacelata*	Spike sedge
Cyperaceae	*Cyperus giganteus*	Umbrella plant
Cannaceae	*Canna phasion*	Cnna indica
Cannaceae	*Canna generalis*	Canna lilly
Poaceae	*Chrysopogon Zizanioides*	Vetiver
Poaceae	*Phragmites communis*	Common reed
Juncaceae	*Juncus effusus*	Juncus
Typhaceae	*Typha angustifolia*	Crrow leaved cattail
Pontederiaceae	*Eichhornia crassipes*	Water hyacinth

2.5 SELECTION OF SUITABLE FILTER MEDIA

Constructed Floating Wetlands (CFWs) utilize a floating medium composed of buoyant carriers that support macrophytes, allowing their roots to extend into the water for pollutant removal. This medium provides a stable anchorage for plants while facilitating nutrient uptake, microbial biofilm growth, and suspended solids filtration. The design varies, with conventional floating mats supporting plant growth, while hybrid CFWs integrate submerged plants and artificial biofilm carriers for enhanced efficiency. Beyond water purification, the floating medium also contributes to ecological benefits by creating habitats, reducing algal blooms through shading, and regulating water temperature. These multifunctional systems play a crucial role in restoring aquatic ecosystems affected by pollution and eutrophication, for example of a floating medium includes buoyant carriers made from materials like bamboo fiber , wood, coconut coir, pumice, perlite, coarse peat, and zeolite. These materials support plant growth, provide a large surface area for microbial biofilm development, and contribute to nutrient absorption (Headley and Tanner, 2006). The removal of N and P by the soil matrix is mainly based on precipitation and adsorption. The characteristics of the soil matrix will directly affect the sewage purification capacity and the final landscape. Nitrogen adsorption capacity followed the order chaff > ceramsite > activated carbon > zeolite, whereas for P adsorption, the order was zeolite > ceramsite > activated carbon > chaff (Wang *et al*., 2023).

In 2011 Cao and Zhang , evaluated two substrates rice straw and plastic filling as well as the lack of substrate to determine the TN and NH_4 removal rates for floats planted with Canna sp. and Calamus sp. In terms of TN elimination, rice straw outperformed the other two by a considerable margin. Additionally, using rice straw as a substrate increased the overall number of nitrifying and denitrifying bacteria as well as their abundance in comparison to using plastic filler. Like other biomaterials, rice straw can create a thick biofilm that serves as a source of carbon and oxygen, which is necessary for the nitrification and denitrification processes.

According to Zhao *et al*. (2012), in the absence of substrate roots, plants are forced to absorb nutrients directly from the water column, which enhances nutrient uptake. However, to support plant establishment in Constructed Floating Wetlands (CFWs), various growth media have been employed, including coarse peat, coconut fiber, pumice, perlite, soil, bamboo charcoal, sand, and compost.

2.6 TYPES OF POLLUTANTS TREATED

2.6.1 Suspended solids

In CFWs, plant roots absorb dissolved organic matter from wastewater and form a mat-like structure that facilitates oxygen transfer from leaves to roots, enhancing the activity of nitrifiers and aerobic microbes (Abed *et al*., 2017; Billore *et al*., 2009; Samal *et al*., 2018). Through rhizodeposition, roots exude organic acids, amino acids, sugars, and vitamins, promoting microbial colonization and biofilm formation (Chang *et al*., 2013). These biofilms aid in the biodegradation of organic pollutants as wastewater passes through the root mat (Chen *et al*., 2012). Water flow enhances the removal of suspended solids via sedimentation, especially in stormwater ponds compared to stagnant waters (Upal *et al*., 2000).

The study titled "Constructed Floating Wetland for the Treatment of Domestic Sewage: A Real-Scale Study" by Tatiane Benvenuti *et al.* was conducted in Novo Hamburgo, South Brazil, at a municipal sewage treatment plant. This real-scale experiment used *Typha domingensis Pers*. on a CFW system to treat domestic sewage from a community of 600 residents. The floating wetland system, in continuous operation since 2012, was monitored over 12 months, evaluating its efficiency in reducing organic matter and nutrients in raw sewage. The study found removal efficiencies of 55% for COD, 56% for BOD_5, 78% for TSS, 41% for total Kjeldahl nitrogen (TKN), and 37% for total phosphorus (TP), showcasing the system's potential as a low-cost, sustainable wastewater treatment alternative.

2.6.2 Nitrogen and Phosphorous Removal

Aquatic plants like water lilies and canna play a significant role in removing nitrogen (N) and phosphorus (P) from eutrophic waters due to their rapid vegetative growth and pollutant uptake (Solanki *et al*., 2017). These plants absorb inorganic N and P directly through their roots (rhizoaccumulation), incorporating them into plant biomass as proteins and organic compounds. Among FTWs, *Pistia stratiotes* showed high nutrient removal efficiencies: 70% ammonium, 59% organic matter, and 29.5% phosphate. Other plants showed varying efficiencies—duckweed (TN 46%, TP 46%), green algae (TN 30%, TP 27%), and water hyacinth (TN 32%, TP 16%). FTWs with

Cyperus ustulatus, Juncus edgariae, and Schoenoplectus removed TN at 45% and TP at 32% from lake water (Arivukkarasu & Sathyananthan, 2022).

Nitrogen removal in FTWs occurs through several mechanisms: ammonification, ammonia volatilization, nitrification–denitrification, microbial absorption, and plant uptake (Vymazal, 2007). Nitrification–denitrification is the primary biological pathway, where ammonia is first oxidized to nitrate (nitrification), and then reduced to nitrogen gas (denitrification), which is released into the atmosphere (Pavlineri *et al*., 2017). Ammonification transforms organic nitrogen into ammonium ($NH4^+$-N), which may volatilize under alkaline conditions or be absorbed by plant roots. Nitrifying bacteria (e.g., Nitrosomonas, Nitrosospira, Nitrococcus) convert NH_4^+-N to NO^{3-}-N. In the oxygen-deficient bottom zone of water bodies, denitrifying bacteria (e.g., Bacillus, Neisseria, Pseudomonas) reduce $NO3^-$-N to N_2 and N_2O gases (Samal *et al*., 2019).

2.6.3 Heavy Metals

Aquatic plants remove heavy metals from wastewater through phytoremediation processes such as phytoaccumulation, Phyto stabilization, phytovolatilization, phytodegradation, Phyto filtration, and phytoextraction. Metals are primarily absorbed by roots and translocated to aerial parts, allowing extraction upon harvesting (Samal *et al*., 2019). The efficiency depends on plant species and pollutant concentration. Floating plants absorb metals via root-water contact, with transport occurring through passive or active mechanisms across membranes. *Phragmites australis* showed greater heavy metal uptake than *Typha latifolia* in monoculture, but co-cultivation enhanced removal efficiency. This improvement is attributed to expanded rhizospheres, which support microbial growth and enhance metal immobilization and uptake (Kumari & Tripathi, 2015). Different aquatic plant species vary significantly in their ability to remove heavy metals from contaminated water. *Lemna minor* exhibits the highest removal efficiency, effectively absorbing a wide range of heavy metals, which highlights its strong potential for phytoremediation applications. *Eichhornia crassipes* shows moderate performance, capable of removing several heavy metals. In contrast, *Pistia stratiotes* and *Salvinia spp.* demonstrate limited removal capabilities, with effectiveness restricted to a single heavy metal each. These differences emphasize the suitability of Lemna minor for use in Floating Treatment Wetlands (FTWs) or similar systems designed to treat heavy metal pollution (Samal *et al.,* 2019).

2.6.4 Pesticides and Herbicides

The elimination of pesticides and herbicides in aquatic treatment systems primarily occurs through microbial degradation and reversible adsorption, while direct plant uptake is minimal (<0.6%) (Chen *et al*., 2017). Due to their high octanol-water partition coefficients, many pesticides bind to root surface lipids without further translocation into plant tissues. Although this reduces their concentration in the water, some residues may still persist. Moderately sorbing herbicides like metazachlor and isoproturon can be remobilized under certain conditions (Passeport *et al.,* 2011). However, over 90% of chloroacetanilide herbicides were removed within 9 days via root adsorption and plant-enhanced microbial activity, demonstrating the effectiveness of plant microbe interactions in contaminant removal (Chen *et al*., 2017).

2.7 HYDRAULIC RETENTION TIME (HRT)

HRT is a fundamental design parameter in constructed floating wetlands, representing the average time that water stays within the system. It directly influences the efficiency of contaminant removal, including nutrients, suspended solids, and pathogens. In floating wetlands, the water flows beneath the buoyant plant mats, creating a subsurface flow pattern that enhances the interaction between water, plant roots, and microbial communities. A longer HRT allows more time for sedimentation, nutrient uptake by plant roots, and microbial degradation of pollutants. This leads to greater treatment efficiency, especially for nutrients such as nitrogen and phosphorus. The floating vegetation platforms help reduce turbulence and short-circuiting by distributing flow more evenly and increasing the effective pathway water must travel through the system. Moreover, the plant roots that dangle into the water column provide a large surface area for biofilm development, further enhancing pollutant breakdown. These biological and physical mechanisms work best when water resides in the system for sufficient time, making HRT a critical factor in the performance of CFWs (Headley and Tanner, 2012).

HRT has an impact on wastewater treatment performance. HRT, is a crucial metric for figuring out how long microorganisms require to proliferate and how long organic compounds take to break down. The duration of interaction between treated water and floating artificial wetlands is influenced by hydraulic retention time. It will take longer to remove metal impurities if the HRT is low.

HRT = V/Q (Headley and Tanner, 2012)

2.8 PERFORMANCE EVALUATION

Floating Treatment Wetlands (FTWs) are an innovative water purification method using floating plant mats instead of rooted systems. They effectively remove pollutants like nitrogen (N), phosphorus (P), biochemical oxygen demand (BOD), and chemical oxygen demand (COD), making them suitable for river water treatment. Studies worldwide show varying success rates. FTWs at Heathrow Airport achieved a 43% BOD reduction, while systems in Belgium reduced COD by 33–68%. In China, an FTW on the Pearl River removed 50% of total nitrogen and 95% of COD in five days. Plant selection is crucial, with native species like *Phragmites australis* and *Typha latifolia* performing well. However, *Chrysopogon zizanioides* showed poor adaptation in this study. Overall, FTWs are a promising, adaptable solution for water quality improvement, but their efficiency depends on site-specific conditions and further evaluation (Stefani *et al*., 2011).

Nitrogen removal in FCWs primarily occurs via nitrification-denitrification, facilitated by microbial activity on plant roots. Oxygen availability and organic carbon sources are critical factors influencing these processes. Phosphorus removal, on the other hand, is largely dependent on sedimentation and adsorption, with plant uptake playing a minor role. Organic matter removal is influenced by its biodegradability, often measured using the BOD/COD ratio. Studies suggest that FCWs are more effective when treating highly biodegradable wastewater, as oxygen diffusion from plant roots supports microbial degradation. FCWs also aid in the removal of microbial contaminants like Escherichia coli through protozoa predation, oxidation, and filtration. Well-developed plant root networks enhance biofilm formation, improving coliform reduction. Seasonal variations and hydraulic shock loadings impact FCW performance. Higher pollutant concentrations during dry seasons enhance treatment efficiency, while mature root networks help stabilize the system against sudden pollutant influxes. Overall, FCWs provide a promising alternative to conventional treatment methods, particularly in urban areas with limited land availability (Saeed *et al*., 2016).

This study examines Floating Treatment Wetlands (FTWs) as a retrofit for stormwater ponds to enhance the removal of suspended solids, copper, and zinc. Traditional retention ponds have limited efficiency for dissolved pollutants, whereas FTWs improve filtration through plant-root interactions and biofilm formation. Previous research confirms FTWs' effectiveness in reducing nutrients and heavy metals, though full-scale stormwater applications remain underexplored. Studies suggest their performance depends on plant selection, hydrology, and seasonal variations. FTWs help trap particulate pollutants and create conditions for metal adsorption and precipitation, improving water quality. However, factors like storm intensity and inflow volume influence their efficiency. Overall, FTWs show promise in enhancing stormwater treatment and can serve as an effective alternative to conventional pond systems (Borne *et al*., 2013). Floating Treatment Wetlands (FTWs) enhance stormwater pond performance by removing nitrogen (N) and phosphorus (P) through plant uptake, microbial activity, and nutrient adsorption. Urban runoff contributes significant pollutants, and traditional retention ponds struggle with dissolved nutrients. Studies show FTWs improve nutrient removal, with efficiency influenced by plant species, mat composition, and retention time.

This study compares two FTW technologies Beemats and BioHaven assessing their effectiveness in reducing total nitrogen (TN) and total phosphorus (TP). The literature supports FTWs as a cost-effective, adaptable solution for improving stormwater treatment (Lynch *et al*., 2015).

2.9 ADVANTAGES

2.9.1Tolerance Of Variable Water Depths

The plants in an FTWs are not impacted by water level variations that could submerge and negatively damage bottom-rooted plants in stormwater systems because they float on the water's surface. This also makes it possible to construct the FTWs to function as an extended detention basin, boosting the percentage of storm flow that is treated by capturing significant runoff episodes and releasing them gradually over a few days. (Headley and Tanner, 2006).

2.9.2 Increased Areal Efficiency

Possess the benefit of the extra surface area that the floating mat and root network offer for the development of associated growth microorganisms (biofilms), which are in charge of many of the preferred treatment procedures. For some contaminants, FTWs may be able to achieve a higher level of treatment per unit surface area (improved areal efficiency) due to their capacity to function at deeper water depths than traditional wetlands.

2.9.3 Long Term Management of Accumulated Solid and Sludge

The sediments at the bottom of the underlying basin, apart from the floating mat and related vegetation, are the final long-term sink for solids in an FTW. Therefore, if the entire water surface is not covered in floating mat, there is a larger chance that this collected silt can be removed from the system without causing significant disruption or harm. (Headley and Tanner, 2006).

2.9.4 Plant Uptake

It is conceivable that plant assimilation of nutrients and other elements, such as metals, may be higher in a floating wetland system compared to a sediment-rooted wetland, as the roots hanging beneath the floating mat are in direct contact with the stormwater to be treated. Furthermore, the plant roots are not in contact with the bottom sediments or soil and only have access to nutrients contained within the floating mat and in the water column, much like a hydroponic cultivation system. (Headley and Tanner, 2006).

2.9.5 Aesthetic Enhancement of Ponds

Floating wetlands may be perceived to enhance the aesthetic values of a stormwater treatment pond, depending on the shape, structure and vegetation used. There may also be some additional benefits in terms of provision of habitat for wildlife, such as birds. A floating wetland can provide protection for birds against some predators. However, the attraction of wildlife may also have deleterious effects on water quality through the introduction of faecal material, nutrients and disturbance. Excessive bird numbers can also lead to vegetation decline due to overgrazing and trampling and make it difficult to initially establish plants on the floating structure (Headley and Tanner, 2008).

2.10 DISADVANTAGES

2.10.1 High Initial Costs and Maintenance

CFWs can be expensive to design, construct, and install. The cost increases with scale and the complexity of the system. Regular maintenance is required to manage plant growth and ensure structural integrity (Headley and Tanner, 2006).

2.10.2 Limited Pollutant Removal Efficiency in Some Cases

Their effectiveness in removing certain pollutants such as nitrogen can vary and may not be sufficient for highly polluted waters without additional treatment systems (Wang *et al*., 2023).

2.10.3 Structural Damage Risk

Floating platforms and anchoring systems are vulnerable to damage from strong currents, storms, or vandalism, which can reduce their lifespan (Vymazal, 2011).

2.10.4 Invasive Species and Plant Management Issues

If not carefully managed, invasive plant species may colonize the system or outcompete desired native plants, reducing biodiversity and effectiveness (Vymazal, 2011).

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

Floating wetlands have emerged as a viable solution for treating municipal and industrial wastewater, offering a more affordable alternative to advanced wastewater treatment technologies. These systems are relatively simple to manage and operate, making them especially suitable for developing nations like India, where low-cost and efficient water treatment options are limited. Floating wetlands hold significant promise in regions experiencing water scarcity, particularly for non-potable domestic applications. In light of their environmental benefits, the present study involves the design, development, and short-term evaluation of a pilot-scale floating wetland system.

This chapter outlines the key steps undertaken to meet the research objectives:

3.1 SITE SELECTION

Floating wetland systems are more appropriate than surface-based treatment methods in densely populated areas. Surface wetlands can attract mosquitoes, rodents, and other pests, posing potential public health risks. Therefore, to ensure effective grey water filtration and disposal in residential or institutional settings, floating wetland systems are preferred over traditional surface wetlands. The decision to install a floating wetland system at the Ladies' Hostel premises of KCAEFT was influenced by these considerations.

When evaluating potential sites for the implementation of a floating wetland system for greywater treatment, the following criteria were taken into account:

- Availability and Easy Conveyance of Grey water: The site chosen offers convenient access to a continuous supply of grey water, which is essential for the functioning of the treatment system.
- Land Requirement: An area of approximately 4–5 m^2 within the Ladies' Hostel premises was identified as suitable for setting up the system.
- Site Topography: The natural slope of the site is a critical consideration, as it influences water flow, surface runoff, and the risk of ponding or erosion. A

minimum gradient of 2% is generally recommended to support efficient drainage and system performance.

3.2 OVERVIEW OF THE STUDY AREA

The location for the floating wetland pilot system was selected based on the ease of grey water accessibility and conveyance. The system was established within the premises of the Ladies' Hostel at KCAEFT, situated in Tavanur village of Malappuram district, Kerala. Geographically, the site lies at 10°51′12.4″ N latitude and 75°59′9.3″ E longitude.

This region receives an average annual rainfall of approximately 2952 mm, contributed by both the southwest (June–September) and northeast (October–December) monsoons. The local climate experiences minimum and maximum temperatures ranging between 22°C and 32°C, with an average annual relative humidity of around 83%.

The greywater used in this study was sourced from the bathroom outlets of the Ladies' Hostel. This wastewater, diverted from the original outlet, served as the influent for the treatment system. The bathroom greywater typically contained contaminants such as soap residues, detergents, hair, lint, oils, and minor mineral compounds like sodium (Na), magnesium (Mg), phosphorus (P), sulphur (S), and nitrogen (N), along with a small quantity of dust and microorganisms.

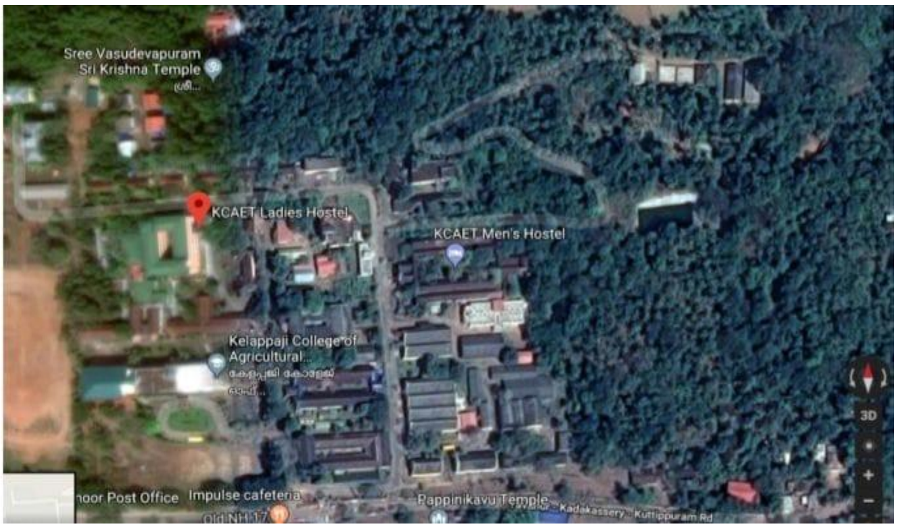

Plate 3.1 Google map location of project site

3.3 GREYWATER CHARACTERISATION

To design an effective floating wetland treatment system, a thorough understanding of the influent's quality is essential. Greywater samples were collected from appropriate outlets for chemical analysis to determine pollutant concentrations. The accuracy and representativeness of sampling-based on proper timing, site selection, and methods—are crucial, as the resulting data guide the system's design.

In this study, greywater samples were collected during peak usage hours (7:30 AM to 8:30 AM) from the diverted bathroom outlets of the hostel. The collected samples were analyzed at the Water Quality Division of the Water Authority Manjeri, MALAPPURAM. Key parameters assessed included Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total dissolved Solids (TDS), Nitrate (NO_3^-), and Phosphate (PO_4^{3-}), pH, Electrical Conductivity (EC).

3.4 EXPERIMENTAL SETUP

The floating wetland system was established considering factors such as space availability, greywater inflow, pre-treatment needs, vegetation, and water conveyance.

3.4.1 Space Considerations

Constraints such as property boundaries, expected inflow volumes, and the site's slope were evaluated to determine the feasible size for the floating wetland installation. The pilot system was constructed within the hostel premises, with greywater from three-bathroom outlets redirected to the treatment area. The system's dimensions were optimized based on the available space and the quantity of greywater to be treated, aiming to meet the target treatment performance.

3.4.2 Pre-Treatment Requirements

Floating wetlands, as biological treatment systems, function effectively only within a specific range of contaminant concentrations. To maintain optimal system performance and longevity, pre-treatment is crucial. It prevents clogging, excessive sludge buildup, and vegetation die-off.

The primary objective of pre-treatment in this setup was to remove solids and reduce the organic load entering the system. This was achieved using two components: a mesh filter and a sedimentation tank.

3.4.2.1 Mesh Filter

A mesh filter was installed at the greywater inlet to remove large solid and semi-solid particles such as hair, plastic, and soap residue. Filters were made from materials like nylon, polyester, or stainless steel, with mesh openings smaller than 10 mm. These filters served as the first stage of pre-treatment and were cleaned manually to maintain performance.

3.4.2.2 Sedimentation Tank

Following the mesh filter, greywater entered a sedimentation tank 220L, which allowed heavier solids to settle at the bottom while lighter substances like oils and grease floated to the surface. The tank is placed on the 1m height frame. The treated water was drawn from the middle layer of the tank to ensure that both settled sludge and floating scum were excluded from entering the floating wetland system.

Plate 3.2 Sedimentation Tank

3.4.3 Constructed Floating Wetland

The efficiency of Floating Wetlands (FWs) in improving water quality has already been demonstrated by many researchers worldwide. Therefore, the FW system has been selected to analyze its performance under tropical climate conditions. Beyond its pollutant reduction capability, the choice of a floating wetland over other wetland types- such as surface or subsurface flow systems- was influenced by additional considerations including minimizing direct human contact with untreated wastewater, reducing mosquito breeding potential, and controlling odour. Given that the experimental constructed wetland system was located within hostel premises and in close proximity to the hostel mess, protecting student health was a key factor in the design of the floating wetland system.

3.4.3.1 Basin

In a FTW system, the basin having size of 1.16 ×0.95×0.8 m serves as a water-holding structure, typically either a natural pond, lake, or an artificially constructed water body, which provides the aquatic environment necessary for the floating wetland to function. Unlike in subsurface systems, the basin in an FTW does not require complete impervious sealing or compartmentalization, as the treatment occurs on the water surface and within the water column. However, it must retain water consistently to support plant growth and maintain contact between the floating mat and the wastewater. The basin provides the physical support for the floating mats- buoyant platforms that host macrophytes. These floating mats are anchored in place but allow plant roots to hang freely into the water, where they interact with pollutants.

Plate 3.3 Basin

3.4.3.2 Floating Mat

The floating mat in a FTW system serves as the primary platform for supporting aquatic plants above the water surface while allowing their roots to extend freely into the water column for treatment purposes. The mat is designed to remain buoyant and stable under various environmental conditions, ensuring continuous contact between plant roots and the wastewater.

In this system, the floating mat was constructed using a lightweight and durable framework composed of PVC pipes, which provided buoyancy and structural rigidity. Trellis netting was securely fastened across the PVC frame to hold planting containers in place. Plastic pots filled with a suitable growing medium, such as coconut coir were placed within the netting. These pots housed the selected macrophytes, such as Canna, enabling easy transplantation, root penetration, and plant management.

This modular design allows for easy assembly, maintenance, and replacement of individual plants or mat sections. It also ensures that the roots are suspended in the water for optimal nutrient uptake and microbial interaction, which enhances the wastewater treatment efficiency of the system.

Plate 3.4 Floating Mat

3.4.3.3 Vegetation

vegetation is the principal component of a wetland system. The ability of the plants to stay healthy and therefore to continue to grow is an important factor in the choice of plants for experiment. The common plants in wetlands are common reed (Phragmites sp.), rush (Juncus sp.), cattail (Typha sp.) and bulrush (Scirpus sp.). The contamination in the selected grey water source is low as compared other industrial grey water, a locally available water tolerant emergent plant Canna was selected for this study.

Canna plants with a minimum stem length of 0.2 meters were sourced from a nursery and transplanted onto FTW mats. The planting was carried out with a spacing of 20 cm between individual plants to ensure adequate root development and nutrient uptake efficiency. Following transplantation, the FTW system was maintained with daily freshwater application for plant acclimatization. A period of approximately three months was allowed for the plants to mature and stabilize, ensuring strong root extension into the water column and optimal performance in nutrient and pollutant removal.

Plate 3.5 Canna Plant

3.5 ALLOWABLE INFLOW

The allowable inflow was determined by HRT and mode of operation (batch or continuous). For the present study the mode of operation was taken batches. But the inflow rate from the source was very large, which difficult to handle in a small scale CFW. So, an arbitrarily selected quantity was diverted to the outlet. Consider 10% of losses due to evapo-transpiration. In this study a 300 l of grey water was diverted to the CFW. The settling tank has provided with three outlets, the outlet through the middle was diverted to the CFW by the use of ball valve. While the top and bottom outlets were used for over flow and to flush the tank respectively.

3.6 DESIGN OF CFW

Similar to all other designs, constructed floating wetland design include hydrologic design and hydraulic design. Hydrologic design comprises of site selection and determination of volume of water diverted to the treatment system. Dimension of CFW is decided by hydraulic design.

3.6.1 Design Procedure

Steps followed for the design of a Constructed Floating Wetland (CFW) suggested by best practices are as follows:

1. Determine the existing condition of influent (BOD, TSS, and COD etc.), average wastewater temperature, and average influent flow diverted.
2. Determine the desired quality of effluent parameters (typically BOD and TSS).
3. Select the type of floating wetland platform, plant species, and root mat density suitable for the climatic and wastewater conditions.
4. Find out the effective root zone depth (equivalent to the active zone where pollutant uptake occurs) and buoyancy requirements of the platform.
5. Select an initial surface coverage area of the floating wetland as a percentage of the waterbody. Generally, 60–80% coverage is considered effective for significant pollutant removal. Aspect ratio considerations (L:W) can also be applied based on available space.

6. Calculate the required surface area of CFW using a first-order BOD removal equation (modified for floating systems):

$$\mathbf{AS = Q_i \times \frac{\ln (C_i / C_e)}{K_t}}$$

Where:

AS = Surface area of CFW (m^2)

Q_i = Inflow (m^3/day)

C_i = Influent BOD (mg/L)

C_e = Effluent BOD (mg/L)

K_t = First-order rate constant (varies depending on temperature and plant species)

For temperature adjustment:

$$\mathbf{K_t = K_{20} \times \theta^{(T - 20)}}$$

Where:

K_t = Rate constant at temperature T (°C)

K_{20} = Rate constant at 20°C (usually 0.3–1.1 day^{-1} for floating wetlands)

θ = Temperature coefficient (typically 1.05–1.06 for biological processes)

7. Evaluate flow and loading capacity by estimating the hydraulic retention and plant uptake potential. If the calculated surface area does not support design flow, adjust the coverage area or use multiple floating islands.
8. Calculate theoretical detention time (HRT) for pollutant contact:

$$\mathbf{HRT = \frac{Volume \times Surface\ Coverage\ Ratio}{Flow}}$$

3.7 BED SLOPE

An acceptable hydraulic gradient needs very little slope on the bottom of the bed to ensure drainage. EPA has recommended a bed slope CFW as 0.5 to 1% bed slope. But practically it is very difficult to precisely design and construct a system with specified bed slope. For the present study the bed slope was kept nearly flat with an adjustable outlet.

3.8 DETENTION TIME/ HYDRAULIC RETENTION TIME (HRT)

Performance of constructed floating wetlands is a function of detention time, among other factors like water depth and plant density. Shorter detention time does not provide adequate time for pollutant degradation to occur; longer detention times can lead to stagnant, anaerobic conditions. The climatic factors that significantly affect the detention time at a constant hydraulic loading rate are evapo-transpiration in summer and ice formation in winter. In summer, evapo-transpiration can significantly increase the detention time, while ice formation in winter can significantly decrease the detention time.

3.9 CONSTRUCTION

The FTW system was developed using a 1000-liter high-density polyethylene (HDPE) tank, serving as the main basin for holding the wastewater up to 300 L. The tank provided a stable, enclosed water body for supporting the floating mat and maintaining controlled experimental conditions.

The floating platform was constructed using a rigid PVC pipe frame to provide buoyancy and structural support. A trellis net was tightly fixed across the frame to hold planting containers in place. Plastic pots filled with a lightweight growing medium, such as coconut coir were placed within the net structure to support the macrophytes. The plant roots were allowed to extend through the pots and net into the water column for effective nutrient uptake and contaminant removal.

To ensure plant stability and optimize root-zone exposure, the platform was designed to float slightly above the water surface, allowing the roots to remain submerged while keeping the stems and leaves in the open air. An overflow outlet was installed on the side of the tank to regulate the water level and allow for the collection of treated effluent.

3.10 OPERATION AND MONITORING OF FLOATING TREATMENT WETLAND

The selected plants were first matured in soil-filled pots under controlled nursery conditions for a period of three months to ensure healthy growth and adequate root development. After this maturation phase, the established plants were transplanted into the floating treatment wetland system and placed in freshwater for a stabilization period of one week. This allowed the plants to adapt to the floating environment and ensured that their roots could extend freely into the water column. After stabilization, the system was operated in a batch-fed mode, with wastewater introduced once daily in a fixed volume. The wastewater was retained in the tank for a specific hydraulic detention time, allowing sufficient interaction between pollutants, plant roots, and associated microbial communities. Weekly monitoring was conducted to assess plant health, microbial activity, and overall system performance. Any invasive weeds or unwanted seedlings appearing on the floating mat were removed promptly to maintain the efficiency and integrity of the treatment process.

3.11 SAMPLING AND ANALYSIS OF FLOATING TREATMENT WETLAND

Water quality monitoring of the constructed floating wetland system was carried out to assess its treatment efficiency over time. For each monitoring cycle, three water samples were collectedone influent sample before the introduction of wastewater and two effluent samples on the 3rd and 4th days after wastewater addition to evaluate the treatment progression during the early phase. Sampling was conducted through designated inlet and outlet ports on a 1000-liter tank to ensure consistency and accuracy. The collected samples were analyzed for key water quality parameters, including Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Calcium (Ca), Magnesium (Mg), pH, Electrical Conductivity (EC), Salinity, and millivolt potential (mV). The analyses were performed at the Irrigation Department Laboratory of KCAET, Tavanur, using the Water Analysis 371 protocol, and at the Kerala Water Authority Quality Control District Laboratory in Malappuram.

Table 4.1: Waste water characteristic concern

CONSTITUENT	UNIT	TEST METHOD
Dissolved Oxygen (DO)	mg /L	IS 3025(part 38)- 2003
Biochemical Oxygen Demand (BOD)	mg /L	IS 3025(part 44)- 2023
Chemical oxygen demand (COD)	mg /L	IS 3025(part 58)- 2023
Total dissolved solids (TDS)	mg /L	Water Analyser 371
pH		Water Analyser 371
Electrical Conductivity (EC)	µS/m	Water Analyser 371
Salinity	Ppm	Water Analyser 371
Calcium (Ca)	mg/litre	IS 3025(part 40)- 2024 EDTA titrimetric method
Magnesium (Mg)	mg/litre	IS 3025(part 46)- 2023 EDTA volumetric method

RESULT AND DISCUSSION

CHAPTER 4

RESULT AND DISCUSSION

The experimental constructed floating wetland unit was designed and installed at the project site. The operation and monitoring of the unit commenced after the establishment of aquatic plants on the floating platform. The treatment performance was evaluated by analyzing water samples collected from both the inlet and outlet of the constructed experimental floating wetland unit.

4.1 WASTE WATER CHARACTERIZATION

Wastewater characterization is important for designing a wastewater treatment plant. To design a treatment process or treatment plant properly, characterization of wastewater is the most critical step. Published information on domestic wastewater characteristics based on actual data is very limited. But literature concerning design parameters and values for varying-strength wastewater that can be used for the design of modern treatment systems are virtually non- existent.

4.2 EXPERIMENTAL SET-UP

Plate 4.1 Experimental Set-up

Table 4.2 Experimental set-up – Design hydraulics

Hydraulics	
Type	Floating wetland unit
Flow regime	Free- floating on tank
Operation mode	Batch flow
Free board	0.21
HRT	2-4 days

Table 4.3 Experimental set-up – Structural dimensions

Structural Dimensions	
Size	1.16m × 0.95m
Longitudinal slope	<1%
Inlet structure	220 L storage tank
Outlet	Outlet directly from basin

Table 4.4 Experimental set-up – Physical parameters of vegetation

Physical Parameters of Vegetation	
Plant type	Emergent plant
Common name	Canna Plant
Scientific name	Canna indica
Numbers	12
Density	12 plants/ m^2

4.3 OPERATION AND MONITORING OF CFW

The constructed floating wetland was operated after all the establishment of plants. The system was operated by diverting approximately 300 L of grey water per day. The valves were calibrated before the operation. The waste water discharged through the valve per time was calculated. Then the valve opened for 6 min per day for getting the desired inflow. The plant growth was measured regularly and grasses or weeds were uprooted and removed periodically.

4.4 SAMPLING AND ANALYSIS OF CFW

Sampling is an extremely important consideration in characterizing wastewater for pollutant removal. Wastewater quality is changing continuously, and these changes affect the ability of a wastewater treatment plant to achieve consistent removal efficiency. Obtaining samples that will actually represent accurate parameters in the wastewater flow through the constructed floating wetland was difficult. Diurnal fluctuations and seasonal fluctuations affect concentration, flow volume, and temperature. Therefore, waste water characteristics fluctuations were related to water usage of students and time.

Water samples were collected from the collecting portion of inlet chamber and outlet chamber of constructed floating wetland unit. The samples were analyzed for DO, COD, BOD, TDS, pH, EC, Salinity, millivolt, Ca and Mg according to standard procedures of waste water analysis. Once a sample is taken, the constituents of the sample should be maintained in the same condition as when collected. The samples were collected in plastic cans. When it is not possible to analyze collected samples immediately, samples were preserved properly.

Plate 4.2 Sample

Table 4.5 Variation of different parameters in influent and effluent samples from experiment

Target constituent	Influent	Effluent 1 (3rd day of retention)	Effluent 2 (4th day 0f retention)
Dissolved Oxygen (DO)	Not Detected	Not Detected	Not Detected
Biochemical Oxygen Demand (BOD)	460 mg/L	160 mg/L	20 mg/L
Chemical oxygen demand (COD)	1400 mg/L	462 mg/L	62 mg/L
Total dissolved solids (TDS)	910 ppm	190 ppm	186 ppm
Ph	6.57	6.84	6.97
Electrical Conductivity (EC)	1970 µS/m	356 µS/m	341 µS/m
Salinity	0.2 ppt	0.18 ppt	0.17 ppt
Calcium (Ca)	7.08 mg/L	7.87 mg/L	8.66 mg/L
Magnesium (Mg)	3.85 mg/L	6.7 mg/L	3.37 mg/L
Nitrate (NO_3^-)	Not Detected	Not Detected	Not Detected
Phosphate (PO_4^{3-})	Trace Amount	Trace Amount	Trace Amount

4.5 ORGANIC REMOVAL

4.5.1 Biochemical Oxygen Demand (BOD)

The concentrations of BOD in the influent were 460 mg/L. The range of the BOD of the source wastewater was from 150-500 mg/l. When the concentration of raw wastewater is diluted, thus lowering BOD concentration. The effluent concentrations were 160 and 20 mg/L. BOD was reduced to very low concentration as shown in fig

4.1. The table 4.6 illustrated that there is a reduction of 65.22% and 95.65% in BOD in different samples by using CFW.

Table 4.6 BOD analysis

Parameter	Influent	HRT (days)	Effluent	% Reduction
BOD	460 mg/L	3	160 mg/L	65.22%
		4	20 mg/L	95.65%

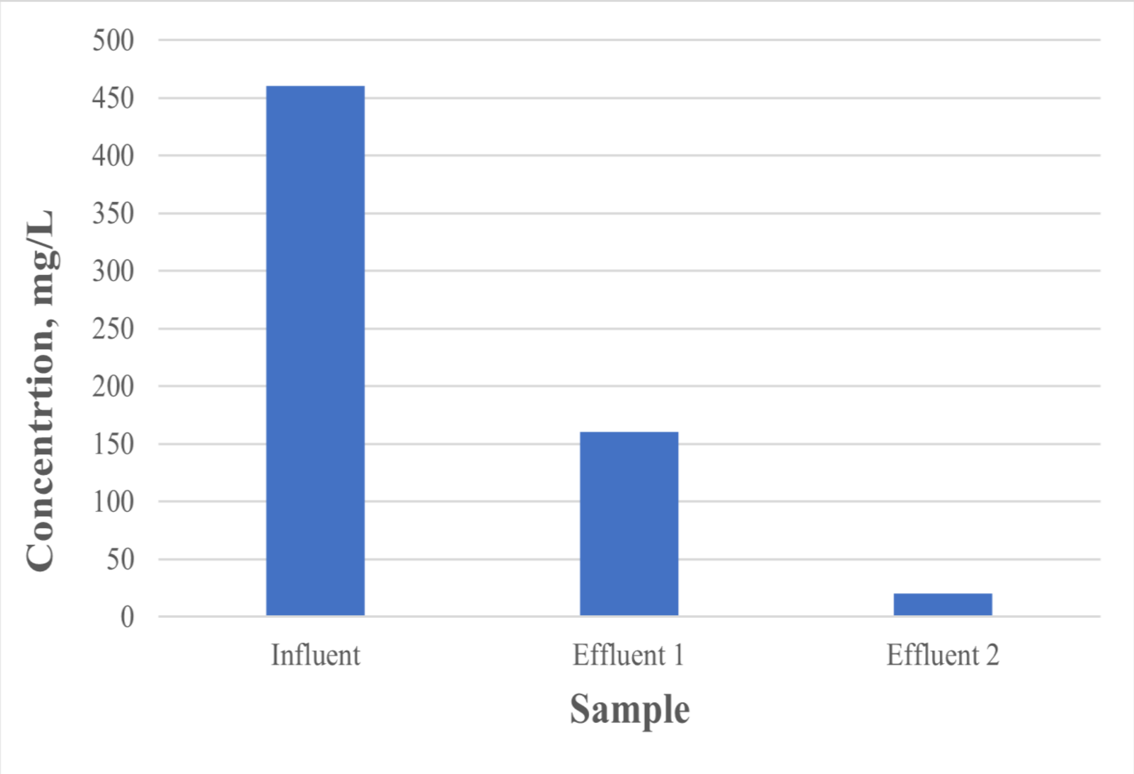

Fig 4.1 Variation of BOD in influent and effluent samples using CFW

The Biochemical Oxygen Demand (BOD) of the influent greywater was recorded at 460 mg/L, indicating a high level of biodegradable organic matter. After treatment in the Constructed Floating Wetland system, the BOD was significantly reduced to 160 mg/L on the 3rd day and further to 20 mg/L on the 4th day of retention, achieving a maximum reduction efficiency of 95.65%. This notable decrease is primarily attributed to microbial degradation processes facilitated by the root systems of *Canna indica*. The roots provide surface area for aerobic bacteria to colonize and form biofilms, where the breakdown of organic matter occurs. The availability of oxygen in the rhizosphere enhances microbial activity, resulting in efficient reduction of BOD. These results align with earlier studies by Vymazal (2007) and Headley and Tanner (2012), which highlight the role of plant–microbe interactions in improving BOD removal in wetland systems.

4.5.2 Chemical Oxygen Demand (COD)

The concentrations of COD in the influent were 1400 mg/L. So, the observed range in the COD of the source wastewater was from 150 to 1500 mg/l. The effluent COD are 462 and 62 mg/l as shown in fig 4.2. The table 4.7 illustrated that there is 67% and 95.57% reduction in COD by using different samples in CFW.

Table 4.7 COD analysis

Parameter	Influent	HRT (Days)	Effluent	% Reduction
COD	1400 mg/L	3	462mg/L	67%
		4	62 mg/L	95.57%

The Chemical Oxygen Demand (COD) value of the influent was 1400 mg/L, indicating a significant load of oxidizable organic and inorganic substances. Following treatment through the CFW system, the COD levels declined to 462 mg/L on day 3 and to 62 mg/L on day 4, yielding a maximum reduction of 95.57%. The high COD removal can be credited to a combination of biological oxidation by microbial biofilms and physical filtration by plant roots and the floating media. Plants like *Canna indica* enhance COD reduction not only through direct uptake of some organic compounds but also by supporting diverse microbial communities capable of decomposing a wide range of pollutants. The results validate findings by Arshad *et al*. (2017), who observed similar COD reductions using floating wetland systems, confirming their effectiveness in treating organic-rich greywater.

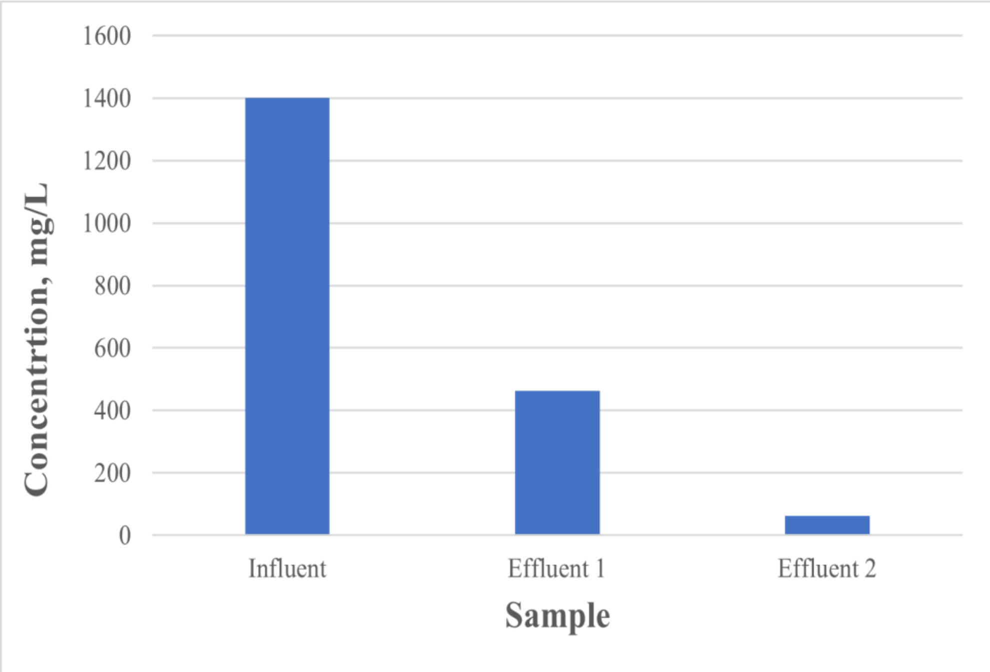

Fig 4.2 Variation of COD in influent and effluent samples using CFW

The efficiency of organic removal was 90% to 95.84 for BOD_5, it was 50.8% to 60% for COD

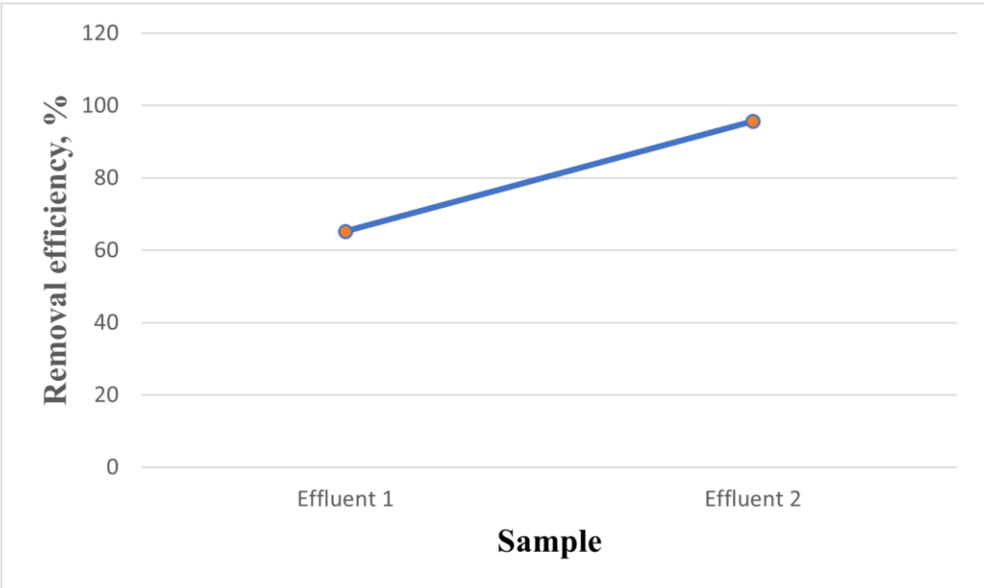

Fig 4.3 BOD removal efficiency of CFW

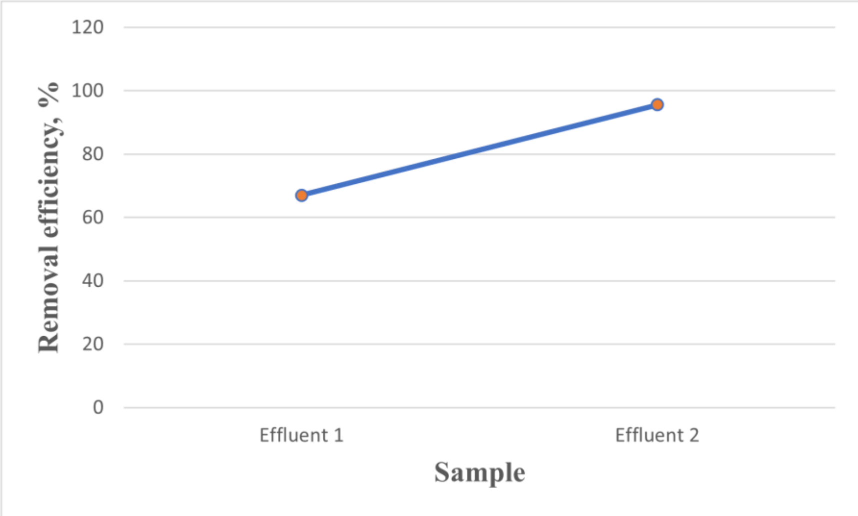

Fig 4.4 COD removal efficiency of CFW

4.6 NUTRIENT REMOVAL

4.6.1 Calcium (Ca)

The concentrations of Ca in the influent were 7.08 mg/L. The effluent Ca were 7.87 and 8.66 mg/L.

Table 4.8 Ca analysis

Parameter	Influent	HRT (Days)	Effluent
Ca	7.08 mg/L	3	7.87 mg/L
		4	8.66 mg/L

In the present study, calcium concentrations showed a slight increase from 7.08 mg/L in the influent to 8.66 mg/L in the effluent on the 4th day of retention. This increase may be attributed to the leaching of calcium-containing compounds from the substrate material, such as coconut coir or other organic media, or from the structural components of the wetland setup. Evapotranspiration could also play a role, as the loss of water volume may concentrate dissolved minerals such as calcium. Similar observations were reported by Wang *et al*. (2023), where the interaction between the substrate matrix and water led to changes in dissolved ion concentrations. Although the increase in calcium was minimal, it highlights the importance of selecting stable and non-leaching filter media in constructed wetlands.

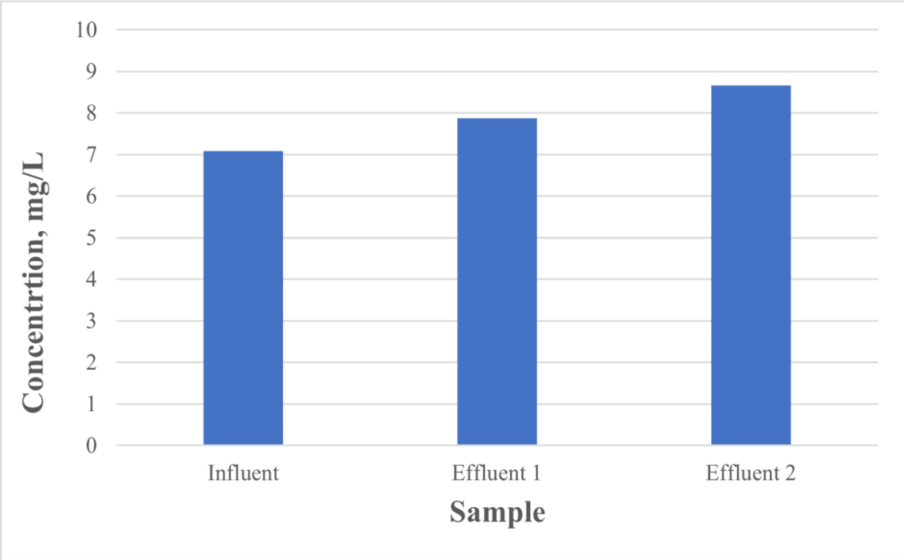

Fig.4.5 Variation of Ca in influent and effluent samples using CFW

4.6.2 Magnesium (Mg)

The concentrations of Mg in the influent were 3.85 mg/L. The effluent Mg were 6.7 and 3.37 mg/L. The highest Mg removal efficiency achieved in CFW was 12.47%.

Table 4.9 Mg analysis

Parameter	Influent	HRT (Days)	Effluent
Mg	3.85 mg/L	3	6.7 mg/L
		4	3.37 mg/L

Magnesium concentrations exhibited a fluctuating trend during the treatment process. The concentration increased from 3.85 mg/L in the influent to 6.7 mg/L on the 3rd day, before reducing to 3.37 mg/L on the 4th day. The initial increase is likely due to the release of magnesium from organic matter or substrate components, while the subsequent decrease may indicate uptake by plants such as *Canna indica* , or adsorption onto root surfaces and associated microbial biofilms. According to Sanjrani *et al.* (2020), plant roots in floating wetlands not only support microbial growth but also contribute directly to nutrient uptake, including secondary nutrients like magnesium. This behaviour suggests active biogeochemical cycling within the CFW system.

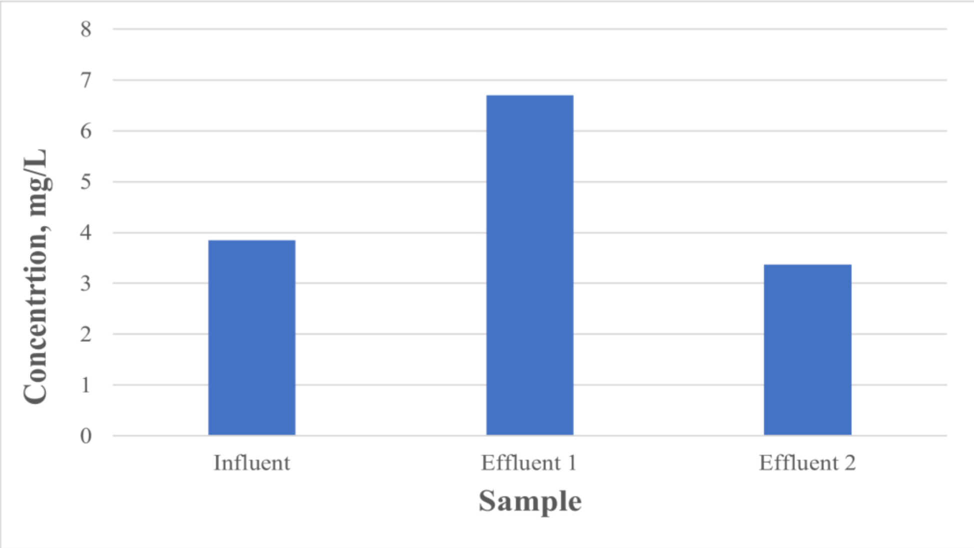

Fig.4.6 Variation of Mg in influent and effluent samples using CFW

4.7 SOLIDS REMOVAL

In CFW, the influent TDS concentration is 910 ppm and the effluent TDS concentration varied between 190 and 186 ppm. The table 4.10 illustrated that there is 79.12% and 79.56% reduction in TDS in CFW.

Table 4.10 TDS analysis

Parameter	Influent	HRT (Days)	Effluent	% Reduction
TDS	910 ppm	3	190 ppm	65.22%
		4	186 ppm	95.65%

The Total Dissolved Solids (TDS) concentration in the influent greywater was 910 ppm, which significantly decreased to 190 ppm on the 3rd day and 186 ppm on the 4th day of hydraulic retention in the Constructed Floating Wetland system. This corresponds to a TDS removal efficiency of approximately 79.5%. The substantial reduction in TDS can be attributed to a combination of plant uptake, microbial assimilation, and adsorption onto the substrate materials such as coconut coir and biofilm-coated root surfaces. Plants like *Canna indica* are known to absorb various dissolved nutrients and minerals, thereby contributing to the decline in TDS. Additionally, as water moves slowly through the wetland, sedimentation and physical filtration by the plant roots aid in reducing suspended and dissolved particles. These results are consistent with the findings of Chang *et al*. (2013), who reported that constructed wetlands promote the removal of dissolved solids through multiple pathways, including biological, chemical, and physical mechanisms. A reduced TDS level in the treated effluent enhances its suitability for non-potable reuse applications such as irrigation.

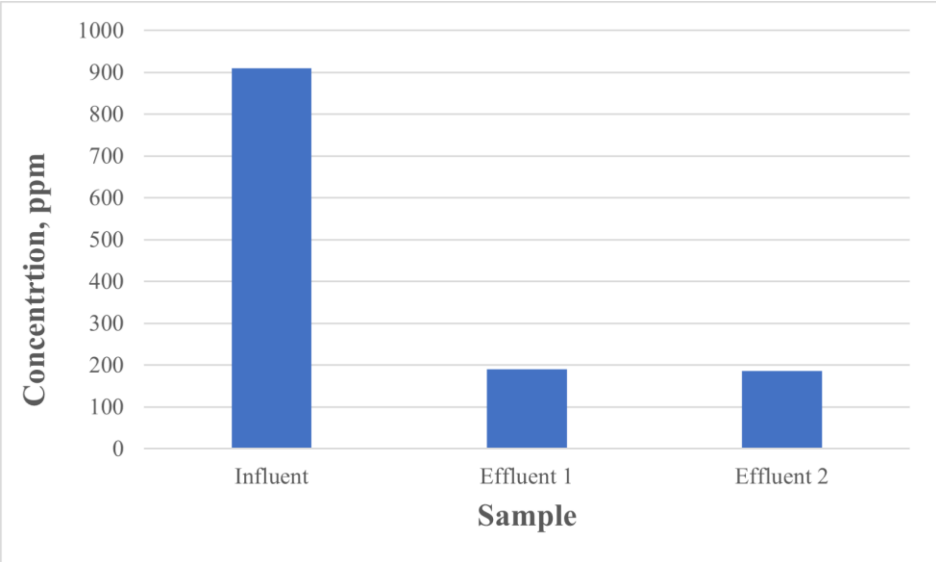

Fig.4.7 Variation of TDS in influent and effluent samples using CFW

4.8 ELECTRICAL CONDUCTIVITY (EC)

The range of EC in the influent were 1970 µS/m. The effluent concentrations were 356 and 341 µS/m. EC was reduced to very low concentration as shown in fig 4.8. The table 4.11 illustrated that there is a reduction of 81.92% and 82.69% in EC in different samples by using CFW.

Table 4.11 EC analysis

Parameter	Influent	HRT (Days)	Effluent	% Reduction
EC	1970 µS/m	3	356 µS/m	81.92%
		4	341 µS/m	82.69%

The Electrical Conductivity (EC) of the influent was measured at 1970 µS/m, reflecting a high concentration of dissolved salts and ionic substances commonly present in greywater. After passing through the CFW system, EC values decreased significantly to 356 µS/m on the 3rd day and to 341 µS/m on the 4th day, showing a removal efficiency of over 82%. The reduction in EC suggests that the system was effective in removing dissolved ions, likely through plant uptake, microbial transformation, and adsorption onto substrate materials. The roots of Canna indica may also assist in regulating ionic content via selective ion absorption. Similar observations were reported by Headley and Tanner (2006), who emphasized that plant-based wetland systems can influence the ionic balance of treated water through natural biogeochemical processes.

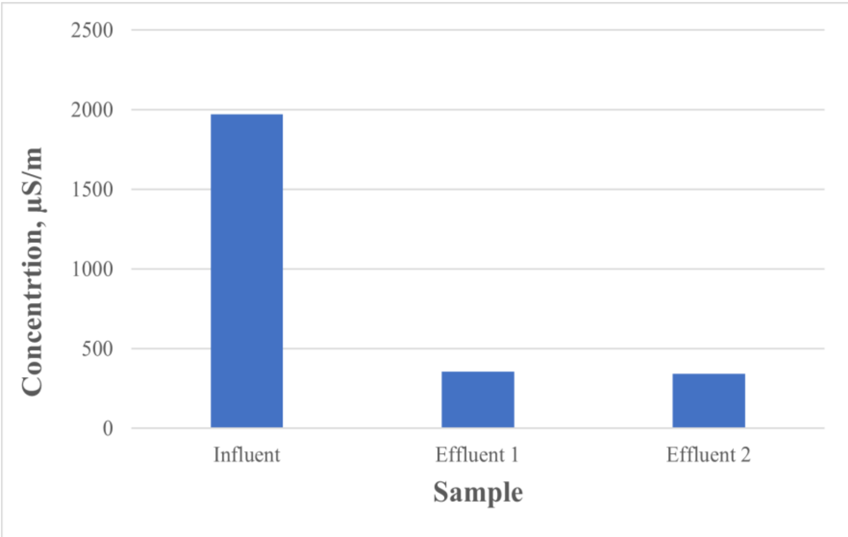

Fig.4.8 Variation of EC in influent and effluent samples using CFW

4.9 HYDROGEN IRON (pH)

The pH in the influent were 6.57. So, the source influent is slightly acidic in nature. Wastewater with an extreme concentration of hydrogen ion is difficult to treat by biological means. In the case of effluent from CFW, pH was 6.84 and 6.97.

Table 4.12 pH analysis

Parameter	Influent	HRT (Days)	Effluent
Ph	6.57 mg/L	3	6.84 mg/L
		4	6.97 mg/L

The pH of the influent greywater was slightly acidic at 6.57. After treatment in the CFW system, it showed a gradual increase to 6.84 on day 3 and 6.97 on day 4, approaching a neutral range. This mild rise in pH may be attributed to biological processes such as photosynthesis, which consumes carbon dioxide and can increase alkalinity in water. Additionally, microbial decomposition of organic matter and nutrient cycling often result in the release of basic ions, which can stabilize or raise pH levels. The observed pH range post-treatment is favourable for both plant and microbial activity and indicates the buffering capacity of the system. According to Saeed *et al*. (2016), maintaining a near-neutral pH is critical for effective wastewater treatment, as extreme pH values can inhibit microbial metabolism and plant health.

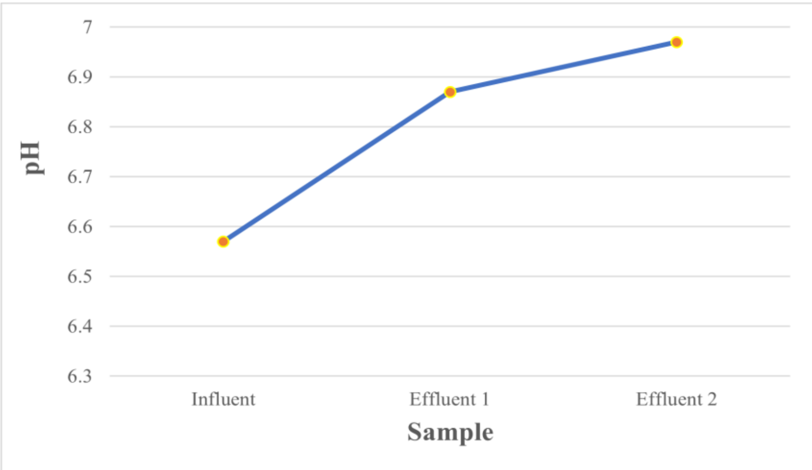

Fig 4.9 Variation of pH in influent and effluent samples using CFW

4.10 SALINITY

Salinity of grey water source was 0.2 ppt when the grey water delivered to the CFW it will change to 0.18 ppt and 0.17 ppt.

Table 4.13 Salinity analysis

Parameter	Influent	HRT (Days)	Effluent	% Reduction
pH	0.2 ppt	3	0.18 ppt	10%
		4	0.17 ppt	15%

The salinity of the influent greywater was recorded at 0.2 parts per thousand (ppt), which reduced to 0.18 ppt on the 3rd day and further to 0.17 ppt on the 4th day of hydraulic retention. Although the initial salinity was low, the observed decrease of up to 15% suggests effective partial removal of dissolved salts during treatment. The reduction in salinity is likely due to plant uptake of ions, particularly sodium, potassium, and chloride, which are common contributors to salinity in greywater. Additionally, adsorption onto biofilms and substrate materials used in the floating wetland (such as coconut coir) could play a role in immobilizing soluble salts. According to Samal *et al*. (2019), aquatic macrophytes and microbial communities in constructed wetlands can help stabilize salinity levels by sequestering dissolved ions. The minor decline also reflects the system's potential in managing salinity buildup, which is important for long-term reuse of treated water in irrigation, where excess salinity can negatively impact soil and crop health.

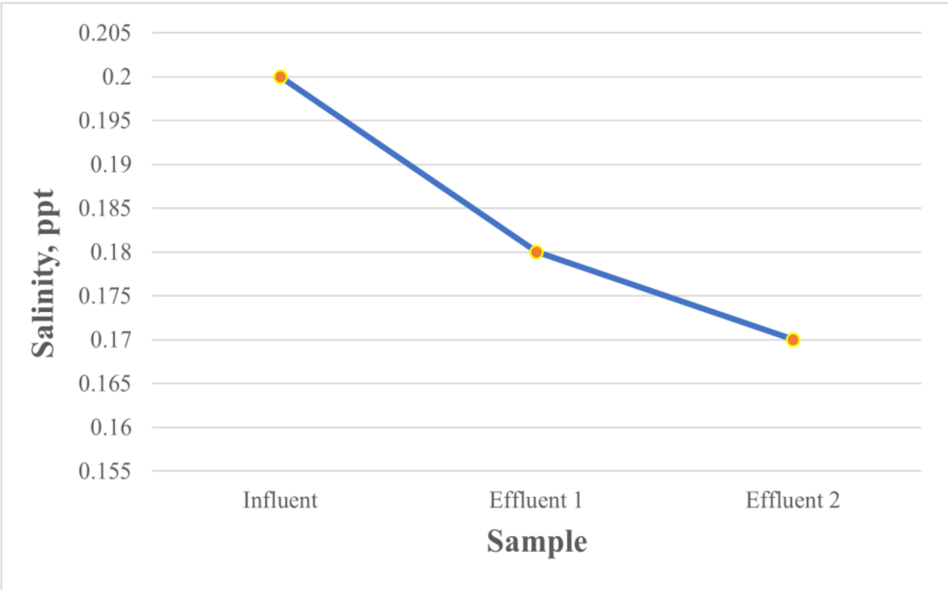

Fig 4.10 Variation of Salinity in influent and effluent samples using CFW

SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

Population growth and industrialization has caused considerable amount of waste water generation. There are many methods to treat the waste water and to reuse for further use mainly irrigation. If the waste water is discharged to the natural water resources without proper treatment, it will cause pollution and also cause diseases for human beings. However, we need to protect our land and conserve water by the proper treatment method. Various studies shown that constructed floating wetland is an effective and eco-friendly water recycling system. This project was an application of subsurface constructed wetland for waste water treating system.

This research included the CFW system with *Canna indica* used for domestic grey water treatment. The treated grey water is found to be good quality and can therefore be used for irrigation purposes. The waste water characteristics after the treatment are noticed a significant change from the inlet.

BOD is a measure of the degree of contamination of water by measuring the oxygen required for the oxidation of organic matter by the aerobic metabolism of the microbial flora. The BOD test gives a measure of the oxygen utilized by bacteria during the oxidation of organic material contained in a wastewater sample. BOD_5 means a 5-day biochemical oxygen demand. The BOD_5 of the influent was 460 mg/L, whereas the BOD_5 of the effluent was 20 mg/L. The maximum BOD_5 removal efficiency was 95.65%.

COD estimates the oxygen equivalent of organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The COD of the influent was 1400 mg/L, for effluent it was 62 mg/L. The maximum removal efficiency obtained was 95.57%.

Calcium (Ca) and Magnesium (Mg) are important minerals commonly found in grey water, mainly originating from detergents, soaps, and water-softening agents. In excessive amounts, they can contribute to water hardness, which affects both soil structure and plant growth in irrigation applications. However, moderate concentrations of Ca and Mg are beneficial, as they are essential nutrients for plant development and microbial activity. It is observed that the plants in the floating wetland system help in reducing the levels of Calcium and Magnesium effectively during the treatment process.

The most important physical characteristic of wastewater is its total dissolved solids. TDS of 910 ppm of influent changes to 186 ppm in effluent. The maximum TDS removal efficiency was 79.56%.

The power of hydrogen ion is pH. pH is the negative logarithm of the hydrogen ion concentration. The pH of influent was below 6.57. I.e. the influent grey water was slightly acidic. But when it is passed through SFCW, pH value was increased considerably and close to 7.

Water quality increases with increase in HRT. HRT can be varied by change of flow and change of flow depth. HRT decreases with increase of flow rate. Also, HRT increase with increasing flow depth. Actual HRT was greater than theoretical HRT. It is because of temperature variation, elevation difference and substrate property etc.

REFERENCES

CHAPTER 5

REFERENCES

Abed, S.N., Almuktar, S.A., and Scholz, M. 2017. Remediation of synthetic greywater in mesocosm-Scale FTWs. *Ecol. Eng. 102*: 303-319.

Al-Mughalles, M. H., Rahman, R. A., and Aris, A. 2012. Assessment of greywater reuse for Agricultural irrigation: Environ. Monitoring Asses. 184(11): 7141–7153. https://doi.org/10.1007/s10661-011-2482-9.

Arivukkarasu, D., and Sathyanathan, R. 2023. Floating wetland treatment an ecological approach for the treatment of water and wastewater–A review. *Mater. Today: Proc.* 77: 176-181.

Arshad, A. 2017. Design of floating wetland for treatment of municipal wastewater and Environment Assessment using emergy techniques. Proc. Int. Acad. Ecol. Environ. Sci. 7(3): 78.

Baker, B. H. 1972. Geology of the Eastern Rift System of Africa. Geol. Soc. of Am. Spec. Pap. 136.

Barco, A., and Borin, M. 2020. Ornamental plants for floating treatment wetlands: Preliminary results. Ital. J. Agron. 15(2): 1602.

Benvenuti, T., Hamerski, F., Giacobbo, A., Bernardes, A.M., Zoppas-Ferreira, J.and Rodrigues, M.A. 2018. Constructed floating wetland for the treatment of domestic sewage: a real-scale study. J. Environ. Chem. Eng. 6(5): 5706-5711.

Billore, S.K., Prashant., and Sharma, J.K. 2009. Treatment performance of artificial floating reed beds in an experimental mesocosm to improve the water quality of river Kshipra. *Water Sci. Technol. 60*(11): 2851-2859.

Borne, K.E., Fassman-Beck, E.A., Winston, R.J., Hunt, W.F., and Tanner, C.C. 2015. Implementation and maintenance of FTWs for urban stormwater management. *J. of Environ. Eng. 141*(11): 401-5030.

Cao, W., and Zhang, Y. 2014. Removal of nitrogen (N) from hypereutrophic waters by ecological floating beds (EFBs) with various substrates. *Ecol. Eng. 62*: 148-152.

Chang, N.B., Xuan, Z., Marimon, Z., Islam, K., and Wanielista, M.P. 2013. Exploring hydrobiogeochemical processes of FTWs in a subtropical stormwater wet detention pond. *Ecol. Eng. 54*: 66-76.

Chen, Y.H., Zhang, Y., Huang, M.S., Zhang, Y.F., Zhao, F., and Luo, J.H. 2012. Ecological restoration by a multistage floating-bed system in a eutrophic urban river, China. *Appl. Mech. Mater. 157*: 945-949.

Stefani, D. G., Tocchetto, D., Salvato, M., and Borin, M. 2011. Performance of a floating treatment wetland for in-stream water amelioration in NE Italy. Hydrobiologia. 674: 157–167.

Ghaitidak, D. M., and Yadav, K. D. 2013. Characteristics and treatment of greywater—A re. Environ. Sci. Pollution Res. 20(5): 2795–2809. https://doi.org/10.1007/s11356-013-1533-0.

Headley, T. R., and Tanner, C. C. 2006. Application of floating wetlands for enhanced stormwater treatment: A re. NIWA Client Report: HAM2006-123, Prepared for Auckland Regional Council, November 2006.

Jamrah, A., Al-Futaisi, A., Prashanth, S., Harrasi, A., and Al-Rawas, G. 2006. Assessment of reclaimed wastewater irrigation in arid regions. Desalination. 185(1–3): 369–382. https://doi.org/10.1016/j.desal.2005.03.086.

Kanabkaew, T., and Puetpaiboon, U. 2004. Aquatic plants for domestic wastewater treatment: Lotus (Nelumbo nucifera) and Hydrilla (Hydrilla verticillata) systems. Aquat. 26(5): 750.

Vlek, K. H. E., Verdonschot, P. F., Verdonschot, R. C., and Dekkers, D. 2014. The contribution of plant uptake to nutrient removal by floating treatment wetlands. Ecol. Eng. 73: 684–690.

Kerr-Upal, M., Seasons, M., and Mulamoottil, G. 2000. Retrofitting a stormwater management facility with a wetland component. *J. Environ. Sci. Health Part A*, *35*(8): 1289-1307.

Kumari, M., and Tripathi, B.D. 2015. Efficiency of Phragmites australis and Typha latifolia for heavy metal removal from wastewater. *Ecotoxicology environ. saf.* 112: 80-86.

Li, F., Wichmann, K., and Otterpohl, R. 2009. Rev. of the Technol. approaches for grey water treatment and reuses. Sci. Total Environ. 407(11): 3439–3449.

Lynch, J., Fox, L. J., Owen Jr., J. S., and Sample, D. J. 2015. Eval. of commercial floating treatment wetland Technol. for nutrient remediation of stormwater. Ecol. Eng. 75: 61–69.

Passeport, E., Benoit, P., Bergheaud, V., Coquet, Y., and Tournebize, J. 2011. Selected pesticides adsorption and desorption in substrates from artificial wetland and forest buffer. *Environ. Toxicol. and Chem. 30*(7): 1669-1676.

Pavlineri, N., Skoulikidis, N.T., and Tsihrintzis, V.A. 2017. Constructed floating wetlands: a review of research, design, operation and management aspects, and data meta-analysis. *Chem. Eng. J.* 308: 1120-1132.

Praveen Solanki, P.S., Maitreyie Narayan, M.N., and Srivastava, R.K. 2017. Effectiveness of domestic wastewater treatment using Floating rafts a promising phyto-remedial approach: a review.

Saeed, T., Paul, B., Afrin, R., Al-Muyeed, A., and Sun, G. 2016. Floating constructed wetland for the treatment of polluted river water: A pilot scale study on seasonal variation and shock load. Chem. Eng. J. 287: 62–73.

Samal, K., Kar, S., and Trivedi, S. 2019. Ecological floating bed (EFB) for decontamination of polluted water bodies: Design, mechanism and performance. *J. Environ. Manag.* 251: 109550.

Sanjrani, M. A., Zhou, B., Zhao, H., Zheng, Y. P., Wang, Y., and Xia, S. B. 2020. Treatment of wastewater with constructed wetlands systems and plants used in this Technol—a re. Appl. Ecol. Environ. Res. 18(1).

Headley T.R, C.C., Tanner. 2012. Constructed wetlands with floating emergent macrophytes: an innovative stormwater treatment technology. *Crit. Rev. Environ. Sci. Technol*. 42: 2261–2310. http://dx.doi.org/10.1080/10643389.2011.574108.

Vymazal, J. 2007. Removal of nutrients in various types of constructed wetlands. *Sci. Total Environ. 380*(1-3): 48-65.

Wang, W., Lv, W., Li, J., Jiao, X., and Ma, Z. 2023. Pollution removal capacities of aquatic plant species in the Datong Wetland Park in North China. J. Environ. Eng. Landsc. Manage. 31(4): 248–254.

Winward, G. P., Avery, L. M., Frazer-Williams, R., Pidou, M., Jeffrey, P., Stephenson, T., and Jefferson, B. 2008. A study of the microbial quality of grey water and an Eval. of treatment Technol. for reuse. Ecol. Eng. 32(2): 187–197.

Zhao, F., Xi, S., Yang, X., Yang, W., Li, J., Gu, B., and He, Z. 2012. Purifying eutrophic river waters with integrated floating island systems. *Ecol. Eng. 40*: 53-60.

WASTEWATER TREATMENT THROUGH CONSTRUCTED FLOATING WETLAND

By

FIBA M (2021-02-019)

SHAHLA SHERIN P P (2021-02-028)

ARATHI N (2021-02-041)

SHAHANA M (2020-02-037)

ABSTRACT OF PROJECT REPORT

Submitted in partial fulfilment of the requirements for the degree of

BACHELOR OF TECHNOLOGY IN AGRICULTURAL ENGINEERING

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

DEPARTMENT OF SOIL AND WATER CONSERVATION ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND FOOD TECHNOLOGY

Tavanur-679573, Malappuram

Kerala, India

2025

ABSTRACT

The growing scarcity of freshwater and the environmental hazards associated with untreated greywater discharge underscore the urgent need for sustainable wastewater treatment solutions. This project explores the use of Constructed Floating Wetlands (CFWs) as an innovative, eco-friendly, and cost-effective method for greywater treatment. A pilot-scale CFW system was designed and developed using Canna indica as the phytoremediation agent, supported by a floating platform constructed from PVC frames and coconut coir-based planting media. The system was installed within the premises of the Ladies' Hostel at KCAEFT, utilizing bathroom greywater as the influent.

Key water quality parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Electrical Conductivity (EC), pH, salinity, calcium, and magnesium were monitored to evaluate treatment efficiency. Results revealed significant reductions in pollutant concentrations, with BOD and COD removal efficiencies reaching up to 95.65% and 95.57% respectively. TDS and EC were also effectively reduced, while pH values improved toward neutral levels. The system demonstrated effective pollutant removal within a 3–4 day Hydraulic Retention Time (HRT), showcasing its viability for decentralized wastewater treatment and non-potable reuse, particularly in space-limited urban environments.

This study validates the potential of Constructed Floating Wetlands as a sustainable solution for greywater management and highlights their applicability in enhancing water reuse for irrigation, thereby contributing to resource conservation and environmental protection.