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Construction of Wetlands and Water Quality Analysis

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***Abstract* - This Constructed wetlands (CWs) are engineered and managed systems gaining worldwide attention for wastewater treatment and reclamation. These systems are cost-effective and easily operated and maintained compared to conventional plants, showing strong potential for application in small communities. Constructed wetlands have substantially developed as an eco-friendly treatment process, enabling effective, economical, and ecological treatment of agricultural, industrial, and municipal wastewater. This project aims to provide solutions and inspiration for the performance and application of Hybrid constructed wetlands (HCWs) by reviewing CW application and the recent development of their sustainable design, operation, and optimization for wastewater treatment. The project provides a tool for localized wastewater treatment and implements the usage of agricultural waste (sugarcane bagasse) and industrial waste (fly ash) in the wetland setup for increased economy. A key focus is the quality analysis of the water treated by the wetland to improve its standard, quality, and overall utilization**

Keywords - constructed wetlands, taro, water quality analysis

I. INTRODUCTION

A. *Background*

A large proportion of the world's developing countries are geographically located in areas that currently face or will face water shortages in the near future. Wetlands are crucial regions of land defined by unique soil and vegetation adapted to seasonal or permanent flooding. Wetlands perform crucial ecological tasks, including water filtration, carbon storage, flood management, and providing habitats for diverse plant and animal species.

Wetlands are primarily classified into Natural wetlands (like marshes, swamps, bogs, and fens) and Constructed wetlands (CWs). CWs are engineered systems designed to utilize the natural processes of wetland vegetation, soils, and associated microbial assemblages in a controlled environment. They are characterized by a complex structure involving wastewater, substrate, vegetation, and an array of microorganisms. CWs have the potential to treat a variety of wastewater types by removing heavy metals, nutrients, organics, suspended solids, and pathogens. [1]

B. *Classification of Constructed Wetlands*

CWs are typically divided into two forms based on their hydrologic processes: Free Water Surface (FWS) CWs and Subsurface Flow (SSF) CWs. FWS structures involve wastewater flowing shallowly over polluted substrates, mimicking natural wetlands. SSF structures involve wastewater passing through the substratum, either horizontally (Horizontal Flow, HF) or vertically (Vertical Flow, VF).

A combination of multiple wetland technologies is recognized as a Hybrid Constructed Wetland (HCW). HCWs are often composed of two phases (e.g., VF-HF CWs, HF-VF CWs) and are utilized to achieve higher effectiveness in wastewater treatment than single constructed wetlands. This project utilizes constructed multi-stage wetlands.[3]

C. *Objectives and Scope*

The main objective of this study is the utilization of wetlands for the purification of greywater from urban areas and the subsequent analysis of the quality of the treated water. Specific objectives include:

1. To utilize Phytorid technology for treating domestic wastewater at the household level.

2. To investigate the significance of emergent macrophyte species for water quality improvement by CWs.

3. To elucidate the significance of provided substrate layers in wastewater treatment.

4. To evaluate the quality of treated water for beneficial purposes.

The scope of this work provides a low-cost, low-maintenance, decentralized wastewater purification system necessary for increasing wastewater generation in urban areas. This approach provides scope for the purification of water in households, allowing the treated water to be used for household purposes other than drinking. This method is highly beneficial economically and spatially for congested and expensive urban areas, offering scope for the construction of low-cost multi-stage wetlands

II. MATERIALS AND METHODOLOGY

The wetlands are constructed using transparent canisters and aquarium, vegetation and substrates are provided accordingly. The sample is collected, tested and is retained in the wetland for a certain period and is collected after the detention period. The water quality of the sample collected from wetland is then analysed with the quality of the fresh sample.

A. Experimental Setup and Materials

The project utilized a **Hybrid constructed wetland (HCW)** setup. The setups included two canisters acting as Vertical Flow

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Constructed Wetlands (VFCW) and one aquarium acting as a Horizontal Flow Constructed Wetland (HFCW).

• **Canisters (VFCW):** Rounded transparent canisters (56 cm height, 33.5 cm diameter) were used, fitted with a 0.5-inch pipe connected 5 cm from the bottom to collect filtered water.

• **Aquarium (HFCW):** A rectangular crate box (62 cm length, 42 cm width, 30 cm height) was used.

The setup utilized different substrates for filtration and plant growth:

TABLE 1:Details of Different MAterials used in the experiment

LAYER	MATERIAL	THICKNESS	PURPOSE
Top Layer	Top Soil	15 cm	Nurturing plant growth
Middle Layer	River Sand	10 cm	Filtration
Bottom Layer	Fly Ash Pebbles	10 cm	pH adjustment, heavy metal removal, filtration medium

Coarse aggregate (4mm-8mm) was placed between the layers for separation and structural support.

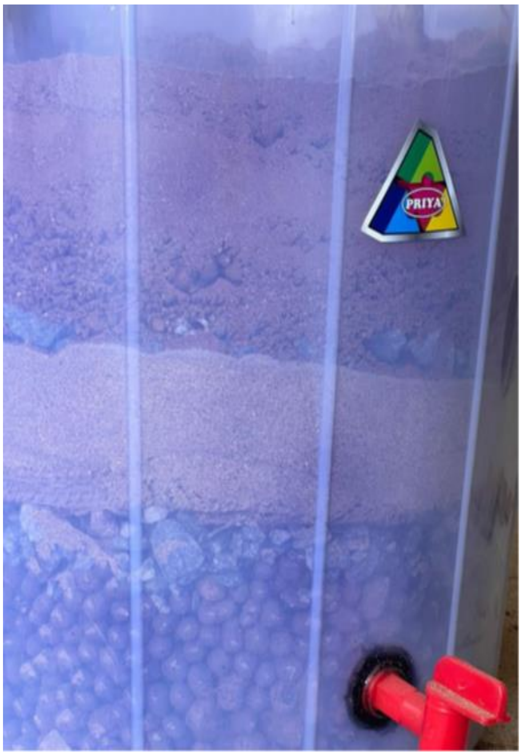

Fig. 1. Layers of the canisters and Aquarium.

B. Vegetation

The project used emergent aquatic macrophytes belonging to different species to study their pollutant removal efficiency. The three wetland setups utilized:

1. **Taro (** *Colocasia Esculenta* **):** Known to decrease nitrate and phosphate content, and aids in the stabilization of organic matter.

2. **Canna (** *Cannaceae* **):** Known for its ability to remove pollutants through phytoremediation.

3. **Water Bamboo (** *Dracaena sanderiana* **):** Known to absorb and remove impurities like chlorine and chemical residues, with roots acting as a filter.

C. Experimental Procedures and Analysis

During the plant maturity period, 40 liters of water were collected from the Sewage Treatment Plant (STP) at FISAT for initial property testing. Once the plants matured, the tested water was poured into the three wetland setups (Taro, Canna, Water Bamboo).

The water was first given a **7-day retention time**, followed by a **14-day retention time**. After each period, the treated water was collected and analyzed. The following water quality analyses were conducted:

• Determination of Total Solids (TS).

• Determination of Total Dissolved Solids (TDS).

• Determination of pH.

• Determination of Turbidity.

• Determination of Chloride.

• Determination of Chemical Oxygen Demand (COD)

III. RESULTS AND DISCUSSIONS

The initial quality analysis of the raw STP sample showed a Total Solids (TS) value of **680 mg/l** (exceeding the 500 mg/l acceptable limit) and a COD of **240 mg/l** (within the 250 mg/l acceptable limit). The initial pH was 6.5, which is at the lower end of the acceptable range (6.5–8.5).

A. Comparative Pollutant Removal Efficiency

Table 2: Test results of treated wetland water with Taro after 7 days and 14 days

Tests	Before Treatment	After 7 Days	After 14 Days	Unit	Acceptable Limit
Total Solids	680	160	112	mg/l	500
Total Dissolved Solids	108	88	75	mg/l	1000
pH	6.5	7.3	7.2	–	6.5–8.5
Chloride	60	22	9	mg/l	250
Turbidity	36	20.7	4.3	mg/l	1 NTU

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Table 3: Test results of treated wetland water with Canna after 7 days and 14 days

Tests	Before Treatment	After 7 Days	After 14 Days	Unit	Acceptable Limit
Total Solids	680	320	260	mg/l	500
Total Dissolved Solids	108	98	96	mg/l	1000
pH	6.5	7.32	7.1	–	6.5–8.5
Chloride	60	44	49	mg/l	250
Turbidity	36	20.7	20.5	mg/l	—
COD	240	166	158	mg/l	250

Table 4: Test results of treated wetland water with Bamboo after 7 days and 14 days

Tests	Before Treatment	After 7 Days	After 14 Days	Unit	Acceptable Limit
Total Solids	680	240	200	mg/l	500
Total Dissolved Solids	108	80	77	mg/l	1000
pH	6.5	7.36	7.15	–	6.5–8.5
Chloride	60	16	10	mg/l	250
Turbidity	36	14.2	6.8	mg/l	—
COD	240	132	108	mg/l	250

The experimental results demonstrated varying removal efficiencies based on the macrophyte used and the retention time.

Parameter	Initial Value (STP)	Taro (14 days)	Canna (14 days)	Water Bamboo (14 days)
Total Solids (mg/l)	680	112	260	200
Total Dissolved Solids (mg/l)	108	75	96	77
Chloride (mg/l)	60	9	49	10
COD (mg/l)	240	112	158	108
Turbidity (mg/l)	36	4.3	20.5	6.8

B. Performance Analysis:

• **Total Solids (TS), Total Dissolved Solids (TDS), and Turbidity:** The sample treated with **Taro** showed the most considerable decrease in TS, dropping from 680 mg/l to 112 mg/l after 14 days. Taro also gave a better efficiency for TDS removal after both 7 and 14 days. Taro consistently showed the greatest decrease in Turbidity after both 7 and 14 days, resulting in a better final result.

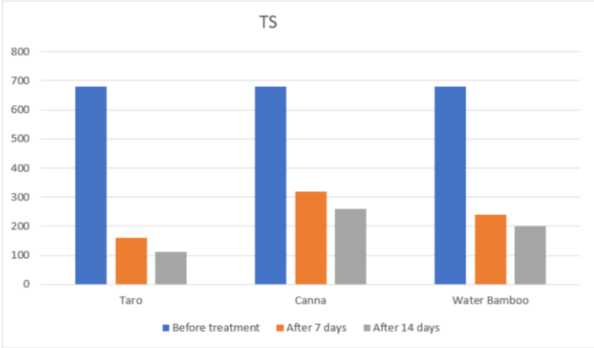


Fig. 2: Variation of TS

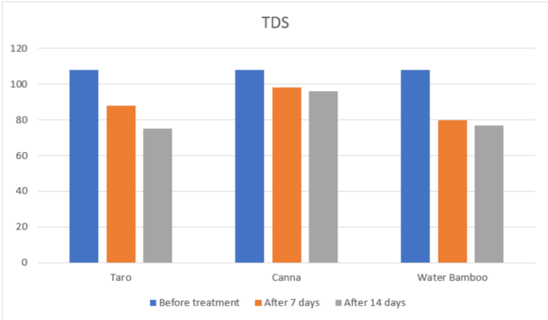
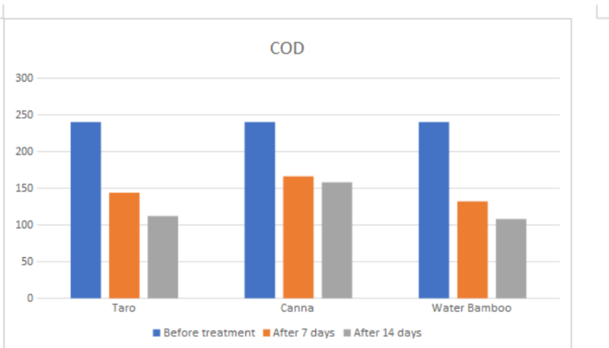


Fig 3. Variation of TDS

• **Chemical Oxygen Demand (COD):** Both the Taro and Water Bamboo setups showed a considerable decrease in COD compared with Canna. The final COD for Taro was 112 mg/l, and for Water Bamboo, it was 108 mg/l.



• **Chloride:** The sample treated with **Water Bamboo** showed the greatest decrease in Chloride compared to Taro and Canna, dropping from 60 mg/l to 10 mg/l after 14 days.

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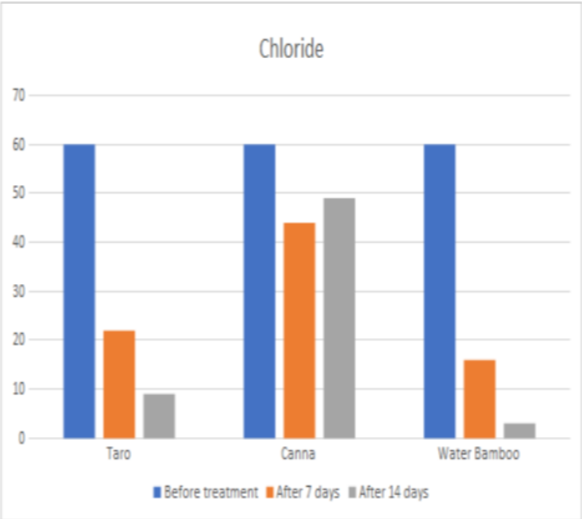

Fig.4. Variation of Chloride

• **pH:** The pH values increased in all treated samples, stabilizing the water quality within the acceptable range (6.5–8.5). The Canna sample showed a considerable increase in pH compared to Taro and Water Bamboo.

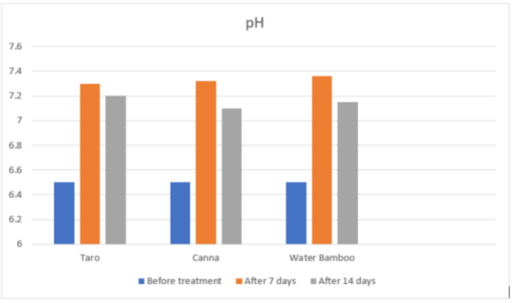

Fig.4. Variation of pH

C. Impact of Retention Time

The experimentation demonstrated that the wetlands had **better efficiency after 7 days** compared to 14 days retention time. The better removal efficiency at 7 days is attributed to the plant maturing and having peak growth, requiring a higher uptake of nutrients necessary for its development.

IV. CONCLUSIONS

The small-scale constructed wetland setup proved feasible for urban areas, offering an **economical solution** with small space requirements and low maintenance.

The comparative study revealed that the wetland setup containing **Taro** (*Colocasia Esculenta*) exhibited the **highest overall efficiency** for pollutant removal, especially for Total Solids and Turbidity. The optimal retention time observed was **7 days**, coinciding with the plant's maturing phase and resulting peak nutrient uptake.

After treatment using this experimental setup, the water quality was substantially improved, making the treated water suitable for irrigation and other domestic purposes. The utilization of waste materials like flyash pebbles further contributes to the economical viability of the system

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