Assessing the Performance of Plant Species in Wetland Construction for Influent Sewage from STP DAVANAGERE Town

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***Abstract*—Sewage treatment plants (STPs) employ a vertical flow artificial wetland (VFAW) system which is subsurface flow is to treat influent sewage, which contains a mixture of nutrients, chemicals, bacteria, and organic and inorganic trash. The systems' goal was to severely treat significant pollutants by raising DO levels and decreasing pollutant levels and to compare the performance of two plant species by constructing a vertical flow artificial wetland. The parameters analysed are pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Ammonia- Nitrogen (A-N) and Ortho- Phosphates (PO_4). The investigation revealed that P. karka and C. esculenta were the most effective choices for nitrogen absorption in artificial wetland (AW) systems. These plants offer an affordable and sustainable way to treat wastewater (WW), particularly in decentralized systems. The findings suggest that P. karka and C. esculenta are good candidates to improve the water quality in STP effluent.**

***Index Terms*—Artificial Wetland, C. esculenta, Influent Sewage, P. karka, Subsurface flow, Vertical.**

I. INTRODUCTION

A major threat to the environment and human being health is sewage, which is a combination of organic and inorganic WW and microorganisms. It may transmit diseases, create problems in water supplies, and harm aquatic habitats. Physical, chemical, and biological processes are used in modern STPs to eliminate contaminants and pollutants and provide treated effluent that may be safely recycled or released back into the environment system. Sustainable sewage treatment methods are essential for environmental health and clean water resources. Sewage treatment using constructed wetlands (CW) is a global approach to waste management and pollution reduction. Domestic WW, storm water, combined sewer overflows, overland runoff, and industrial WW can all be treated by wetlands. Protecting species variety, controlling water mass, and minimizing water damage all depend on wetlands. They can be purposefully built to exacerbate environmental deterioration, expand the habitats of different species, and offer long-term fixes for water management and quality enhancement [1]. The increasing amount of manmade wetlands throughout the world has made WW treatment more important. These wetlands are intended to keep an eye on both inorganic and biological processes, guaranteeing the right conditions for removing pollutants. They also gather contaminants and naturally dump silt. Wetlands, which are found close to sources of pollution like agricultural areas, can aid in halting the spread of contamination across ecosystems. Even though CW don't offer as excellent of habitats as natural wetlands, they are still beneficial to animals and aid in environmental protection. Rivers, and wetlands are examples of natural water purifiers that are essential to preserving the sustainability and purity of water. By eliminating contaminants, these systems lessen pollution and protect biodiversity. Wetlands are said to as the "kidneys of the earth," rivers help convert pollutants, and woods reduce sedimentation. Comprehending these systems facilitates efficient water management that benefits the ecosystem and the community [2].

Above-ground structures or shallow excavations with an impermeable liner made of clay or synthetic materials are referred to as vertical flow system (VFS). Their characteristic loading and resting periods, during which the WW percolates vertically through the substrate, are irregular (discontinuous). By enhancing oxygen transport, batch and intermittent loading enhance nitrification. Plants in VFS primarily exist to maintain the hydraulic conductivity of the bed. It's crucial to select the filter material, hydraulic loading

rate, and water distribution technique appropriately to avoid overloading certain surface regions. Their optimal performance is contingent upon a well-functioning pressure distribution, which makes them more appropriate for settings with inherent gradients where gravity serves as a filter. Since flat regions require the use of pumps, they require a steady power supply and ongoing upkeep. VFS can be further separated into down flow and up flow categories according on whether the WW is supplied into the wetland's surface or bottom. VFS's primary function is to treat domestic or municipal sewage. In addition, the method has been successfully applied in urban and industrial settings (food processing, airport de-icing water, acid mine drainage), aquaculture, and swine feedlots [3].

II. MATERIALS AND METHODOLOGY

A. Materials

Pond: To create an AW pond, a 0.35 x 0.22 x 0.17 m fiber tub was used. a photo of the VFCW in the figure 1, the container that emphasizes its durability, excellent transparency, and versatility in terms of drilling, cutting, and moulding. Fine Aggregate: These are crushed stones or sands that pass completely through the 9.5 mm screen. The type of fine aggregate used is river sand. Coarse Aggregate: Crushed stone and gravel retained on the 4.75mm screen make up the majority of this. The used aggregate size is between 20 and 40 mm. River Bed Stone: The origin of this specific type of limestone is sedimentary. Its composition includes quartz, calcium carbonate, and other elements. The dimensions range from 2.64 mm to 4 mm. Naturally occurring in the riverbed is river stone. Stainless Steel Wire Mesh: A wide variety of consumers can benefit from this multipurpose stainless steel product. The layer of filtration was separated by wire mesh. The mesh size in the sieve apertures is 4.76 mm. Fiber Tap: The fiber tap is composed of reinforced plastic. A pickoff with a half-inch diameter was used. Containers: A few and five-litres containers were used to collect treated water from the artificial VFAW pond and release influent from the sewage treatment plant.

B. Study Area

Davanagere, situated in the centre of Karnataka, is being built as part of the Smart City plan of the Central Government. According to the 2021 census, Davanagere City is home to about 5,30,000 people. The thoughtfully constructed municipal STPs efficiently handle the wastes of the metropolis. One of the STPs is located in Shivanagar, Davanagere, and has two 20MLD capacity. The treated WW from this STP is received by the canal that runs beside Doddabudihal, Chikkabudihal, and other villages that join the Thunga Bhadra river. In this experiment, samples of influent sewage are selected for treatment and comparison of the two test facilities ability to remove pollutants.

C. Details of Test Plant

Phragmites karka: This herbaceous perennial grass is a study that, as figure 2 illustrates, grows from a broad, creeping rhizome to produce somewhat woody culms that can reach heights of 4 to 10 meters and diameters of 15 to 25 mm. In perfect conditions, the P. karka can produce wide areas of thick growth that block most other plant growth. In the region, the plant has many uses, mostly as a food source but also as a pack of resources. It could be planted by rivers to stop soil erosion also in beds to purify the water [2].

Colocasia esculenta**:** It is a tropical plant that goes by several names, including Taro and Eddoe. Xanthosoma and Caladium, which are also primarily planted as ornamentals, are closely related to taro. Elephant ear is another name for it that is occasionally used, as figure 3 shows. It's called "arbi" or "arvi" in India. The greatest size of C. esculenta, a member of the Kingdom Plantae, is 40 x 24.8 cm. Its basal lobes have rounded or sub rounded ends, and its apex is mucronate, triangular-ovate, and sub rounded. The leaves grow from a rhizome [1].

D. Experimental Flow Rate Analysis

To calculate the stream rate, the crushed stone of size 20mm was placed in the pond till full and filled with water. Then the water quantity was calculated comes out to be 8 litre. For 28day period of hydraulic retention time (HRT) it is calculated as 0.8 litre per day. Since 7day interval was considered to check the rate of purification/ absorption the calculation goes like:

Flow rate= 0.8*7= 5.6 which is less than 8 litre. Hence water capacity can be maintained and fulfilled in the pond [4].

E. Experimental Setup

The study is carried out in AWs equipped with configurable input and outflow configurations and VFCW. An acrolithic sheet measuring 0.35 m by 0.22 m by 0.17 m and 0.05 mm in thickness makes up the wetland cell. The entire cell is filled with crushed stones that are trapped on a 20 mm sieve size. The

influent tank allows WW to enter the cell, and batch operation is employed. The plants used include P. karka and C. esculenta, as shown in figure 3. They serve a variety of purposes, such as eliminating sulphates and chlorides and supplying oxygen to the root zones to promote the decomposition of organic waste. The entire system was housed on a roof, and WW was continuously injected into the system. Fourteen days before to the WW being injected into the cell, wetland vegetation was sown there [5].

F. Sample Collection

The STP in Shivanagar, Davanagere town, is where the samples are taken from the moment they enter the building. To reduce bacterial activity, WW samples were collected in polythene water bottles and chilled at 4° C. During the summer, in May 2024, the sample was collected. Before the experiment began, the samples were examined in order to examine the experiments first reading.

G. Methodology

First, the pond is assembled by layering the materials, and the plants are sown 14 days before the experiment's first day. The 0.8 liter of influent sewage per day is added to the pond, and water from the tap is filtered at regular intervals of 7 to 28 days. Tests are conducted on the filtered water in the containers to determine its pH, BOD, COD, TSS, TDS, A-N, and PO_4 levels. Keep a regular eye on the wetlands animal presence, plant growth, and water quality. Carry out the required upkeep, such as clearing out trash or undesirable species. On days 7, 14, 21, and 28, the treated WW flow is gathered in a container for the analysis in the report [6].

Fig 1: Layer in the pond

Fig 2: P. karka setup in pond

Fig 3: C. esculenta setup in pond

III. RESULT AND DISUSION

The parameters selected for testing the pollution removal/ nutrient absorption are pH, TDS, TSS, DO, BOD, COD, A-N and PO_4 for the treated samples from VFAW pond during the interval of 7 days HRT for 4 times, which completes the 28days period of experiment. The DO, BOD, COD are analysed using titration method and nutrients A-N and PO_4 are analysed using Spectrophotometer.

A. Colour: The colour was dark greyish in the influent. After treating in VFAW the colour turned into yellowish in both results [7].

*B. Temperature***:** The samples were collected during summer season, recording 20℃. After the treatment the temperature dropped to 19℃ with P. karka and 18℃ with C. esculenta [7].

*C. pH***:** pH meter was used to measure pH. As seen in the figure 4, the pH of the treated sample steadily dropped throughout the HRT period in the C. esculenta plant and varied in the P. karka plant. The slightly alkaline influent of the sewage sample is neutralized by the considerable reduction in pH in C. esculenta. Day 7's pH was 7.9; day 14's was 7.6; day 21's was 7.5; and day 28's was 7.2. pH values for P. karka have been 7.8 on day 07, 8.0 on day 14, and 7.9 on day 28.

Because it has alternated between positive and negative variation on different days, the pH has somewhat decreased. This demonstrates that P. karka plants are not appropriate for pH treatment in CW; instead, pH is altered by other parameters such substrate presence, HRT, flow pattern, aeration, and others.

D. TDS: The study used a TDS meter to measure TDS in WW over time. P. karka eliminated the most TDS, while C. esculenta decreased TDS by 29% on days 7-14. C. esculenta removed the highest percentage of TDS on the first day of growth, with a 30% removal rate. C. esculenta showed superior removal efficiency as shown in the figure 5.

E. TSS: The study used a filter and evaporation method to measure TSS in water. Results showed that P. karka removed the most TSS from all hydrophytes, with C. esculenta reducing TSS by 14.1% and P. karka by 14.6%. P. karka eliminated TSS 50% of the time, while C. esculenta removed 41.1% as shown in the figure 6.

F. DO: In the figure 7, it demonstrates the water's cleanliness, and DO could have a big role. The water design's high DO concentration indicates a discernible decrease in the contaminants BOD and COD. Additionally, the findings of our tests indicate that the DO levels were gradually increased within the influent of sewage WWs treated with C. esculenta and P. karka. The BOD content has considerably dropped and the DO has risen in C. esculenta. The DO levels were 1.2 mg/l, 2.3 mg/l, 3.6 mg/l, and 4.9 mg/l on days 7, 14, 21, and 28. P. karka DO has been shown to contain 1.2 mg/l on day 7, 2.6 mg/l on day 14, 4.1 mg/l on day 21, and 5.3 mg/l on day 28.

G. BOD: In the figure 8, The research shows that BOD is being removed from sample at both test plants, with P. karka and C. esculenta successfully reducing BOD_5 throughout the HRT. C. esculenta showed a good reduction, with values of 260 (29%), 184 (39%), 156.8 (46%), and 140 (54.30%). BOD_5 decreased in P. karka by an average of 60% throughout all HRT intervals. The majority of BOD_5 elimination in P. karka occurred in 7-14 days (28%) [8].

F. COD: the open reflux method was used to measure the COD in the treated sample. The COD of the sewage is a reliable indicator of contamination levels. The C. esculenta test plant effectively eliminated COD from influent sewage. Figure 9 shows COD elimination in C. esculenta and P. karka plants. Both plants eliminated COD at a Similar rate, indicating they are suitable for CW COD reduction compared to the first two weeks.

G. A-N: Both test plants showed significant reductions in A-N levels from the wastewater after 28 days of HRT. C. esculenta A-N levels decreased by up to 60%, while P. karka A-N levels decreased significantly, making the plant suitable for nitrogen removal. Both plants can absorb urea through their roots, eliminating urea on average by 60% as shown in the figure 10.

H. PO_4: The orthophosphate PO_4-P level in the influent fluctuates, typically between 3 and 15 mg/l, influenced by factors like A-N content. C. esculenta and P. karka showed decreases in PO_4 levels over the HRT period. C. esculenta removes 70% of PO_4, while P. Karka eliminates PO_4 in the same amount for each of the four weeks due to changes in other parameters as shown in the figure 11 [9].

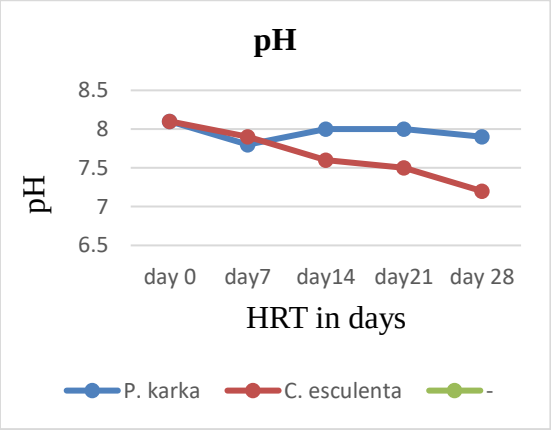

Fig 4: Variations in pH of both plants from day 0 to day 28

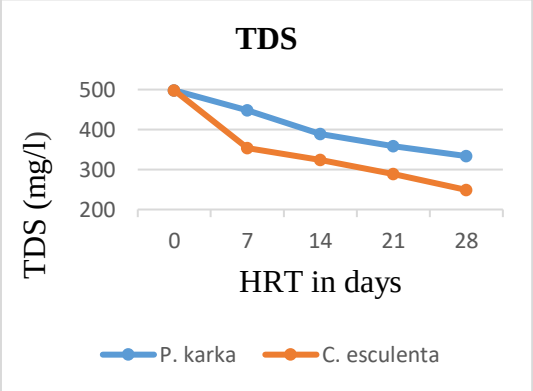

Fig 5: Variations in TDS of both plants from day 0 to day 28

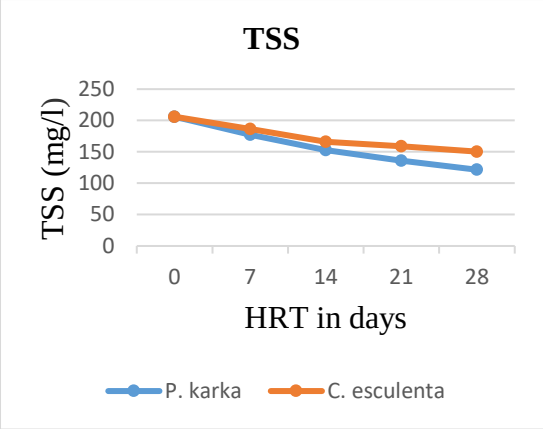

Fig 6: Variations in TSS of both plants from day 0 to day 28

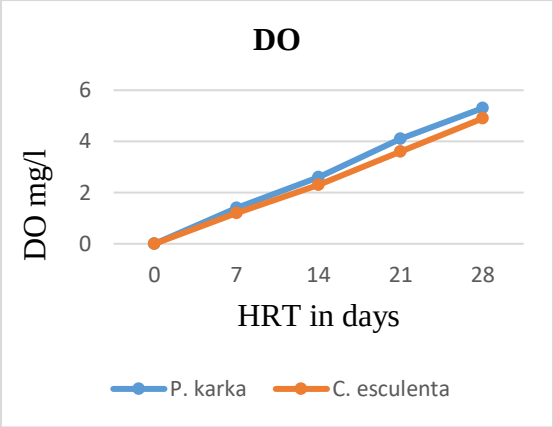

Fig 7: Variations in DO of both plants from day 0 to day 28

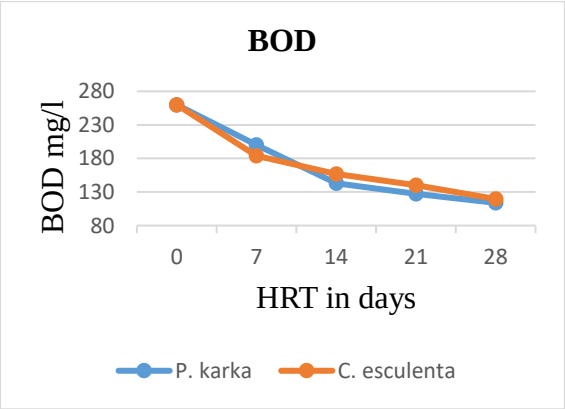

Fig 8: Variations in BOD of both plants from day 0 to day 28

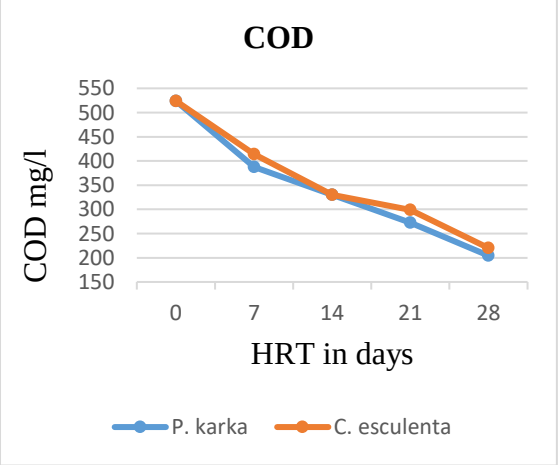

Fig 9: Variations in COD of both plants from day 0 to day 28

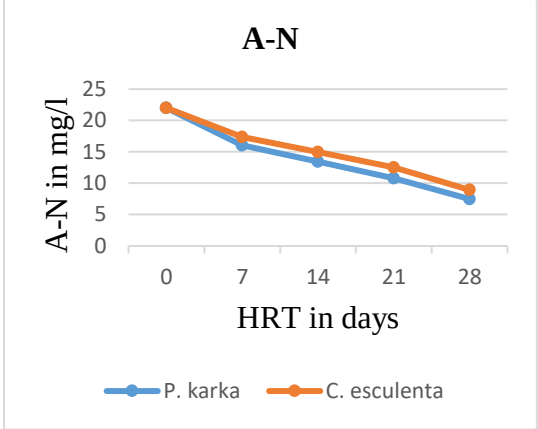

Fig 10: Variations in A-N of both plants from day 0 to day 28

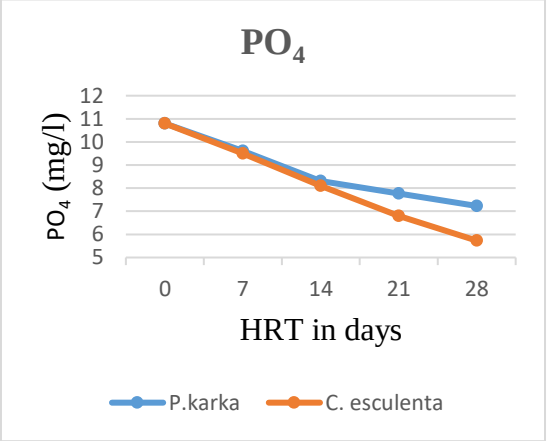

Fig 11: Variations in PO_4 of both plants from day 0 to day 28

IV CONCLUSION

P. karka eliminates and captures TSS, improving WW purity. P. karka is able to eliminate BOD, TSS, and A-N in greater proportions. Large leaves and a deep root system provide a microbial population that aids in the breakdown of organic debris in C. esculenta. More efficiently, C. esculenta eliminates pH, COD, and A-N in the produced wetland. Both plants aid in the process of nitrifying, which reverts ammonia into nitrate and reduces the amount of A-N present. Comparing both plants, P. karka is suitable to removes the parameters such as TSS, BOD, A-N while C. esculenta is suitable to remove the parameters such as pH, COD, A-N and PO_4. Both test plants are suitable for removal of A-N as per experimental study of influent sewage on artificial WC for a period 28 days [10].

LIMITATION

Constructed Wetlands require regular maintenance to function effectively, including vegetation management, sediment removal, and monitoring of water quality. Constructed Wetlands with only two test plant species may not be effective in removing a big range of pollutants. Different test plant species

have different abilities to uptake and break down specific contaminants. The efficiency of Constructed Wetlands could be effected by seasonal changes. Plants have different growth rates and metabolic activities depend on the season, which can impact the wetland's ability to consistently treat sewage.

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REFERENCES

[1]. Chavan B.L. and Dhulap V.P, "Developing a Pilot Scale Angular Horizontal Subsurface Flow Constructed Wetland for Treatment of Sewage through Phytoremediation with Colocasia esculenta", International Research Journal of Environment Sciences ISSN 2319–1414 Vol. 2(2), Pages 6-14 2013.

[2]. Atif Mustafa, "Constructed Wetland for Wastewater Treatment and Reuse: A Case Study of Developing Country", International Journal of Environmental Science and Development, Vol 4, No 1, February 2013.

[3]. Surabhi Singh, "Wastewater Pretreatment Methods for Construction Wetland: A Review" International journal for Research in Applied Science and Biotechnology, ISSN: 2349-8889, Vol-9, Issue-3 May 2022

[4]. Asghar Ebrahimi, Ensiyeh Taheri, Mohammad Hassan Ehrampoush, Sara Nasiri, Fatemeh Jalali, Rahele Soltani, and Ali Fatehizadeh, "Efficiency of Constructed Wetland Vegetated with Cyperus alternifolius Applied for Municipal Wastewater Treatment", Hindawi Publishing Corporation Journal of Environmental and Public Health Volume 2013, Article ID 815962, page 5.

[5]. Kruti B Jethwa, "A Review on Design Basis for Constructed Wetland for Wastewater Treatment" International Journal for Research in Applied Science and Engineering Technology, ISSN: 2321-9653, Vol 9 Issue VIII August 2021.

[6]. Borkar.R.P and Mahatme.P.S, "Wastewater Treatment with Vertical Flow Constructed Wetland", International journal of environmental sciences volume 2, no 2, 2011, ISSN: 0976 – 4402.

[7]. Gikas G D, C S Akratos, V A Tshihrintis, "Performance Monitoring of a Vertical Flow Constructed Wetland Treating Municipal Wastewater", Global NEST Journal, Vol 9, No 3, Pages 277-285, 2007.

[8]. Marwa M, Taha Ahmed, Ziyad Abunda, Slobodan B Mickovski, Criag Thomson, "Constructed Wetland for Sustainable and Low Wastewater Treatment: Review Article", 24th August 2022, MDPI Switzerland 2022, 11, Pages 1388.

[9]. G. Baskar, V.T. Deeptha, Abdul A Rahman, "Treatment of Wastewater from Kitchen in an Institution Hostel Mess using Constructed Wetland", International Journal of Recent Trends in Engineering, Vol. 1, No. 6, May 2009.

[10]. G N Kaushalya, "Wetlands Becoming Wastelands; Factors Contributing to the Degradation of Wetlands in Sri Lanka" IJRAR September 2020, Volume 7, Issue 3.