

# Innovative Treatment of Municipal Sewage at Shivanagar STP, Davangere with Vertical Flow Constructed Wetlands

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**Abstract**— Constructed wetlands have gained much importance for treating domestic, industrial and agricultural wastes and are considered as an effective secondary or tertiary treatment method. The main characteristics affect the removal efficiency of constructed wetland are the vegetation type, Hydraulic retention time and substrate. This study investigates the effectiveness of vertical flow constructed wetland planted with *C.indica* for the treatment of municipal sewage influent. Over a period of 28 days, various water quality parameters were monitored, including pH, TSS, TDS, DO, BOD, COD, Nitrates and Phosphates. The result for *C.indica* showed a pH of 7.1, TSS removal efficiency of 72%, DO of 5.1 mg/l, TDS reduction of 70%, BOD removal of 75%, COD reduction of 57.24%, Nitrate removal of 54% and Phosphates removal of 39%. The study concludes that plant species effectively improve water quality in vertical flow constructed wetland, with *C.indica* showing performance in TSS, TDS, BOD, and Nitrate removal.

**Key words**— *C.indica*, Hydraulic retention time, Municipal sewage influent and Vertical flow constructed wetland

## I. INTRODUCTION

Water is acknowledged globally as an essential human resource with major economic, political, social, and environmental implications. The main source of water for agriculture and consumption is the water source. Since pollution can alter the structure and functionality of biological systems, it is imperative to keep it clean and shield it from contamination. A major global issue is currently being brought on by a lack of pure freshwater and poor sanitary facilities. Fresh water availability per person is drastically decreasing. About

80 countries, or 40% of the world's population, are currently under water stress. Almost thirty of these nations have a water scarcity for a sizable portion of the year. Over the last four decades, the number of countries experiencing water scarcity has increased. from seven countries in 1955 to thirteen in 1990, most of which were developing nations. By 2025, the estimated number is expected to reach 34 [1]. An estimated 2–5 million people die each year from lack of access to clean water and adequate sanitary facilities, especially in developing nations [2]. These problems will get worse as the world's population grows and freshwater supplies are depleted and used more frequently. Concern over water, including problems like pollution, scarcity, and declining water supplies, is growing on a global scale [3]. Surface and groundwater pollution results from the infiltration and surface runoff of household wastewater from poorly sited and built on-site sanitation systems in rural areas and highly populated metropolitan canters without suitable planning [4]. Sewage treatment entails the removal of impurities to allow for the wastewater's safe release into the environment or subsequent usage for approved purposes. In doing so, the direct release of raw sewage into the water is lessened. Sewage is made up of perhaps pre-treated industrial effluent as well as wastewater from homes and businesses. There are many approaches of sewage treatment accessible. These systems can range from large, centralized ones with a network of pipelines and pump stations (known as sewerage) carrying the sewage to a treatment canter to scattered systems that include on-site treatment systems [5]. In order to enhance the quality of water from both point and nonpoint sources, artificial

treatment techniques like as built wetlands are available for various industrial agricultural municipalities and other WW. Built wetlands offer a minimally operational, low-energy, and economical WW treatment. The treatment technology known as vertical flow built wetlands involves the intermittent application of wastewater at the surface, which then percolates vertically through a sequence of filter layers and plant roots, ultimately collecting at the bottom. This technique promotes aerobic microbial activity and efficient pollutant removal by allowing for increased oxygenation, which makes it effective for treating municipal sewage. The current study uses *Canna indica* plants in artificial wetlands to investigate the effects of vegetation type on the elimination of TS, TSS, DS, TDS, BOD, COD, nitrates, and phosphates under varied hydraulic retention times.

## II. MATERIAL AND METHODOLOGY

### Samples of wastewater

The study site is situated in the town of Davangere, in Shivanagara. Samples are gathered from the research area's inlet and stored in a dry, cool place in an airtight container.

### Vertical flow constructed wetland

Artificial wetland beds are used in the research to study vertical flow beneath the surface. The artificial wetlands used for the testing were created using *Canna indica* flora, and they had dimensions of 0.4 m by 0.4 m by 0.2 m in length, width, and height. The wetland was created using vertical flow technology. River bed stone ranging in size from 4 mm to 264 mm, fine aggregate with a 9.5 mm sieve, and Wier mesh serving as a separator between the filter layers are the media that were used. mesh size of 4.76 mm in the sieve apertures.

### Wetland plants

*indica Cannabis* The Cannaceae family includes this perennial herb. It may grow in tropical and subtropical regions with full or partial sunshine, on loamy soils, and at plant heights of 0.5 to 3.0 meters. This perennial herbaceous wetland plant, *Typha* species, is commonly used to remediate industrial and urban effluents. It is said to have originated in Central America. Growing to plant heights of 1.5 to 3 meters, it can be found in locations with full or partial sunshine, on loamy soils, and in tropical and subtropical climates with leaves that are 2-4 cm broad.

### Experimental setup

For the experiment, wetlands with integrated vertical flow and specified inlet and outlet configurations are used. The plastic wetland cell, measuring 0.4 x 0.4 x 0.2 m, has a thickness of 5 mm. The entire cell is filled with pounded stones that have been retained on a 20 mm sieve size. The influent tank allows WW to enter the cell when operating in batch mode. Figure 1 displays a picture of an artificially created wetland setup. *Canna indica* plants are used to achieve a number of goals, such as eliminating BOD and COD and supplying oxygen to the root zones to aid in the purification of organic pollutants.



Fig 1. Artificial vertical flow constructed wetland model

As seen in Figure 2, stainless steel mesh separates the layers. Coarse aggregate fills the first layer at a depth of 0.5 meters. The second layer is filled with fine aggregate at a depth of 0.5 meters. The third layer, which is composed of river bed stone that is 0.5 meters below the surface, is covered with the soil medium for the growth of flora. Observation periods of 7, 14, 21, and 28 days were used in the process.



Fig 2. An image of the VFCW pond's strata

## III RESULTS AND DISCUSSION

wetland plant, *C. indica*, was examined to see if they could get rid of pollutants from influent WW in an

external cultivation experiment through wetland construction studies. Changes in the physical, chemical, and biological properties of the WW during the experiment were investigated in order to gauge how well the wetland plants performed in the produced wetland. variations in any other aspect of the water quality, such as the pH. During the treatment time with the two different selected wetland plants, standard procedures were employed to assess pH, TDS, DO, BOD, COD, Nitrates, and Phosphates.

Table 1: The variations in the final treated and untreated influent of WW that were seen throughout the treatment period with two distinct plants.

Specifications	Raw waste water	Treated effluent Readings	
		Canna indica	28 Days
pH	8.1	Reduction	7.1
TSS	206	72 %	56
DO	0	Increased	5.1
TDS	498 mg/l	70 %	148
BOD	260 mg/l	75 %	65
COD	538 mg/l	57.24 %	230
Nitrates	11.2 mg/l	54 %	5.1
Phosphates	10.8 mg/l	39 %	6.5

pH reduction

The pH of the wetland system decreases over time as the HRT increases. The initial pH of 8.1 at 0 days drops to 7.1 by 28 days as shown in Fig 3. This trend suggests a gradual acidification of the system over time. Canna indica, like other wetland plants, can influence pH through nutrient uptake and excretion. As plants grow, they can absorb bases (like calcium carbonate) from the water, and as they decompose, organic acids can be released, potentially lowering pH.

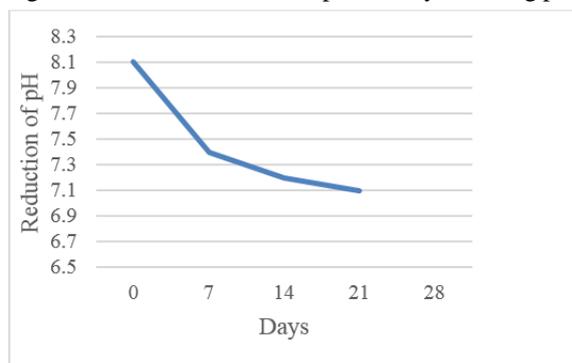


Fig 3. Reduction of pH for HRT period with selected plant

TSS removal

The TSS values decrease over time with increasing HRT. The initial TSS of 206 mg/L drops to 56 mg/L

by 28 days as shown in Fig 4. This indicates a significant reduction in suspended solids as the HRT progresses. The root systems of Canna indica can trap and filter suspended solids from the water, contributing to the decrease in TSS. The dense root matrix acts as a physical filter, capturing particles as water passes through. The significant reduction in TSS over time with increasing HRT in your constructed wetland using Canna indica highlights the system's effectiveness in removing suspended solids. This trend reflects the combined effects of sedimentation, plant filtration, and microbial activity.

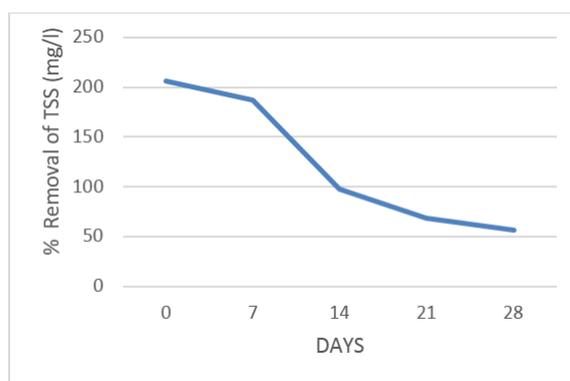


Fig 4. % of TSS elimination with C.indica plant during the HRT period

DO removal

The DO levels increase over time with increasing HRT. Starting from 0 mg/L at 0 days, the DO rises to 5.4 mg/L by 28 days. This indicates a gradual improvement in the oxygen levels within the wetland system as HRT increases as shown in Fig 5. Canna indica, through photosynthesis, contributes to the production of oxygen. As plants mature and grow, they produce more oxygen, which can increase DO levels in the water. Longer HRT allows more time for aeration and gas exchange between the water and atmosphere, enhancing oxygen levels.

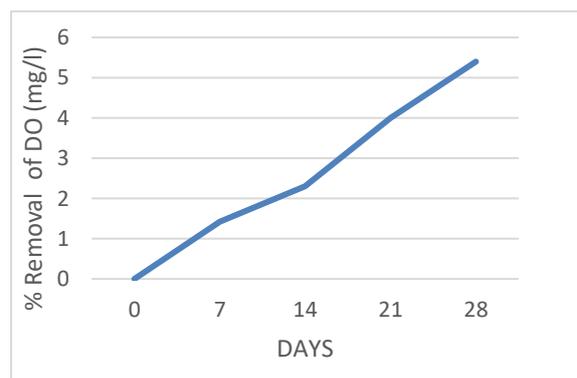


Fig 5. % of DO removal for the HRT period with canna plant

TDS removal

Canna indica can absorb various dissolved solids, including nutrients and minerals, from the water. As the plants grow, they take up these dissolved solids, which can lead to a decrease in TDS levels. The TDS levels decrease over time with increasing HRT. Starting from 498 mg/L at 0 days, TDS decreases to 148 mg/L by 28 days as shown in Fig 6. This shows a significant reduction in dissolved solids in the water as the HRT increases. The decrease in TDS over increasing HRT in your constructed wetland with Canna indica indicates that the system effectively reduces dissolved solids through plant uptake and other treatment processes.

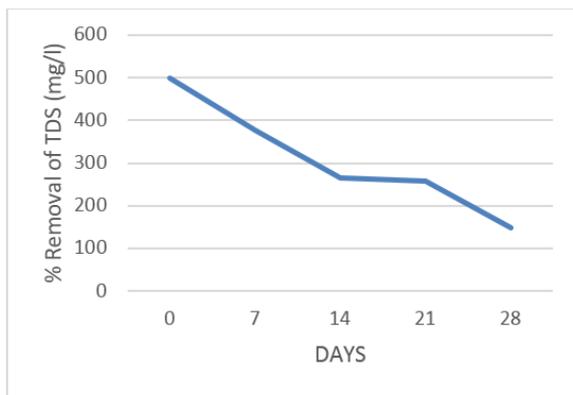


Fig 6. % of TDS Removal for the selected plant during the HRT period

BOD removal

Canna indica can contribute to the reduction of BOD through its uptake of organic matter and nutrients. By absorbing these substances, the plant helps to lower the organic load in the water. The BOD values show a clear decreasing trend over time with increasing HRT. Starting at 260 mg/L at 0 days, BOD reduces to 65 mg/L by 28 days as shown in Fig 7. This significant decrease indicates effective biological treatment of organic matter in the constructed wetland. The wetland system's microbial community plays a crucial role in decomposing organic matter. Over time, as microorganisms break down the organic material, BOD decreases because the amount of oxygen required to decompose the remaining organic matter reduces. The data indicates that the wetland is efficiently treating wastewater, improving water quality, and reducing the environmental impact of the effluent.

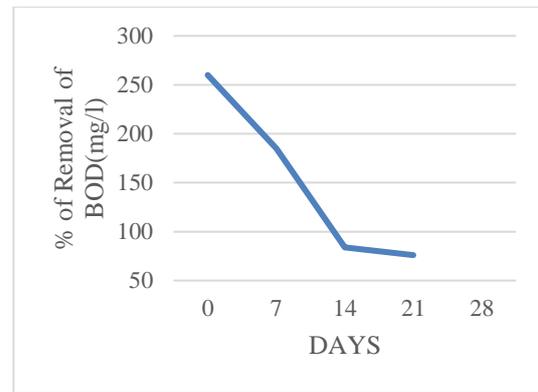


Fig 7. % of BOD removal with canna indica plant for the HRT period

COD removal

The constructed wetland's microbial community is crucial in breaking down organic compounds. As microbial activity continues, more organic matter is decomposed, leading to a reduction in COD. Longer HRT provides more time for these biological processes to occur. Sedimentation and filtration processes in the wetland may also contribute to COD reduction by removing particulate organic matter that contributes to the overall COD. Chemical reactions within the wetland, including those facilitated by microorganisms or plant roots, can lead to the breakdown of organic compounds, thereby reducing COD levels. The COD values show a decreasing trend over time as HRT increases. Starting from 538 mg/L at 0 days, COD decreases to 230 mg/L by 28 days as shown in figure 8. This indicates a significant reduction in the chemical oxygen demand of the water, reflecting the system's effectiveness in reducing organic pollutants. The trend indicates that the wetland is successfully treating organic pollutants and improving water quality, making it a reliable option for wastewater treatment.

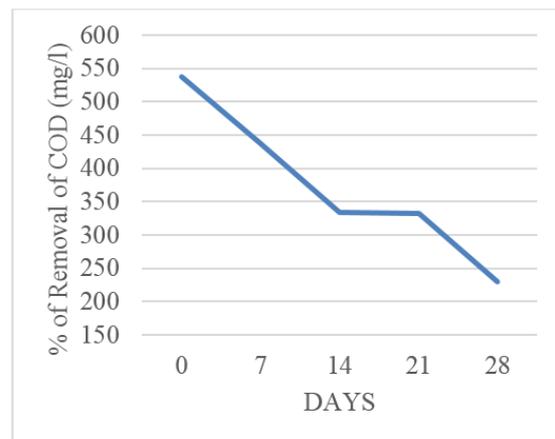


Fig 8. % of COD Removal with selected plant over the period of HRT.

Nitrates removal

The constructed wetland likely supports both nitrification and denitrification processes. Nitrification, carried out by nitrifying bacteria, converts ammonia to nitrate. Denitrification, performed by denitrifying bacteria in an anaerobic environment, converts nitrate to nitrogen gas, which is released into the atmosphere. The observed reduction in nitrate suggests that denitrification is effectively occurring in the wetland. The nitrate concentration decreases over time with increasing HRT. Starting from 11.2 mg/L at 0 days, nitrate levels decrease to 5.1 mg/L by 28 days as shown in Fig 9. This trend indicates effective nitrate removal by the constructed wetland system over the course of the HRT. This the success of the wetland in managing nitrate and improving water quality, which is essential for preventing nutrient pollution and supporting a healthy aquatic environment.

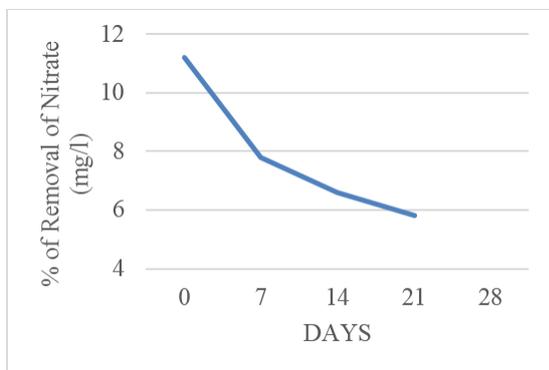


Fig 9. % of removal of Nitrate using canna indica plant

Phosphate removal

The reduction in phosphate levels indicates that the constructed wetland using *Canna indica* is effective in removing phosphates. This is crucial for managing nutrient pollution and preventing issues such as eutrophication in receiving water bodies. The phosphate levels show a general decreasing trend over time, with an initial value of 10.8 mg/L at 0 days dropping to 6.5 mg/L by 28 days. However, there is a slight increase in phosphate concentration between 21 and 28 days as shown in Fig 10. Despite this minor increase, the overall trend indicates effective phosphate removal over the HRT period. the reduction in phosphate levels over time with increasing HRT in your constructed wetland with *Canna indica* reflects the system's effectiveness in phosphate removal. Despite a slight increase towards the end of the monitoring period, the overall trend demonstrates

successful nutrient management and improved water quality.

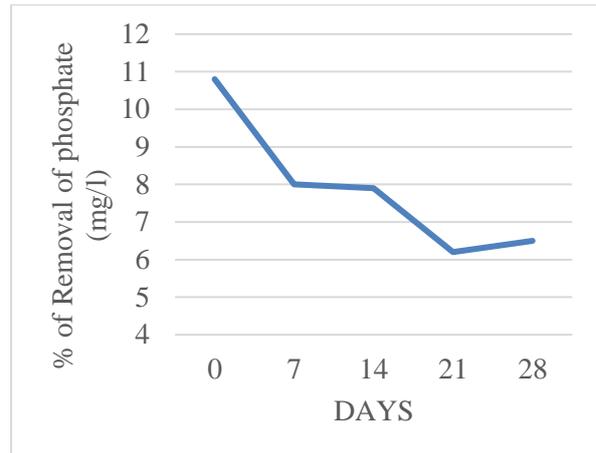


Fig 10. % of removal of phosphate using canna indica for HRT period

IV CONCLUSION

The vertical flow constructed wetland using *Canna indica* has proven to be an effective system for treating wastewater. It successfully reduced key water quality parameters, including TSS, BOD, COD, TDS, nitrate, and phosphate, while enhancing DO levels. These improvements indicate that the wetland provides effective treatment and enhances overall water quality. The use of *Canna indica* contributes positively to the system's performance through nutrient uptake, pollutant removal, and support for biological processes. Continued monitoring and optimization of the wetland will ensure sustained performance and address any potential issues to maintain high treatment efficiency.

ACKNOWLEDGEMENTS

The authors of the paper are thankful to prof. Dr. D P Nagarajappa, Principal, University BDT College of engineering, Davangere, for providing the facilities that were very much for this preparation.

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