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Research paper

Comparative Treatment of Municipal Sewage from Shivangar STP, Davangere, Using two Plant Species in Constructed Wetlands

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ABSTRACT

This work examines the efficacy of artificial wetlands with vertical flow, planted with C. indica and T. latifolia, in treating influent municipal sewage. Water quality measures, such as pH, TSS, TDS, DO, BOD, COD, nitrates and phosphates, were observed for a duration of 28 days. pH was 7.1, TSS removal efficiency was 72%, DO was 5.1 mg/l, TDS reduction was 70%, BOD removal was 75%, COD reduction was 57.24%, nitrate removal was 54%, and phosphate removal was 39% for C. indica. While T.latifolia showed a pH of 7.3, an efficiency of 67% in removing TSS, a DO of 5.4 mg/l, a reduction of 62.24% in TDS, a removal of 71% in BOD, a reduction of 63% in COD, a removal of 46% in nitrate, and a 50% removal of phosphate, the results were comparable. The study finds that in VFCW, both plant types significantly enhance water quality.

1. Introduction

Water is widely recognized as a crucial human resource with significant economic, political, social, and environmental significance worldwide. The water source serves as the primary supply for drinking and agricultural. It is crucial to maintain its cleanliness and protect it from contamination, since pollution may cause alterations in the structure and functioning of biological systems. Currently, there is a growing worldwide problem caused by the scarcity of clean freshwater and inadequate sanitary services. The per capita availability of fresh water is declining significantly. Approximately 80 nations, which account for 40% of the global population, are now under water stress. Among these countries, almost 30% experience water shortage for a significant a portion of the year. In the previous forty years, there have been a rise in the quantity of nations facing water scarcity. from seven in 1955 to thirteen in 1990, with the majority of these countries being in developing countries. It is anticipated that the projected figure will reach 34 by 2025 (Gleick 2006). The insufficiency of potable water resources and sanitation facilities leads to an annual mortality toll of 2-5 million, mostly in poor countries (Gleick 2004). As the global population expands and freshwater supplies are increasingly used and deteriorated, these issues will worsen. There is a rising global concern over water, which includes issues such as water scarcity, water pollution, and the deterioration of water supplies (Wu et al., 2013).

In rural regions and densely populated metropolitan canters without proper planning, the infiltration and surface runoff of residential wastewater from poorly located and inadequately constructed on-site sanitation systems lead to pollution of surface and groundwater (Denny 1997).

The process of treating sewage involves removing contaminants so that the treated wastewater can be safely discharged into the environment or used again for designated uses. This helps reduce water contamination caused by the direct discharge of untreated sewage. Sewage comprises of domestic and commercial wastewater, together with potentially pre- treated industrial effluent. There are many approaches of sewage treatment accessible. These systems might vary from distributed systems, including on-site treatment systems, to massive centralized systems with a network of pipelines and pump stations (known as sewerage) transporting the sewage to a treatment canter.

To ensure that improve the water quality of both point and nonpoint sources, constructed wetlands serve as artificial treatment options for various industrial agricultural municipalities and other WW. Constructed wetlands provide a low-energy, low-cost, and minimally operated WW treatment.

Vertical flow constructed wetlands are type of treatment system where wastewater is applied intermittently at the surface and percolates vertically through a series of filtration layers and plant roots before being collected at the bottom. This method is effective for treating municipal sewage, as it allows for enhanced oxygenation, promoting aerobic microbial process and efficient pollutant removal.

The aim of present study is to examine effect of vegetation type on TS, TSS, DS, TDS, BOD, COD, Nitrates and Phosphate removal under varying hydraulic retention period in two Different plants in constructed wetlands.

2. Materials and Methods

2.1 Wastewater Samples

The study site is located at the shivanagar, davangere town. The sample are collected from the inlet of study area in an air tight container and storage in cool and dry place.

2.2 Vertical flow constructed wetland

Vertical flow beneath the surface for the research, artificial wetland beds are employed. Two sets of tests were conducted on Canna indica vegetation in artificial wetlands: one set tested the plant's viability, while the other set tested Typha latifolia. The vertical flow constructed wetland are made of plastic with a length, width and height 0f 0.4 m by 0.4 m by 0.2 m . The media used are 20-40 mm coarse aggregate, fine aggregate with 9.5 mm sieve, river bed stone with 4 mm to 264 mm and Wier mesh was used as a separators between the filter layers. Sieve openings with 4.76 mm mesh size.

2.3 Wetland plants

There are two categories: perennial herbaceous species and cannaceae species. Commonly utilized plants in artificial wetlands. Two of the world's most prolific, widely distributed, and diverse wetland species are Canna indica and Typha latifolia. It is the most common species utilized in artificial wetlands because of its fast growth and ability to withstand various climates.

Canna Indica This perennial herb belongs to the family Cannaceae. It may grow in areas with full or partial sunshine, on loamy soils, and at plant heights of 0.5 to 3.0 meters in tropical and subtropical climates. It is believed to have started in Central and Typha species, which is a common wetland plant utilized in the treatment of urban and industrial effluents, includes this perennial herbaceous wetland plant It can grow in areas with full or partial sunshine, on loamy soils, reaching plant heights of 1.5 to 3 meters, and with leaves that are 2-4 centimeters broad in tropical and subtropical climes.

2.4 Experimental setup

Wetlands with integrated vertical flow and configured inlet and outlet configurations are used for the investigation. The 0.4 x 0.4 x 0.2 m plastic wetland cell is composed of 5 mm thick plastic. Pounded stones that have been retained on a 20 mm sieve size fill the entire cell. In the batch mode of operation, WW is supplied into the cell through the influent tank. A photograph of an artificially constructed wetland setup is shown in Fig 1. The vegetation utilized in canna indica and Typha latifolia serves various objectives, including the removal of BOD and COD and the provision of oxygen at the root zones for the purification of organic materials.

Fig. 1 The model of VFCW system

The layers are divided by stainless steel mesh, as shown in Fig 2. At a depth of 0.5 meters, the first layer is filled with coarse aggregate. At a depth of 0.5 meters, fine aggregate fills the second layer. The soil medium for the growth of vegetation is placed above the third layer, which is filled with river bed stone that is 0.5 meters below the surface. The observation process was carried out with a variation of HRT of 7,14,21 and 28 days.

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

3. Results

Two wetland plants, C. indica and T. latifolia, were 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

Specific-ations	Raw waste water	Treated effluent Readings			
		Canna indica	28 Days	*Typha latifolia*	28 Days
p H	8.1	Reduction	7.1	Reduction	7.3
TSS	206	72 %	56	67 %	66
DO	0	Increased	5.1	Increased	5.4
TDS	498 mg/l	70 %	148	62.24 %	188
BOD	260 mg/l	75 %	65	71 %	74
COD	538 mg/l	57.24 %	230	63 %	198
Nitrates	11.2 mg/l	54 %	5.1	46 %	6.0
Phosphates	10.8 mg/l	39 %	6.5	50 %	5.4

4. Discussion

4.1 TSS removal

Both Canna indica and Typha latifolia showed notable TSS reduction during the experiment. C.indica exhibited a faster TSS reduction during the first two weeks, with the concentration dropping from 187 mg/L to 98 mg/L by the 14th day, representing a 47.6 % reduction. By the end of the experiment 28 days, the TSS concentration reached 56 mg/l, an overall reduction of 72%. Typha latifolia, on the other hand, had a higher TSS concentration at the day 14th day mark 145 mg/L, indicating a 26.8% reduction from the initial 198 mg/L. However, by the 28th day, the TSS concentration reached 66 mg/L, an overall reduction of 66.7% shows in Fig 3.

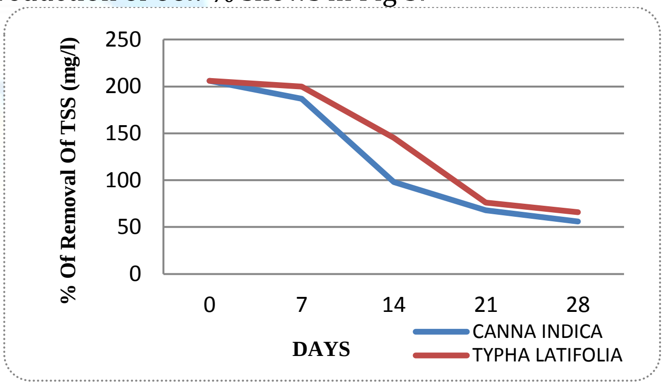

Fig. 3 % of TSS elimination with two plants of choice during the HRT period

4.2 DO Removal

C. indica and *Typha latifolia* exhibited an increase in DO over the 28 days of HRT shown in Figure 4. The rise in DO is likely due to oxygenation through plant roots and improved water aeration as the wetland matures. C.indica showed an increase in DO from 1,42 mg/L at 7 days to 5.4 mg/L at 28 days. This represents a increase in DO over the 28 days. Typha latifolia started with a DO concentration of 1.4 mg/L at 7 days and reched 5.1 mg/L by the 28th day. While both plants increased the DO levels significantly, C.indica had a slightly higher DO concentration at the end of the experiment compared to Typha latifolia .

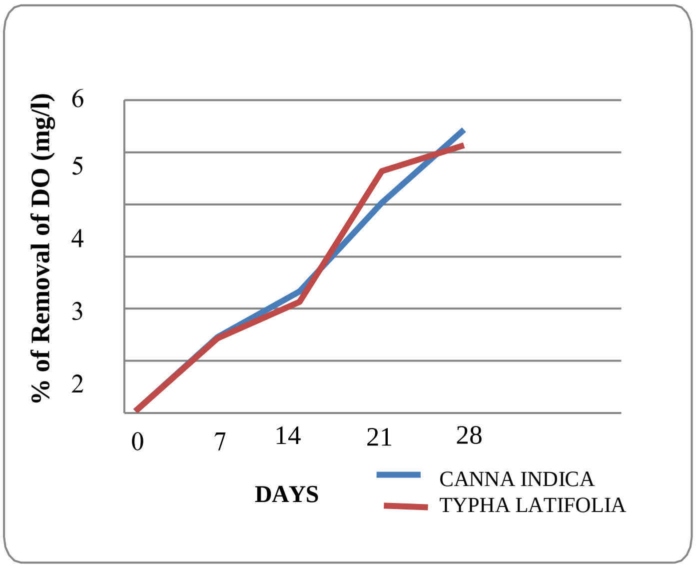

Fig. 4 % of DO Removal for the HRT period with two chosen plants

4.3 TDS Removal

C.indica had a 29.3% reduction in TDS from 7 to 14 days from 376 mg/L to 266 mg/L and smaller reduction of 2.6% between 14 days from 266 mg/L to 259 mg/L. The most significant reduction occurred between 21 and 28 days, where TDS dropped by 42.9% from 259 mg/L to 148 mg/L. Typha latifolia showed a 28.1% reduction in TDS from 7 to 14 days from 398 mg/L to 286 mg/L, followed by a 8.4% reduction between 14 and 21 days from 286 mg/L to 262 mg/L. The final reduction from 21 to 28 days was 28.2% from 262 mg/L to 188 mg/L. These results show that C.indica was more effective in reducing TDS during the final stage as shown in Figure 5, while Typha latifolia demonstrated a more consistent reduction over time but with a lower overall efficiency by the 28th day.

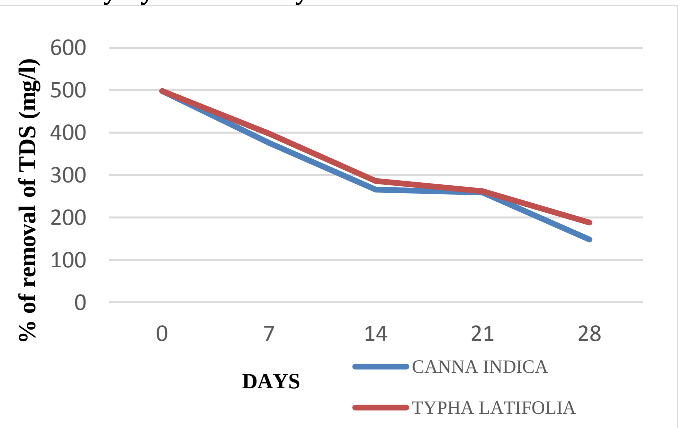

Fig. 5 % of TDS Removal for the Selected Two Plants during the HRT Period

4.4 BOD Removal

Both C.indica and Typha latifolia effectively reduced BOD during the 28 days experiment . BOD is a key indicator of the organic load in wastewater, and its reduction signifies the breakdown of organic matter by plant roots and associated microbial communities. C.indica reduced BOD from 185 mg/L at 7 days to 65 mg/L at 28 days, an overall reduction of 64.9%. Typha latifolia reduced BOD from 198 mf/L at 7 days to 74 mg/L at 28 days, an overall reduction of 62.6%. While both plants achieved significant BOD reduction the outcomes of result displayed in Figure 6, C.indica was more effective, especially in the early stages 7 to 14 days and at the final stage 28 days.

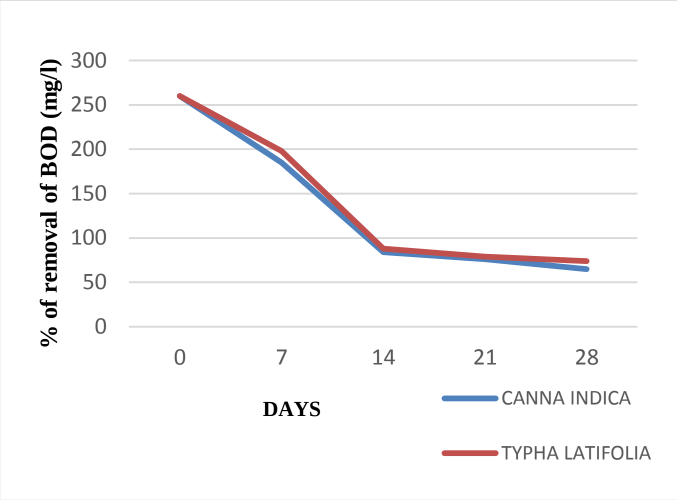

Fig. 6 % of BOD Removal with Two Selected Plants for the HRT Period

4.5 COD Removal

Both C.indica and Typha latifolia effectively reduced COD over the 28 days period as shown in Figure 7. COD is an indicator of the total amount of organic compounds in the water, including both biodegradable and non-biodegradable substance. C.indica reduced COD from 436 mg/L at 7 days to 230 mg/L at 28 days, a total reduction of 57.2%. Typha latifolia reduced COD from 328 mg/L at 7 days to 198 mg/L at 28 days, a total reduction of 63%. Typha latifolia achieved a greater COD reduction.

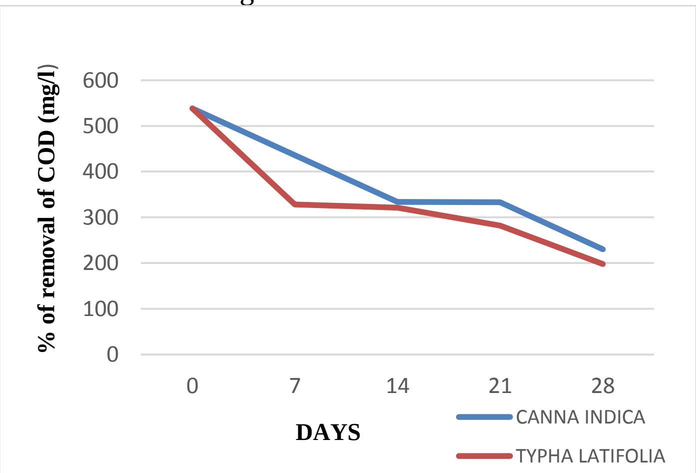

Fig. 7 % of COD Removal with two chosen plants over the course of the HRT period

4.6 Nitrates Removal

C.indica and Typha latifolia show a clear trend of nitrate reduction with increasing HRT. This is typical in constructed wetlands where the denitrification process becomes more effective as water is retained for longer periods, allowing more time for bacterial activity and plant uptake C.indica shows a slightly better performance than Typha latifolia in reducing nitrate concentrations across all HRTs. The final nitrate concentration after 28 days of HRT is 5.1 mg/L for C.indica, compared to 6.0 mg/L for Typha latifolia as shown in Figure 8.

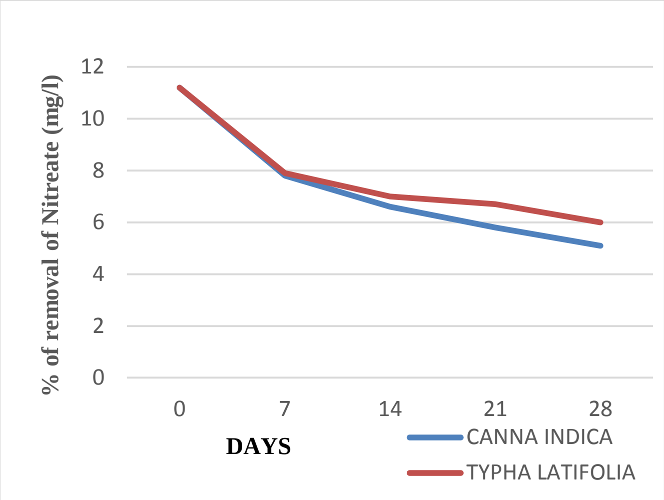

Fig. 8 % of Nitrate Removal with Selected Two Plants for the HRT Period

4.7 *Phosphate Removal*

Typha latifolia demonstrates superior performance in phosphate removal compared to C.indica. At 28 days, Typha latifolia has reduced phosphate by 1.6 mg/L, while C.indica has only reduced it by 1.5 mg/L over the same period. The performance gap becomes apparent after 14 days of HRT, where Typha latifolia shows a sharper decrease in phosphate concentration compared to C.indica. for example, at 21 days, Typha latifolia reaches 5.8 mg/L, while C.indica is still at 6.2 mg/L Figure 9 shows the result.

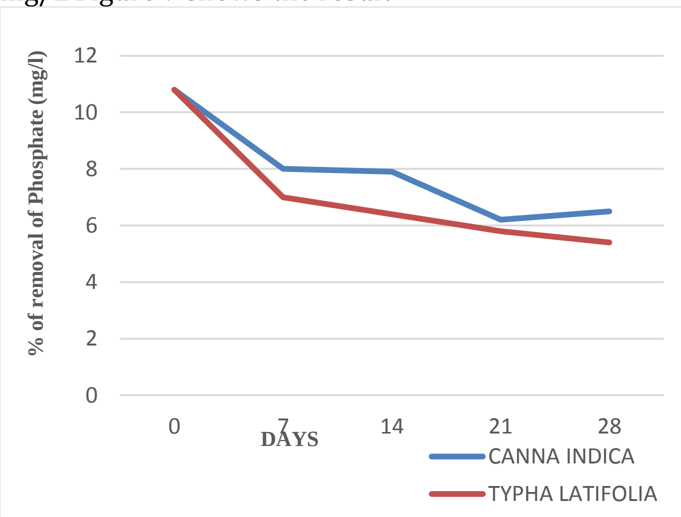

Fig. 9 % of Phosphate Removal with Selected Two Plants for HRT Period

5. Conclusions

The use of VFCW planted with C.indica and T. latifolia has shown its effectiveness as a method for the elimination of both physicochemical and biological pollutants. It was found that there is a rise in pH of managed WW for each case which is because of the existence of filter media in the bed assembly. C.indica enable to achieve TSS, TDS, BOD and Nitrates removal efficiency at 72%, 70%, 75% and 54% in created wetland more effectively. It is because of the oxygen diffusion from roots of the C.indica and nutrient uptake and insulation of the bed surface. T.latifolia manges to remove COD 63% and Phosphate 50% in more percentages compare to C. indica. It was found that the overall percentage removal of all pollutants were better the detention time of 28 days as compare to other detention time. No odors or insects were detected during the 28 days operation of VFCW.

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Declaration of Conflict

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

1. Badhe N, Saha S, Biswas R, Nandy T (2014) *Role of the algal bio film in improving the performance of free surface, up flow constructed wetland*. Bioresour Technol 169:596– 604
2. Chen Y, Wen Y, Zhou Q, Vymazal J (2014) *Effects of the plant biomass on denitrifying genes in sub surface flow CW.* Bioresour Technol 157:341–345
3. Denny P (1997) Implementation of CWs in the developing countries. *Water Sci Technol* 35:27–34
4. Gleick P (2004) *The world's water, 2004–2005. The biennial report on freshwater resources. Island Press, Washington*, DC, p 362.
5. Gleick P (2006) The world's water (2008-2009) the biennial report on the freshwater resources. *Island Press, Washington, DC,* pp 171–176.
6. Holding Company for Water and WW Report (2012) *1st Egyptian-German work- shop, Cairo University*. 1–3 Feb
7. Kivaisi A K (2001) *The potential for the CWs for WW treatment and reusing developing countries*: a review. Ecol Eng 16(4):545–560

8. Li Y, Zhu G, Ng WJ, Tan SK (2014) *A review on the removing pharmaceutical contaminants from WW by CWs: design, performance and the mechanism.* Sci Total Environ 468:908–932
9. Rai UN, Tripathi RD, Singh NK, Upadhyay AK, Dwivedi S, Shukla MK, Nautical CS (2013) *CWs an ecotechnological tool for pollution treatment for conservation of the Ganga river.* Bioresour Technol148:535–541
10. Trang NTD, Brix H (2014) *Use of planted bio filters in the integrated recirculating aquaculture hydroponics systems in the Mekong Delta,* Vietnam. Aquacult Res 45(3):460– 469
11. Villa JA, Mitsch WJ, Song K, Miao S (2014) *Contribution of different wetland plant species to the DOC exported from a mesocosm experiment in the Florida Everglades*. Ecol Eng 71:118–125.
12. Water UN (2008) Trans boundary waters: sharing benefits, sharing responsibilities. Thematic Paper. http://www.Unwater.Org/downloads/UNW–TRANSBOUNDAR
13. World Health Organization (2005) *Water for life, making it happen.* WHOUNICEF924 (5):156–293
14. Wu H, Zhang J, Li C, Fan J, ZouY (2013) *Mass balance study on the phosphorus removal in CW microcosms treating polluted river water*. Clean the Soil Air Water 41 (9):844–850
15. Wu S, Kuschk P, Brix H, Vymazal J, Dong R (2014) *Development of the CWs in performance intensifications for the WW treatment: a nitrogen and organic matter targeted review.* Water Res 57:40–55