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Phytoremediation prospective of Indian shot (*Canna indica*) in treating the sewage effluent through hybrid reed bed (HRB) technology

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Abstract
A lab scale hybrid reed bed (HRB) system was designed by combining horizontal flow (HF) and vertical flow (VF) beds and their pollutant removal efficiencies was assessed at the hydraulic retention time (HRT) of 3, 5, 7 days. Indian shot (*Canna indica*) was planted in both the VF and HF beds. The results of the lab scale hybrid reed bed system utilizing *Canna indica*, revealed that pollutant removal efficiency of the system was found to be 68 % Biological oxygen demand (BOD), 61.8 % Chemical oxygen demand (COD), 71.7 % Total dissolved solids (TDS), 73.3% Total suspended solids (TSS). The heavy metal (Chromium, Lead, and Nickel) uptake was found to be higher in the root portion of *Canna indica* compared to the stem and leaf portion.

Keywords: Hybrid reed bed system, *Canna indica*, BOD, COD, Heavy metals

Introduction
Constructed wetlands which was progressed during the last four decades of 20th century are the most widely used ecological wastewater treatment systems. There are several types of constructed wetlands which could be distinguished according to several criteria such as presence / absence of free water surface, macrophytes used or direction of flow [1]. Horizontal flow (HF) systems is used to remove the organics and suspended solids whereas Vertical flow (VF) systems are used to remove further organics and also to nitrify ammonia to nitrite. Hybrid reed bed system comprises of both HF and VF in a staged manner. Though numerous studies has been conducted with constructed wetlands using the various plants, utilization of Indian shot in hybrid reed bed system is meagre. Hence, an attempt has been made to assess the phytoremediation potential of Indian shot (*Canna indica*) in treating the sewage effluent through hybrid reed bed technology

Material and Methods
The study was carried out in the Department of Environmental Sciences, Tamil Nadu Agricultural University (TNAU), Coimbatore. A lab scale Hybrid Constructed Wetland System (HCWS) was designed with both horizontal and vertical flow treatment (HF-VF) system. Total of four cells was installed in the HCWS. All the cells were uniform in size of 80 x 57 x 42.5 cm (L x W x H). Sewage was collected from Tamil Nadu Agricultural University (TNAU) sewage collection area near TNAU staff quarters and used for experiment purposes. Sewage samples were analyzed as per standards analytical procedures. The first cell was screening cell where stainless steel filter mesh was used for filtering the solid materials and sewage was pumped into the first cell. The second cell was the horizontal flow (HF) treatment system. From the screening cell, sewage effluent entered the HF cell through gravity. The third cell was the vertical flow system where the perforated pipes were installed for the vertical movement of sewage from the HF cell. Both HF and VF cells are packed with pre-sterilized media *viz.*, pebbles (40mm), gravels (20mm), coarse sand, and soil in a sandwich manner respectively. The fourth cell was the treated water collection cell. Indian shot (*Canna indica*) plants was collected from the Department of Floriculture and landscaping, TNAU and used after stabilization for the recycling of sewage effluent in the established Hybrid reed bed system. Young healthy rhizomes of *Canna indica* plant was selected and 8 nos. of rhizomes was planted in each of both horizontal flow and vertical flow tanks of the reed bed system. After flowering stage of *Canna indica*, the plants were uprooted. Hydraulic retention time

(HRT) of 3, 5, 7 days were maintained throughout the experimental period for evaluating the treatment efficiency of HRB.

Results and discussion

Characteristics of Sewage effluent

The quality of the collected sewage was assessed by analyzing its pH, Biological oxygen demand (BOD), chemical oxygen demand (COD), Total Suspended Solids (TSS), Total dissolved solids (TDS) and total coliforms. The parameters analyzed in the sewage effluent were presented in the Table 1. The pH of the sewage effluent was found to be 6.97. The EC was 3.1 dS m^{-1}. BOD values was 387 mg L^{-1}. An increase in the BOD levels is usually an indication of an influx of some type of organic pollutant in the collected water. The COD value of the sewage was 1100 mg L^{-1}. The COD value of the sewage effluent recorded the same trend as that of BOD level. Since the level of COD was very high it point toward the high loading of both organic and inorganic pollutants. The high BOD and COD values of collected sewage water samples exceed the prescribed levels of 100 and 250 mg L^{-1} (CPCB) for irrigation. Hence, the sewage water should be treated before its usage for crop irrigation. The TSS was found to be 1500 mg L^{-1} and TDS values was found to be 2150 mg L^{-1}. This could be due to the presence of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates) and some small amounts of organic matter that are dissolved in the sewage water. The total coliforms concentration was 1600/ 100ml. This may be due to the incorporation of the domestic waste from the staff quarters i.e., residence into the sampling site. It has been reported that the fecal coliform and *E. coli* concentrations are highly variable, especially along urban streams and generally increase with stream flow and precipitation events [2]. Carbonate and Bicarbonate content of the samples were found to be 0.9 and 6 me.L^{-1} respectively. Results were in line with the findings of Rattan [3] who reported that the carbonate and bicarbonate contents in effluent samples collected from Keshopur Sewage Treatment Plant varied from traces to 0.8 and 4.4 to 9.8 me L^{-1} respectively. Carbonate concentrations in all the samples were much lower as compared to bicarbonate concentrations, which is also reflected in acidic reaction of effluents. Heavy metals *viz*., Chromium, Nickel and Lead in the sewage effluent was found to be 0.38 ppm 2.66 ppm and 0.17 ppm respectively.

Table 1: Initial Characteristics of sewage effluent

S. No	Parameters	Values
1.	pH	6.97
2.	EC (dS m^{-1})	3.1
3.	Biological oxygen demand (ppm)	387
4.	Chemical oxygen demand (ppm)	1100
5.	Total Dissolved solids (ppm)	2150
6.	Total Suspended solids (ppm)	1500
7.	Total coliforms (MPN / 100 ml)	1600
8.	Calcium (me.L^{-1})	4.16
9.	Magnesium (me.L^{-1})	8.31
10.	Carbonate (me.L^{-1})	0.90
11.	Bicarbonate (me.L^{-1})	6.00
12.	Chromium (ppm)	0.38
13.	Nickel (ppm)	2.66
14.	Lead (ppm)	0.17

Effect of HRB in effluent treatment

pH and EC

Sewage samples collected at the HRT interval of 3, 5, 7 days were analyzed for pH and EC and was presented in the Fig1. The results indicated that there was minimum reduction in the pH value as the HRT progressed. But there was sizeable decrease in the EC value from 3.1 to 1.4 dS m^{-1}. This may be due to the removal of dissolved solids by the plants grown in the hybrid reed bed system.

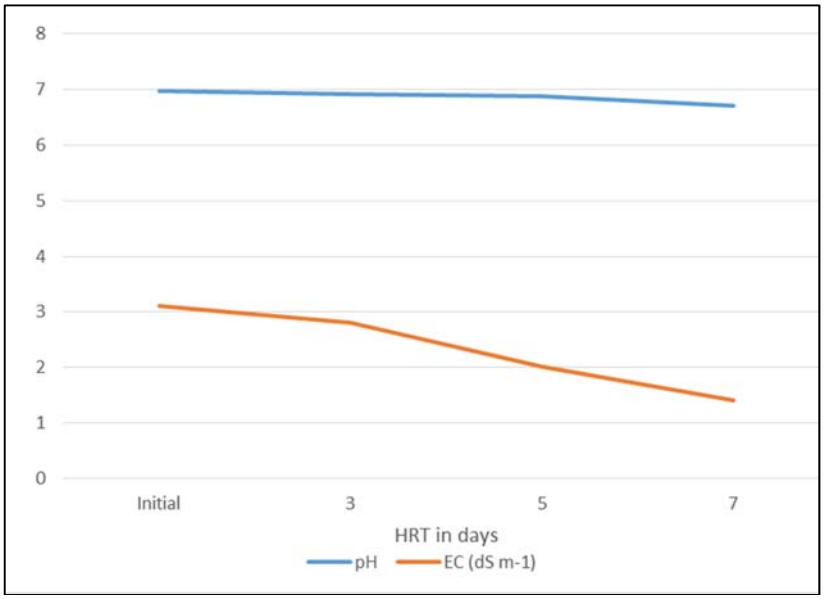

Fig 1: Effect of HRB in the pH and EC of the sewage effluent

BOD removal

The BOD removal efficiency of the HRB was recorded at HRT of 3, 5 and 7 days. BOD removal efficiency was significantly higher at HRT of 7 days (60%) followed by 5 days (15%) and 3 days (7 %) respectively. This may be due to the effect of the hybrid reed bed systems which emulate the natural treatment processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality [4]. High aeration provided by the aeranchyma cells of roots of *Canna indica* may be contributed to the

degradation of organic pollutants and thereby resulted in the reduction of BOD of the effluent. This is line with the literature [5]. BOD removal efficiency was found to be higher which may be due to the organic pollutants degradation by the microorganisms adheres to the rhizosphere region of constructed wetlands. It has been also revealed that the rhizosphere microbial communities will remediate the polluted systems through biotransformation of hazardous organic compounds in the root zone [6]. The present study comprises of two stage treatment i.e., Horizontal flow (HF) and Vertical flow (VF), which could likewise contribute to the higher BOD removal. Similar trend was observed that the three-stage hybrid constructed wetland consisting of saturated vertical flow, free-drained vertical-flow and horizontal sub-surface flow wetlands, proved to be very effective in reducing organics, suspended solids and BOD_5 removal amounted to 78.1% and 94.5%, respectively with outflow concentrations of 16 and 10 mg/l from municipal wastewater [7].

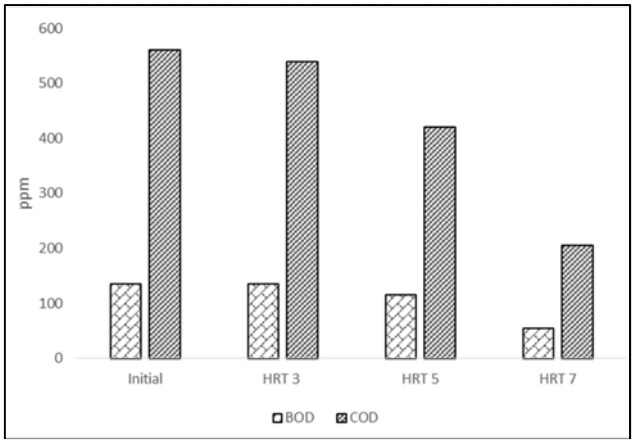

Fig 2: BOD and COD removal efficiency of HRB system

COD removal

COD removal efficiency of HRB system was recorded and was presented in Fig 2. The COD removal efficiency increased in order of HRT of 7d > 5 d > 3 d. This might be due to the higher growth rate of Indian Shot (*Canna indica*) and more contact time with the pollutants tends to react with and reduce the pollutant load. Reports revealed that the growth of plants depends on the HRT and the media used in the constructed wetland systems [8]. *Canna indica* is considered to be one of the best plants for phytoremediation purpose. It is effective in the treatment of industrial waste waters through constructed wetlands. The combined effect of HF and VF in the HRB proved to be significant in the pollutant removal efficiency. The hybrid ecological wastewater treatment systems were effective in the treating the reclaimed water [9].

Heavy metal removal

The sewage effluent collected from the treated water collection cell was analyzed for its heavy metals content *viz*., Chromium, Nickel and Lead and was presented in Fig 3. Heavy metal Chromium, Nickel and Lead removal was found to be 57.8%, 50.3%, and 58.3 % respectively at the HRT of 7 days. Compared to 3 and 5 days HRT, the removal efficiency was higher at 7 days. The root growth and the rhizome characteristics of *Canna indica* may attributed to the higher absorption of heavy metals from the sewage effluent and thereby reducing the heavy metal content in the treated effluent. Results corroborates with the research highlights which specified that *Canna indica* is one of the best phytoremediation plant for remediating the heavy metal contamination [10].

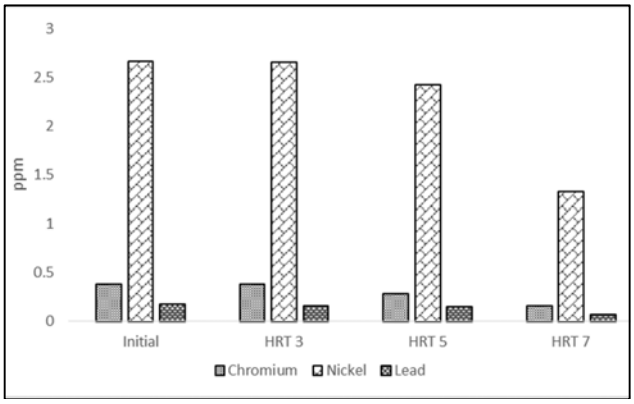

Fig 3: Heavy metal (Chromium, Nickel and Lead) removal of HRB system

Conclusion

Hybrid reed bed system comprising of horizontal and vertical flow treatment aids for the reduction of pollutants from the sewage effluent. Indian shot (*Canna indica*) being a perennial monocot with thick and strong rhizomes used in the study effectively translocate the heavy metals *viz.*, Chromium, Nickel and Lead from the sewage effluent and also reduces the BOD and COD of the sewage effluent. The plant concerts as a best phyto-accumulator in reducing the pollutant load and in recycling of sewage effluent.

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