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Potentials of Constructed Wetland for the Treatment of Wastewater from Cocopeat Production Industry

Lokesh S. [a], E. Parameswari [a*], P. Janaki [b], R. Jayashree [a] and R. Poorniammal [c]

[a] Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.
[b] Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.
[c] Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The cocopeat production industry generates a significant amount of wastewater containing high organic loads and chemical residues, posing environmental challenges and economic concerns. This study aims to assess the potential of constructed wetlands as an innovative and sustainable approach for managing coco peat production industry wastewater. An artificial wetland was created and filled with 30% soil, 40% sand, 10% bio and hydrochar, and 20% gravel along with Canna indica was used as the plant component. Three types of hydraulic loading rates were studied: 5 ml/min, 10 ml/min, and 15 ml/min, with a retention time of 7 days.

The results showed that the wastewater contains significant levels of Electrical Conductivity (5.24 –

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*Corresponding author: E-mail: parameswari.e@tnau.ac.in;

6.31 dS m^{-1}), Total Dissolved Solids (4190 - 5150 mg/L), Biochemical Oxygen Demand (730 - 818 mg/L), and Chemical Oxygen Demand (1825 – 2045 mg/L). The utilization of artificial wetlands along with *Canna indica* decreased the pollution loads by 42% of Electrical Conductivity, 41% of Biochemical Oxygen Demand, and Chemical Oxygen Demand, 45% of Total Suspended Solids, and 55% of Total Dissolved Solids.

Based on the above results, constructed wetlands are recognized as a reliable wastewater treatment technique and a good solution for the treatment of coirpith washwater, which is a step towards a greener and more sustainable future. By integrating these natural filtration systems into the wastewater treatment process, industries can foster a harmonious coexistence with the environment, ensuring a balance between economic growth and environmental well-being.

Keywords: Coco peat production; wastewater; biological treatment; constructed wetland.

1. INTRODUCTION

As industries continue to grow and flourish, they bring forth both prosperity and environmental challenges. One such industry that has experienced exponential growth is the cocopeat production industry, driven by the increasing demand for eco-friendly alternatives in agriculture and horticulture. Cocopeat, derived from coconut husks, has emerged as an essential component in the horticultural sector due to its exceptional water retention and aeration properties [1]. However, with the expansion of this industry, the environmental impact of wastewater generated during the cocopeat processing has become a pressing concern. The coirpith industry demands a substantial water supply, resulting in a significant volume of wastewater discharge containing 27.8% cellulose, 28.5% lignin, and 8.12% soluble tannin-like phenolic compounds (Vinodhini et al., 2006). The effluent produced by this industry is not only acidic but also contains phenolic compounds and other hazardous substances.

In response to the shortcomings of traditional pollutant removal methods, which are costly and environmentally harmful, the demand for affordable and efficient wastewater treatment systems has been growing. Phytoremediation, a method that utilizes plants to cleanse contaminants from wastewater, offers a promising solution [2]. Among the plant species used, Canna indica stands out with its sturdy, towering stems and deep, penetrating roots, showcasing exceptional resilience to harsh environmental conditions and high concentrations of hazardous compounds. Research indicates that Canna indica is highly effective in absorbing phosphate and nitrogen from water, making it an ideal candidate for purifying eutrophic water and treating waste leachates. Moreover, Marisa et al. (2017) have demonstrated its potential for removing metallic pollutants in constructed wetland systems. In the wake of these challenges, a promising and sustainable solution has emerged as constructed wetlands. Drawing inspiration from nature's own filtration systems, constructed wetlands offer an environmentally friendly and cost-effective approach to treat wastewater while minimizing adverse effects on the ecosystem. This article explores the potentials of using constructed wetlands as a viable method for the treatment of wastewater from the cocopeat production industry.

Constructed wetlands, inspired by the natural filtration systems of wetland ecosystems, have proven their efficacy in purifying wastewater from various industries, and the cocopeat production sector is no exception. With its unique ability to retain contaminants like cellulose, lignin, and soluble tannins, constructed wetlands provide a cost-effective alternative to traditional, expensive, and environmentally unfriendly wastewater treatment methods [3].

The remarkable adaptability of plants like *Canna indica* within constructed wetlands is a testament to the potential of nature in addressing human-made environmental challenges. *Canna indica's* robust nature, capable of thriving amidst dangerous compounds and severe conditions, has shown exceptional promise in absorbing phosphate, nitrogen, and even metallic pollutants. This makes it an ideal candidate not only for treating eutrophic water and waste leachates but also for contributing to the removal of hazardous substances from the wastewater produced in cocopeat processing.

By incorporating constructed wetlands into wastewater treatment strategies, cocopeat production industries can significantly reduce their ecological footprint and demonstrate their commitment to sustainable practices. These wetlands not only purify wastewater but also offer additional environmental benefits, such as preserving biodiversity and creating new habitats for various flora and fauna. By shedding light on the advantages and challenges of using constructed wetlands, this article aims to emphasize the importance of sustainable wastewater management practices in the cocopeat production industry [4]. Additionally, we discussed the potential environmental benefits that can be achieved through the adoption of these innovative treatment systems, which extend beyond mere wastewater purification. As global concern for sustainable practices heightens, industries must seek innovative solutions that align with environmental preservation without compromising economic growth. The integration of constructed wetlands in the cocopeat production industry holds promise in not only mitigating the impact of wastewater but also contributing to the conservation of biodiversity and the promotion of a healthier ecosystem [5].

Join us as we embark on this enlightening journey, exploring the vast potentials of constructed wetlands and their role in revolutionizing wastewater treatment practices within the cocopeat production industry. Together, we can envision a future where economic prosperity and ecological well-being go hand in hand, harmoniously coexisting for generations to come.

2. MATERIALS AND METHODS

The coir pith washwater was collected from Remmy Substrates India Pvt. Ltd, Kattampatti, Pollachi. The following standard methods were used to analyze physicochemical parameters of the effluent.

The Department of Environmental Sciences at Tamil Nadu Agricultural University conducted an experiment using a lab-scale constructed wetland model (Reactors). The model was designed with a vertical flow system, consisting of seven reactors made of glass columns. Each reactor had an inlet at the top and an outlet at the bottom. The wetland was arranged in a sandwich manner, starting from the bottom with gravel, followed by river sand, hydrochar, biochar, and garden soil. The gravel size used was 20 mm, while the porosity of sand and soil was 40% and 30%, respectively, for each reactor. To introduce wastewater into the wetland model system, various types of PVC (Polyvinyl chloride) pipes were manually arranged from the main tank. The wastewater flow was controlled and distributed using a peristaltic pump, drip irrigation pipes, and valves to optimize the average flow rate through the constructed wetland system. For collecting the treated effluent, outlets were arranged at the bottom of each reactor with the use of silica tubes.

Each constructed wetland (CW) system operated for 7 days with hydraulic loading rates of 5 ml/min, 10 ml/min, and 15 ml/min, using Canna indica as the plant component. The study employed a total of seven reactors, with two replications planted and one control unplanted. Aquatic plants were collected in uniform size and weighed before transplanting, then left undisturbed for one week to establish in the reactors. After establishment, the wastewater was pumped into the CWs, and different hydraulic loading rates were regularly monitored. During the study, treated water from the outlet was collected at different hydraulic retention times and water samples were analyzed using standard methods as described in the procedures.

Table 1. Method of analysis of effluent samples

S.No	Parameters	Method	Reference
a.	**Physical properties**		
1	Total Dissolved Solids	Gravimetric method	[6]
2	Total Suspended Solids	Gravimetric method	[6]
b.	**Chemical properties**		
3	pH	pH meter	[7]
4	Electrical Conductivity	Conductivity bridge	[7]
5	Biochemical Oxygen Demand	5 days at 20^o C, dissolved oxygen method	Young *et al.*, 1981
6	Chemical Oxygen Demand	Chromic acid- reflux method	[8]

3. RESULTS AND DISCUSSION

The Coir pith washwater was neutral in pH with high electrical conductivity (5.24 – 6.31 dS m^{-1}). The total dissolved solids concentration was 4190 - 5150 mg/L. The effluent's biological oxygen demand (BOD) and Chemical oxygen demand (COD) were in the range of 730 - 818 and 1825 – 2045 mg/L, respectively. The Total Suspended Solids are ranged between 740-756 mg/L and Total Dissolved Solids varied from 4190 – 5150 mg/L. Similar values were reported by Kasthuri *et al*. [9]. According to their report, the Dissolved Oxygen (DO) value was low, indicating a highly obnoxious condition. The BOD and COD levels of the effluent were measured at 240 and 482 mg/L, respectively. Although these levels were higher than the IS Standard, they were not excessively elevated. The effluent showed no carbonate presence, but relatively high levels of free CO_2 and bicarbonate were recorded, as 128 mg/L and 150 mg/L, respectively.

The constructed wetland reduced the pH of the coirpith washwater to 6.59-6.60 at all hydraulic flow rates. A decrease in pH was observed in all the hydraulic loading rates (HLR) tried. The decrease in pH with the lower HLR may be due to more contact time of the effluent with the plant, variation in temperature, and the growth of the plant. Furthermore, salts of NaCl, which are neutral, could result in a neutral reaction, whereas salts of CO_3 and OH nature could exhibit an alkaline nature. In this experiment, these salts could have been neutralized by the organic acids produced by the plants' root exudates. Elzein et al. (2016) also reported that HRT (Hydraulic Retention Time) plays a major role in the reduction of pH based on the plants and substrate utilized for the study (Fig. 1).

The EC (Electrical Conductivity) of the coirpith washwater follows the same trend as that of the pH of the effluent. EC was significantly reduced (42 %) at a lower hydraulic loading rate (5 ml/min) compared to the other loading rates (Fig. 2). One of the ways of reducing salt content is the sorption process, which may be due to adsorption or precipitation phenomena. In this study, the soluble salt responsible for EC may

Table 2. Characterization of coirpith washwater

Sl. No.	Parameters	Values
1	Colour	Brownish yellow
2	pH	6.6 – 7.2
3	Electrical conductivity (dS m^{-1})	5.24 – 6.31
4	Total Suspended Solids (mg/L)	740-756
5	Total Dissolved Solids (mg/L)	4190 - 5150
6	Biochemical Oxygen Demand (mg/L)	730 - 818
7	Chemical Oxygen Demand (mg/L)	1825 - 2045

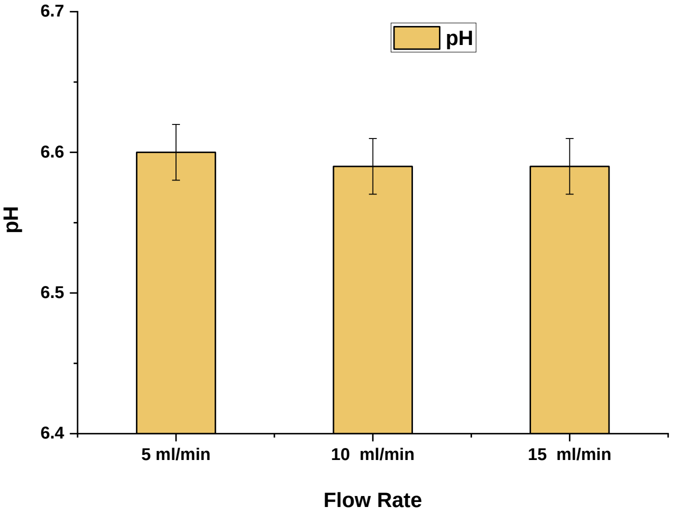

Fig. 1. Influence of different hydraulic loading rate of pH of the effluent

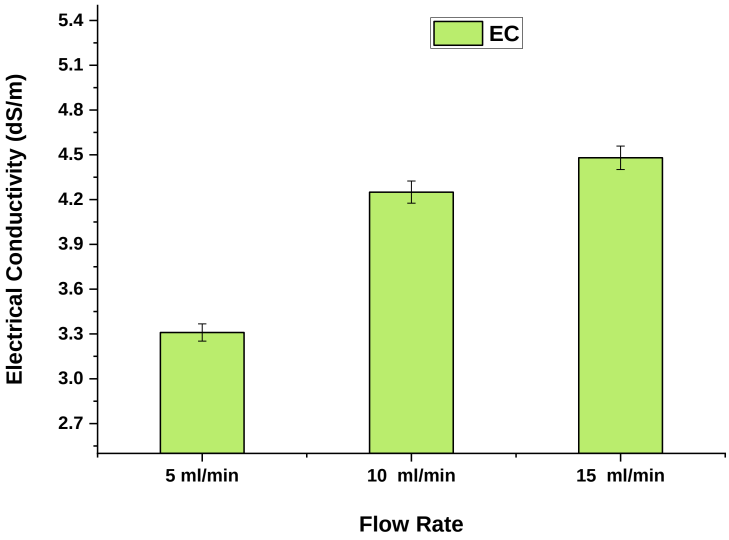

Fig. 2. Influence of different hydraulic loading rate of EC of the effluent

get adsorbed to the medium and roots or fallen litter of the plants grown in the model CW (Constructed Wetland).Tilak, et al. [10] reported that there was a significant reduction in EC due to the removal of dissolved solids by the plants grown in a hybrid reed system, which may be due to the uptake by the plants and adsorbents used in the system.

At all flow rates, TSS (Total Suspended Solids) of the effluent was found to be decreased with an increase in the HRL (Hydraulic Retention Time) (Fig. 3). The highest reduction of TSS (45%) was observed at the flow rate of 5 ml/min (HLR) compared to the other flow rates. This reduction was clearly observed on the 7th day of retention time. Trang, et al. [11] reported that TSS removal efficiency was significantly higher at lower HLRs (93%) than at higher HLR (60%). Similar findings were reported by Karathanasis et al. [12] that *Typha angustifolia* had a positive effect on the removal of TSS.

The parameter TDS (Total Dissolved Solids) is vital in assessing the treatment efficiency, and the percentage reduction of TDS in the effluent used in the model was given in Fig. 4. The HLR of 5 ml/min is superior compared to other HLRs. The reduction of TDS may be due to the increased contact time of the effluent with aquatic plants and the different medium. The highest reduction of TDS (55%) was observed at HLR with a retention period of 7 days using *Canna indica.*

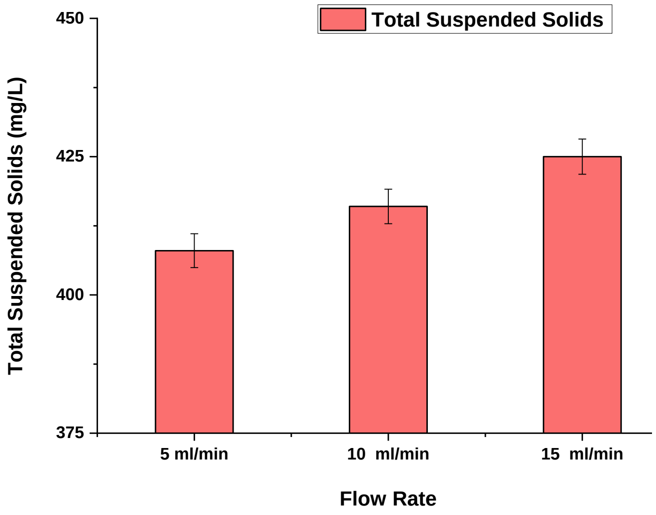

Fig. 3. Influence of different hydraulic loading rate of TSS of the effluent

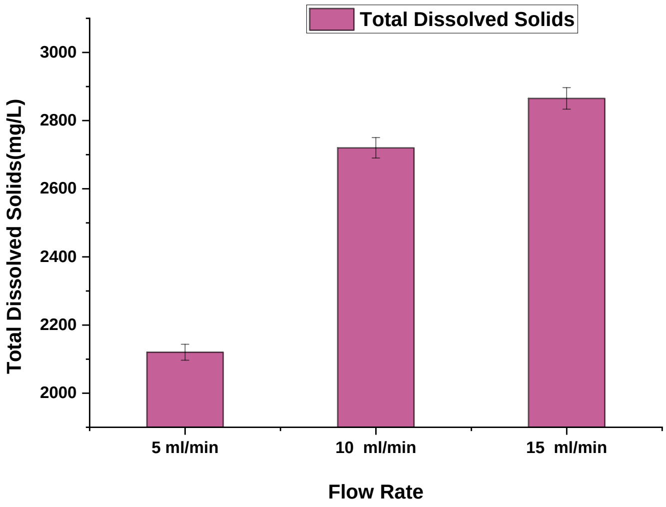

Fig. 4. Influence of different hydraulic loading rate of TDS of the effluent

BOD (Biological Oxygen Demand) removal efficiency was observed in the model constructed wetland with the HLR. At the retention time of 7 days, BOD removal efficiency (41%) was higher in HLR compared to other flow rates tried by the plants. This might have been due to non-optimal biological processes such as decomposition of organic matter by oxygen released by plants through roots, creating aerobic conditions. The organic matter in the effluent may undergo hydrolysis and turn into a soluble form, entering the media and attaching to biofilm, and then ions [13]. Aquatic plants mostly possess a large surface area for gas diffusion, which could have led to similar findings reported by Suganya [14].

The COD (Chemical Oxygen Demand) of the effluent gradually showed a declining trend consequent with different hydraulic loading rates. In COD removal, vegetation also plays a major role, with microorganisms attached to the plant's roots in the matrix layer, performing the degradation of organic compounds. The mechanism of COD reduction may be due to oxygen produced by the plants during photosynthesis and transferred to roots through well-developed tissues to support bacteria, which function to break down the content (Yang et al. 2007). The percentage removal of COD at D7 at a flow rate of 5 ml/min was 41%, while the other flow rates were found to have lesser performance (Fig. 6). These findings were related to the results of Maris Merio Solis et al. (2013), who stated that *Canna* hybrids had higher COD removal efficiency at lower LRT (Longitudinal Retention Time) of two days in wastewater through Ecological Wastewater Treatment System [15].

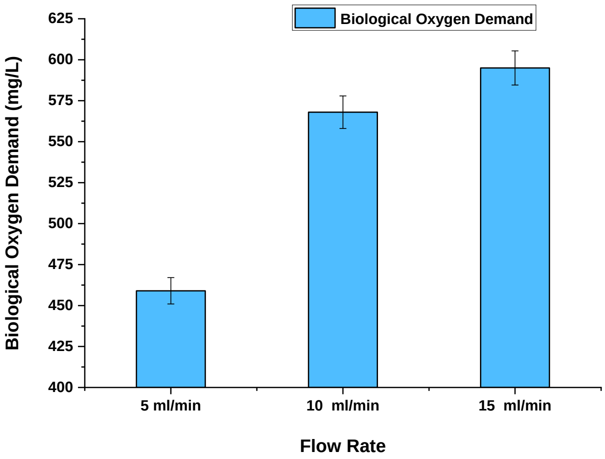

Fig. 5. Influence of different hydraulic loading rate of BOD of the effluent

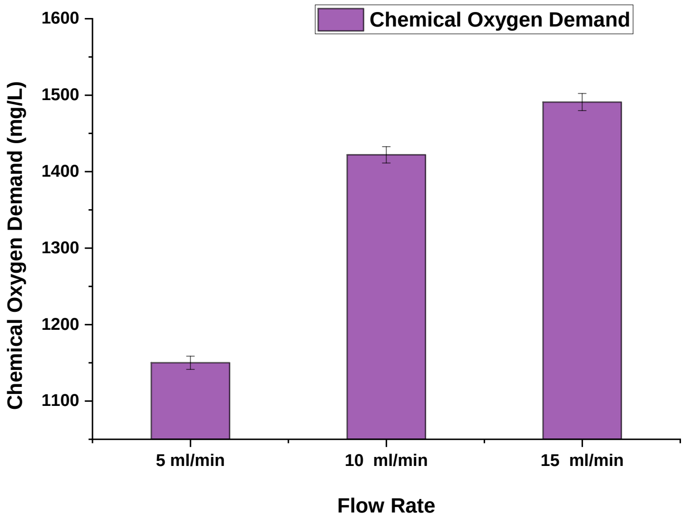

Fig. 6. Influence of different hydraulic loading rate of COD of the effluent

4. CONCLUSION

The potentials of constructed wetlands as an eco-friendly and efficient method for treating wastewater from the cocopeat production industry cannot be overlooked. This article explores the environmental challenges posed by the rapid expansion of cocopeat production and the consequent generation of large volumes of wastewater. In response to this pressing issue, constructed wetlands emerge as a beacon of hope, offering a sustainable solution that harmonizes economic growth with environmental preservation.

As the world increasingly recognizes the importance of ecological preservation and the impact of industrial activities on the environment, the adoption of constructed wetlands becomes more crucial than ever. As stakeholders in the cocopeat production industry, it is imperative to prioritize sustainable practices that align with nature's inherent ability to regenerate and restore. In conclusion, embracing the potentials of constructed wetlands for the treatment of wastewater from the cocopeat production industry is a step towards a greener and more sustainable future. By integrating these natural filtration systems into the wastewater treatment process, industries can foster a harmonious coexistence with the environment, ensuring a balance between economic growth and environmental well-being. Together, let us seize this opportunity to embrace innovative, sustainable practices and safeguard our planet for generations to come.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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