Original Research Article

Efficiency of *Vetiver zizanioides* and Vermiculite in Coir Wastewater Treatment

ABSTRACT

Pilot scale low cost system was carried out in the Coconut Research Station for treating coir industry wastewater using *Vetiver zizanioides* along with Vermiculite clay mineral. Wastewater collected from the two different sites were considered as two treatments. The reduction in pH, EC, BOD, COD, TDS and Polyphenols at both the treatments (T_1 and T_2) was observed. Major reduction was observed in the TDS content with the reduction percentage of 49.73% and 51.03% for T_1 and T_2 respectively. Likewise, reduction percentage of polyphenols in T_1 and T_2 were 4.76% and 4.9% to the respectively. Hence, phytoremediation using vetiver was found to be a promising approach for remediation of coir industry wastewater.

Keywords: Coir industry wastewater, Vetiver zizanioides, Vermiculite clay mineral, Phytoremediation

1. INTRODUCTION

Coconut palm is an important plantation crop grown in 1.89 million ha in India supporting livelihood of many farmers in the country. One of the important cottage industries related to coconut palm is the coir industry. In India, most significant coconut growing areas are Kerala (48.79 %), Karnataka (18.9 %), Tamil Nadu (17.7 %), and Andhra Pradesh (5.5 %) which together account for 91 % of India's coconut growth. The coir fibre production and coir pith processing industries are mainly focused in Pollachi tracts, Tamil Nadu. The washing and buffering processes for coir pith require large volumes of water. On-site studies suggest that up to 300 litres of water is required to wash 1 cubic metre of coir pith in controlled (tanked) environments. Although this will change depending on the season, the rainfall patterns and volumes in different coir pith processing regions and with the efficiency of the washing process. Coir washing is generally achieved by hosing or spraying water over mounds of coir pith placed directly on soil or on floors. The run-off from these processes will contain high salts, chemical, microbial and physical contaminants. The run-off will contaminate surface water, groundwater and soils. In terms of impacts, extensive washing will contain high levels of sodium and potassium. Wastewater from coir industry has also been shown to contain 27.8% cellulose, 28.5 % lignin and 8.12 % soluble tanning-like phenolic compounds (Vinodhini, 2006) and microbial contamination as well as other physical contaminants such as sand, grit and stones. Kasthuri *et al.* (2011) reported that Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrates, nitrites, ammonia, calcium and magnesium were recorded in high amounts, as were bacteria, fungi and algae in the wastewater from the coir industry.

There are a variety of traditional methods for purification and elimination of pollutants and toxins, but the majority of them are costly and not ecofriendly. As a result, there is a rising need to design wastewater systems that are both low-cost and effective. Phytoremediation serves this purpose by using plants for removing the pollutants present in wastewater. Vetiver grass (Vetiver zizanioides) is characterized by stiff, tall stems that have deep, penetrating roots. It has been proven to be very tolerant to high levels of hazardous substances as well as adverse According to literature, vetiver grass is effective in removing phosphorus and nitrogen from water (Dela Mora-Orosco et al., 2018), making it a good plant for purifying eutrophic water (Oshunsaya and Aliku, 2017) and treating garbage leachates (Maharjan and Pradhanang, 2017). Vetiver zizanioides has a good potential in Nitrate-N and COD removal in subsurface vertical flow wetland systems, according to Almeida et al. (2019). Therefore, a pilot scale treatment system was used to test the effectiveness of Vetiver zizanioides and Vermiculite clay mineral in eliminating pollutants from retting areas.

2. MATERIAL AND METHODS

2.1 Pilot scale low cost system for treating coir industry wastewater

Vetiver zizanioides and Vermiculite was test verified for the wastewater treatment at the vicinity of coir industry. Pilot scale low cost systems for treating coir industry wastewater have been setup at the Coconut Research Station. Healthy Vetiver clums with root and shoot were selected and planted in the setup system filled with alternate layers of vermiculite and geo fibres. Each setup was kept in natural light along with a control. Coir wastewater was allowed to pass through the media, root zones of rhizospheric soil and the treated water was collected from two sites of different ecological conditions and the Physico-chemical properties of waste water was analyzed. The treatment setup for the experiment are as follows

T_1 —- Coir wastewater from site I

T_2 —- Coir wastewater from site II

The Physico-Chemical parameters like pH, Electrical Conductivity (EC), Total dissolved Solid (TDS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and phenols were analyzed by standard methods (APHA, 1995). Scanning Electron Microscope (SEM) micrographs was determined for *Vetiver zizanioides* and vermiculite.

3. RESULTS AND DISCUSSION

The discussion should not repeat the results, but provide detailed interpretation of data. This should interpret the significance of the findings of the work. Citations should be given in support of the findings. The results and discussion part can also be described as separate, if appropriate.
The measured values of pH, Electrical conductivity (EC), Total dissolved Solid (TDS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and phenols are shown in Table 1 and 2.

There is a decrease in pH and EC of both site I and site II respectively (Fig. 2). The pH lowers from neutral to the acidic range in the T_1 and alkali to near neutral in the T_2 that indicates the releasing of acidic substances from the root part of the plants.
Biological Oxygen Demand (BOD) is an indicator of pollution in water. It determines the amount of DO used up for the oxidation of degradable biological waste materials present in water. The results (Table 1 & 2) show that the BOD content of the coir waste waters was higher with 680 and 850 mg L^{-1} initially in site I and site II respectively. After treatment, the BOD was found to be 585.34 and 442.45 mg L^{-1} respectively. The BOD has shown a reduction of 21.4 % and 59.7 % in site I and site II respectively. The removal of organic contaminants from the wastewater can be accomplished by the mechanisms such as chemical and physical adsorption, flocculation and adhesion. It was well understood in the study where *Vetiver zizanoides* was used as reeds in the constructed wetlands for the treatment of wastewater. The reduction in the BOD was due to the action of rhizospheric microbiome in association with the roots (Shivhare and Roy, 2013).
Chemical Oxygen Demand (COD) indicates that high degree of pollution load in water. From the results (Table 1 and 2) it can be observed that, *Vetiver zizanoides* is very effective in treating coir wastewater containing 1728 and 1376.54 mg L^{-1} in site I and site II respectively (Fig. 3). The COD of the wastewaters were considerably reduced after the treatment to 1189 and 696.34 mg L^{-1} in site I (31.1%) and site II (49.1%) respectively. The reduction in COD can be employed by the metabolic activity of microorganisms and physical and chemical interaction within the root zone/substrate (Vipat *et al.* 2008).
Total dissolved solids (TDS) are the solids dissolved in water. It was found that after the experimental period the TDS of the wastewater were reduced to 49.7 % and 51.02 % in site I and site II respectively. The solids present in the effluents are removed by *Vetiver zizanoides* whose roots act as a site for the metabolic reaction and vermiculite which acts as a strong adsorbent for the suspended solids present in the wastewater. Polyphenol in site ranges from 134.2 to 152.6 mg/L. The phenolic compounds contained in the wastewater are the major organic pollutant which tends to increase the oxygen demand in the receiving water. In the current study of low-cost adsorbent setup, the concentration of polyphenols was reduced to about 4 – 5 % which agrees with phenol absorption by the *Vetiver zizanioides* along with Vermiculite clay mineral (Singh *et al*., 2008; Luu *et al.,* 2009).
Organic pollutants are degraded by variety of microorganisms present in plants root. The rhizospheric root zone plays an important role in wastewater treatment by controlled seepage of pollutants (Baskar *et al.,* 2009).

The *Vetiver zizanoides* has thick massive root system and therefore the surface area is also very high. The wide spread root system provides enough space for the microbial metabolism to occur and increase their biomass. The uptake of nutrients and other contaminants from wastewater helps the microorganisms to multiply and thrive in the rhizospheric region. The surface area of *Vetiver zizanoides* and vermiculite were studied under Scanning Electron Microscope (SEM) (Fig. 1A&B) and the nature of the roots and clay material was seen which led to the effective adsorption of pollutants and solids. The SEM micrographs of the *Vetiver zizanoides* and vermiculite shows a numerous pore in the surface. The large network of pores and voids in the system has led to the physical and chemical mechanisms to occur at the root zone and substrate. Moreover, the development of pores can be one of the reasons for higher surface area.

4. CONCLUSION

In this pilot scale system using vetiver grass with vermiculite, there is a remarkable reduction in total dissolved solids, biological oxygen demand, chemical oxygen demand, nitrates in coir wastewater. The treated water can be directly used for the coconut field. Therefore, *Vetiveria zizanioides* L. Nash is a good phytoremediant for coir wastewater. Phytoremediation is a way to resolve the pollution by self-remediating mechanism using vetiver.

REFERENCES

1. AICRP. Annual Report, 2013-14: AICRP on Palms. Central Plantation Crops Research Institute, Kasaragod, Kerala; 2014.
2. Almeida A, Ribeiro C, Carvalho F, Durao A, Bugajski P, Keirelc K, Pochwatka P, Jozwiakowski K. Phytoremediation potential of Vetiveria zizanioides and Oryza sativa to nitrate and organic substance removal in vertical flow constructed wetland systems. Ecological Engineering. 2019: 138: 19-27.
3. APHA. Standard Methods for the Examination of Water and Wastewater. 22nd ed., APHA- AWWA- WEF, Washington, DC; 2012.
4. Baskar G, Deeptha UT, Rahman AA. Root Zone Technology for campus wastewater treatment. Journal of Environmental Research and Development. 2009; 3(3):695-705.
5. De La Mora-Orozco C, González-Acuña IJ, Saucedo-Terán RA, Flores-López HG, Rubio-Arias HO, Ochoa-Rivero J. Removing Organic Matter and Nutrients from Pig Farm Wastewater with a Constructed Wetland System. International Journal of Environmental Research and Public Health. 2018; 15(5):1031.
6. Dhanya G, Jaya D. Waste water treatment efficiency of vetiver grass in constructed wetlands. Journal of aquatic Biology and Fisheries. 2014; 2:119-125.
7. Luu TD, Paul T, Raffaella M, Tam T, Neil F. Vetiver grass, Vetiver zizanioides: A choice plant for phytoremediation of heavy metals and organic waste. Inter. J. phytoremediation. 2009; 11: 664-691.
8. Maharjan A, Pradhanang S. Potential of vetiver grass for wastewater treatment. Environment and Ecology Research. 2017: 5(7): 489-494.
9. Neena C, Ambily PS, Jisha MS. Anaerobic degradation of coconut husk leachete using UASB Reactor. J. Environ. Biol. 2007; 28(3): 611-615.
10. Oshunsaya S, Aliku O. Vetiver Grass: A tool for Sustainable Agriculture. In: Almusaed A, SalihAl-Samaree SM, editors. Grasses-Benefits, Diversities and Functional Roles. Intech Open Limited: London, United Kingdom; 2017.
11. Reed SC, Crites RW, Middle Brookes EJ. Natural systems for waste management and Treatment. Mc. Graw. Hill Inc.; 1995: 430.
12. Shivhare N, Roy M. Gravel Bed Constructed wetland for treatment of Sewage water. Poll Res. 2013; 32(2): 415-419.
13. Singh S, Melo JS, Susan E, Souza D. Potential of Vetiver (*Vetiver zizanioides* L. Nash) for phytoremediation of phenol. Ecotoxicology and Environmental safety. 2008; 71(3): 671-676.
14. Vipat V, Singh UR, Billore SK. Efficacy of Root Zone Technology for Treatment of Domestic wastewater: Field scale study of a pilot project in Bhopal (MP), India, pp. 995-1003. In: Proceedings of Taal: The 12th World Lake Conference, 2007; 2008.

Table 1. Physico–chemical parameters of site I

S.No.	Parameters	T_1 (Site I)*		% reduction
		Initial	**Final**	
1.	pH	7.18	5.17	28%
2.	EC	6.28	5.73	8.76 %
3.	BOD	618	485.34	21.47 %
4.	COD	1728	1189	31.19 %
5.	TDS	4012	2017	49.73 %
6.	Polyphenols	140.9	134.2	4.76 %

Table 2. Physico–chemical parameters of site II

S.No.	Parameters	T_2 (Site II)*		% reduction
		Initial	**Final**	
1.	pH	8.6	7.8	9.3 %
2.	EC	5.87	4.48	23.68 %
3.	BOD	850	342.45	59.71 %
4.	COD	1376.54	696.34	49.41 %
5.	TDS	3308.8	1620.4	51.03 %
6.	Polyphenols	152.6	145.1	4.9 %

**mean of three replications*

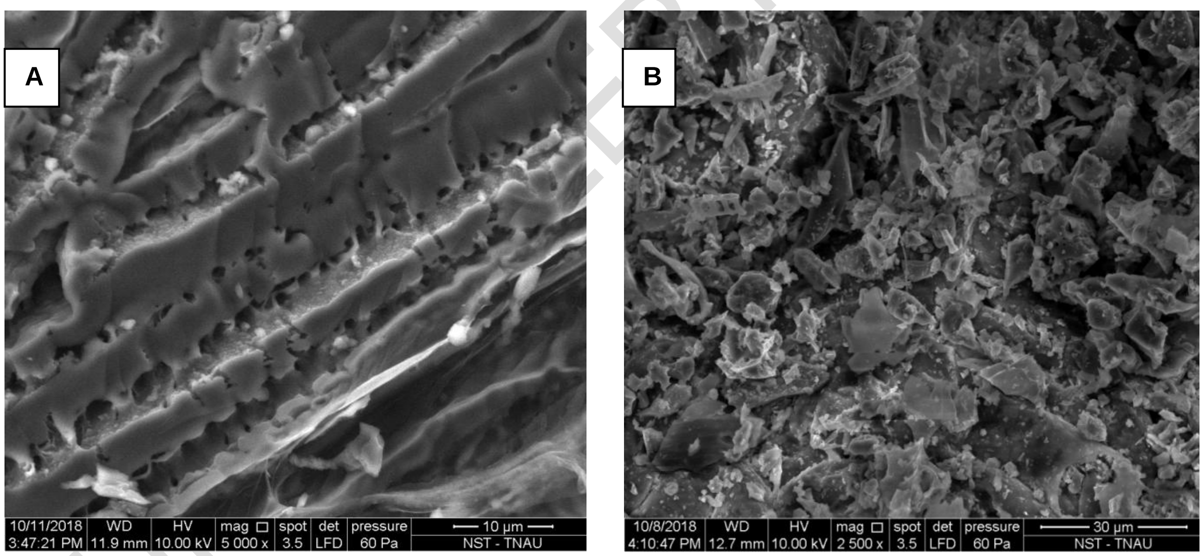

Fig. 1. SEM images of Vetiver (A) and Vermiculite (B)

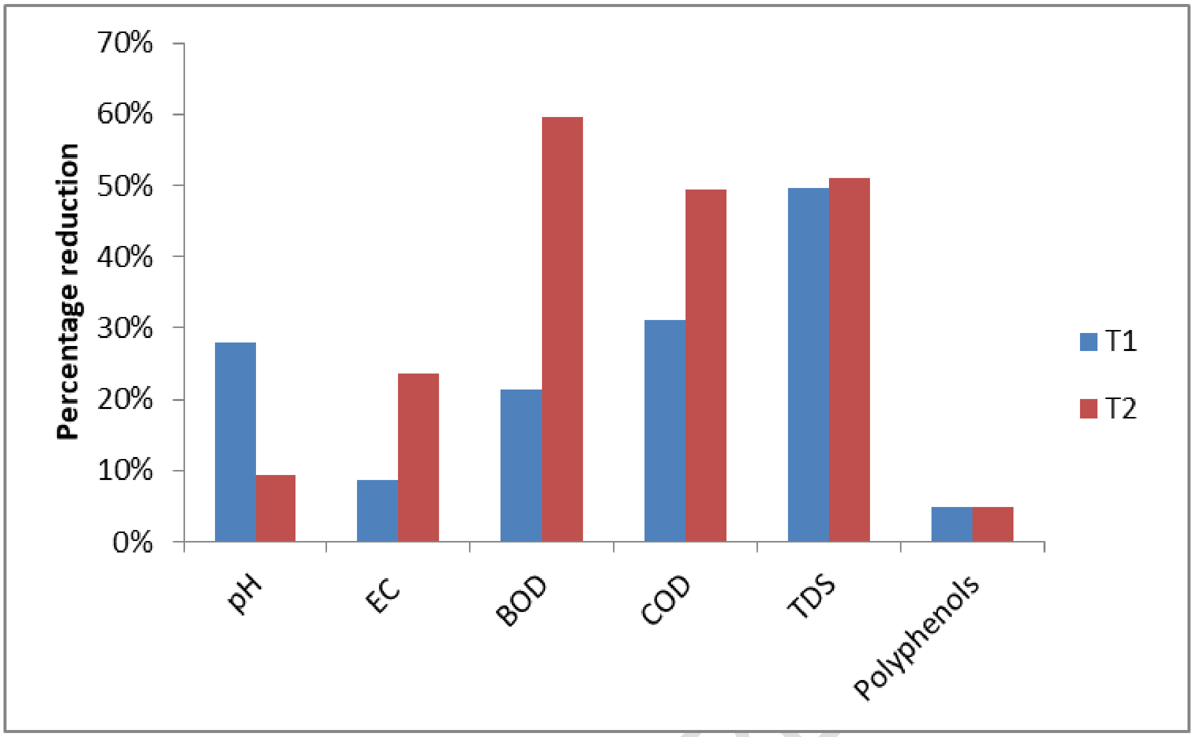

Fig. 2. Percentage reduction of Physio-chemical characters