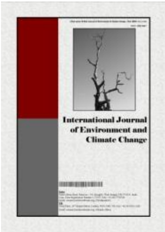

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Vetiver Floating Wetlands for Dyeing Effluent

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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

As a result of industrialization, the degree of global water contamination has drastically grown in recent decades. Both rich and developing nations are seeing this worldwide trend, although the later are experiencing it more pronouncedly. Due to its extraordinary and distinctive morphological and physiological characteristics, the Vetiver Floating Wetlands (VFWs), which is based on Vetiver grass (*Chrysopogon zizanioides*), has been successfully used as a phytoremediation tool to remediate both polluted water like municipal wastewater such as sewage effluent, landfill leachate, urban runoff, drainage channels, industrial wastewater such as food processing factories, and contaminated land (mine overburden and tailings, solid waste dumps). This study focuses on the use of hydroponics and floating wetlands to clean contaminated dyeing effluent. This study aims to find the efficiency of Vetiver Floating wetlands over various physio-chemical parameters in Dyeing effluent. The study was laid down in Tamil Nadu Agricultural University, Coimbatore in 2022 during the month of April- May. The effluent was diluted to different concentrations namely 25%, 50%, 75% and 100%. Various parameters were analyzed in these treatments in Dyeing effluent. The samples were collected at 15 days interval analyzed for one month. In Dyeing effluent, 50% concentration of the effluent showed better results over Vetiver Floating Wetlands and the removal efficiency was greater at this particular concentration.

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Keywords: Vetiver floating wetlands; dyeing effluent; physio-chemical characteristics; different concentrations.

1. INTRODUCTION

Clean water is becoming one of the rarest and most valuable resources. Rapid industrialization results in the creation and discharge of large quantities of waste into water sources. Industrial effluent may quickly pollute traditional water supplies. Untreated wastewater typically includes nutrients, mostly nitrogen and phosphorus, which can boost the growth of aquatic plants, resulting in a variety of environmental pollution-related issues. As a result, wastewater treatment is not only desirable but also required.

In India, Textile industries are rapidly increasing and it has grabbed a quite heavy number of industries leading to the production of large quantities of wastewater whose treatment should be considered and given more attention. In Tamil Nadu despite the installation of CETPs (Common Effluent Treatment Plants), dyeing companies in the Karur and Tiruppur districts have been a cause of worry due to its colour and dyes infiltrating water sources and the soil ecology. In the above districts, there is a need to generate a cost- effective biological wastewater treatment technology, based on the performance of VFWs in removing various pollutants, it was seen as a promising technology.

Phytoremediation, and its impact on the Floating Wetlands in the removal of various contaminants, seems to be a good choice. Variants of natural floating wetlands have been used to treat anthropogenic discharge in recent years, including industrial effluents, agricultural runoff, and municipal sewage. These include hydroponic root mats (HRMs), floating treatment wetlands (FTWs), constructed wetlands (CWs), etc. [1]. Floating Wetlands have been reported to be effective in lowering metals, organic pollutants, and pathogens [2].

Phytoremediation through the use of vetiver grass is the best option as it is capable of detoxifying various organic and inorganic toxins in its tissue in addition to removing them from soil and water [3]. Vetiver grass is belongs to the Poaceae family and it is native to south and south-east Asia [4].Vetiver grass has been widely utilized across the world to stabilize riverbanks and slopes, reduce soil erosion, and promote ecological restoration in addition to environmental cleanup [5]. Vetiver grass is renowned for its quick development, extensive root system, tolerance of hazardous contaminants, resistance to adverse environmental circumstances, and rapid growth [6]. According to reports, vetiver may remove hazardous heavy metal contamination from water and soil [7].

For soil and water conservation and stability, pollution management, and wastewater treatment, VFS is a low-cost, high-effective method. The use of VFS for wastewater treatment is a cutting-edge phytoremediation technique [8]. It is a good plant for Rhizoremediation because of its unique morphological and ecological properties, which include a high level of resistance to heavy metals and unfavorable climatic circumstances such as protracted drought, flood, submergence, and excessive temperature [9].Because of its recognized efficacy, low cost, ease of multiplication, and availability, vetiver grass was chosen as the ideal plant species [10].

Textile factory effluents contain a combination of colours, metals, and other contaminants [11]. Natural and synthetic dyes are the two types of colourants. Synthetic dyes are more extensively used than natural dyes because they are easier to prepare, come in a variety of colours, and are rapid [12]. Synthetic dyes are divided into classes based on their chemical structure (e.g., azo, anthraquinone, sulphur, phthalocyanine, and triarylmethane) and application method (e.g., reactive, direct, dispersion, basic, and vat dying) [13].

Vetiver grass has been chosen as the preferable plant species for this study because of its well-known effectiveness, low cost, ease of propagation, and availability [14]. The project's goal is to show how particular plant species may operate as primary cleansers of dirty water from the textile industry.

2. MATERIALS AND METHODS

2.1 Collection and Characterization of Wastewater

The study was conducted between April and May 2022 in the Compost Technology Park present in Tamil Nadu Agricultural University. Barrels used for containing water were used for the establishment of the experiment. Vetiver plants were procured and acclimatized in floats for a period of one month. The effluent used in this experiment was dyeing effluents. Dyeing effluent was collected from Common Effluent Treatment Plant (CETP) in State Industries Promotion Corporation of Tamil Nadu Ltd. (SIPCOT) present in Perundhurai, Erode. Low TDS effluent was collected straight from the treatment plant. The Physio- chemical parameters like pH, Electrical Conductivity, Total solids, Hardness, Dissolved Oxygen and Biological Oxygen Demand. In the experiment, shade mesh was used to prevent effluent from being diluted by incoming rain while allowing free passage of ambient air to minimize temperature and humidity. Hydroponic system was created from Vetiver Floating Wetlands.

2.1.1 Experimental setup

Each effluent was made as different concentrations *ie.* 25% (T_1), 50%(T_2), 75%(T_3) and 100%(T_4) [15]. Barrels were filled with 50 litres of different concentrations accordingly and covered with styrofoams. Dilution was made with ordinary water. Each barrel which consists of vetiver floats which are the foams, had three holders for plants and each holder contained three slips so that the roots are completely immersed in effluent. So totally a barrel contained 9 slips of vetiver. Vetiver slips were collected and it was allowed to grow in hydroponics. The water in which the plants were grown was mixed with Hogland's solution to facilitate more nutrients and healthy growth to the plant [16]. After two months of acclimatization the slips were established in the experimental setup in hydroponics. Before setting the slips in hydroponics system, it was cut down to an uniform size of 20 cm. This setup was maintained up to 30 days.

2.1.1.1 Sampling

Three replicate samples from the different concentrated effluents were taken, each measuring 0.5 litre from the 50 litres barrel were collected for initial characterization. Once mixed, the samples were taken. All the samples were collected during midmorning [17]. At each sampling opportunity, the float trays were momentarily removed to make sample collecting easier [18]. The effluent samples were taken right away to the lab for examination. Samples were collected at 0(D_1), 15(D_2) and 30(D_3) days retention time.

2.1.1.2 Analysis of Samples

The methods of water analysis outlined by USEPA were used to analyse the effluent from Dyeing industries for pH, total dissolved solids, electrical conductivity, dissolved oxygen, biological oxygen demand immediately after collection as well as at 0, 15, 30 days of effluent retention. Prior to analyses, all of the glassware and crucibles used to analyze the samples were acid-washed.

2.1.1.3. Statistical analysis

The data was represented with Standard error. The statistical design fixed was Factorial Completely Randomized Design (FCRD). Graphs were drawn using Origin Pro 2021.

3. RESULTS AND DISCUSSION

The effect of Vetiver Floating wetlands over different concentrations of Dyeing effluent was investigated. Floating wetlands (FWs) are man-made systems for treating wastewater that include channels or small ponds filled with aquatic vegetation. Especially in poor countries, FWs are used to treat municipal, industrial, and agricultural wastewater [19]. For instance, [20] showed that the effectiveness of artificial wetlands for livestock wastewater was 65% for BOD5, 53% for TSS, 48% for NH4-N, 42% for TN, and 42% for TP using statistical computation.

For such Floating Wetlands the cultivable plants should be selected based on the locality of the species and wide distribution in the country and their survival rate in a saturated medium. The Vetiver System was first created to save soil and water, but in the last six years its use has expanded to include environmental preservation, notably in the fields of wastewater treatment and solid waste dumps. According to studies conducted in Australia and China, VFW is a very efficient way to treat contaminated water, home effluent, industrial wastewater, and landfill leachate [21].

Table 1. Physico-chemical properties of dyeing effluent

	Dyeing effluent
pH	8.20
Electrical Conductivity (dS/m)	2.77
Total solids (mg/l)	2850
Total Hardness (mg/l)	350
Dissolved Oxygen (mg/l)	1.0
Biological Oxygen Demand (mg/l)	220

3.1 Initial Characteristics of dyeing effluent

The pH values observed are in accordance with [22]. [23] obsereved a similar trend where it was mentioned that the pH ranges from 5 to 10. [24] observed the EC between 4 S/m and 5 S/m which is very high than the above recorded values. [25] observed Solids range from 6000 to 7000 mg/l which is comparitively higher than these observed values. [26] explains that Biological Oxygen Demand ranges between 250- 350 mg/l which is been acceptable in this case.

3.1.1 Removal of pollutants from effluents

Each parameter reacted to vetiver and retention time. Biochemical oxygen demand (BOD) and chemical oxygen demand are the measurements of the organic strength of wastewater (COD). One of the most often used indicators of water quality is BOD evaluation. BOD observed here was 220 mg/l which is higher than the BOD range observed by [22] who stated the value as 164 mg/l.

3.1.1.1 Effect of Vetiver on pH:

Dyeing effluent was collected from Vetiver Floating Wetlands at different intervals of retention time of 1^{st,} 15th and 30th day. The pH of the dyeing effluent tends to decrease from 1st day to 30$^{th\ day}$. Thus, the solubility of many hazardous compounds and heavy metals is influenced by the pH of the water. The reduction in pH with an increase in retention time may be attributed to the release of organic acids by the vetiver over the testing period. The pH of the effluent was on the decline at various points throughout the day. Efficiency of pH was greater in T_2 with 1.27% followed by T_1 with 0.67% and 0.61% in T_4. While in case of [22], the concentration of 50% ie) T_2 showed the major reduction in pH.

3.1.1.2 Effect of Vetiver on EC:

From the 1st day to the 30st day of the retention duration, the electrical conductivity (dS/m) of the effluent steadily declined. Initially EC was 2.69 dS/m in T_4 .Efficiency was EC was found high in T_3 up to 15.24% followed by 15.16% in T_4 and 12.56% in T_1. [18] also reduced EC from 6.6 to 3.9 S/m and experienced upto 20% reduction of Electrical Conductivity in Municipal wastewater using Vetiver Floats.

3.1.1.3 Effect of Vetiver on Total solids:

The assimilation by the vetiver plant will depend on the amount of pollutants. Total Solids content seems to be decreased steadily. After 30 days of remediation the Total Solids reduction was highest in T_2 with 22.79% followed by T_4 with 22.11% and T_1 with 21.26%. [15] also observed nearly same range of Total solids initially which was around 2950 mg/l and was reduced to 42% in 100% concentration of the effluent. [27] showed results that removed a maximum of 81.42% of Solids with Vetiver.

3.1.1.4 Effect of Vetiver on Hardness:

Total Hardness showed a great difference in the reduction. Efficiency of Total Hardness was highest in T_1 with 58.18% and the second highest was observed in T_4 with 57.14% followed by T_3 with 52.5%.

3.1.1.5 Effect of Vetiver on Dissolved Oxygen:

Dissolved Oxygen exhibited the most efficiency than any other parameters. $W_1$50% was observed with the highest efficiency of 70.57% followed by T_4 with 65.16% and T_1 with 64.71%. Likewise 77% of efficiency was found in Dissolved Oxygen by [24]. [27] also observed an efficiency of over 71% in domestic wastewater using VFWs. [21] also observed the same trend in DO range of 3 to 6 mg/l.

Table. 2. Effect of pH and EC using Vetiver in dyeing effluent under different treatments

Treatments	pH	EC (dS/m)
D_1 T_1	7.43	2.23
D_1 T_2	7.89	2.47
D_1 T_3	8.01	2.69
D_1 T_4	8.20	2.77
D_2 T_1	7.43	2.14
D_2 T_2	7.83	2.32
D_2 T_3	8.00	2.42
D_2 T_4	8.19	2.51
D_3 T_1	7.38	1.95
D_3 T_2	7.79	2.11
D_3 T_3	7.97	2.28
D_3 T_4	8.15	2.35

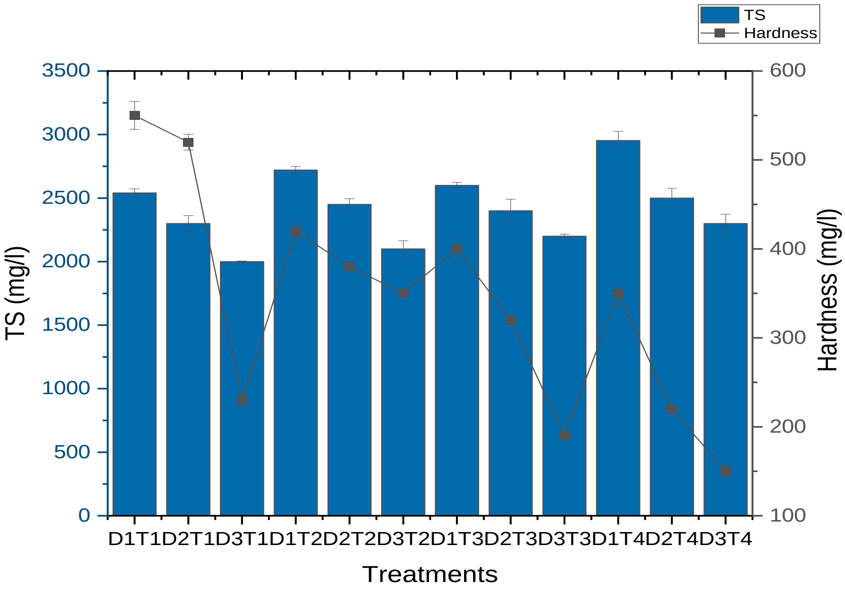

Fig. 1. Effect of Vetiver Floating Wetlands in Dyeing effluents over Total Solids and Total hardness

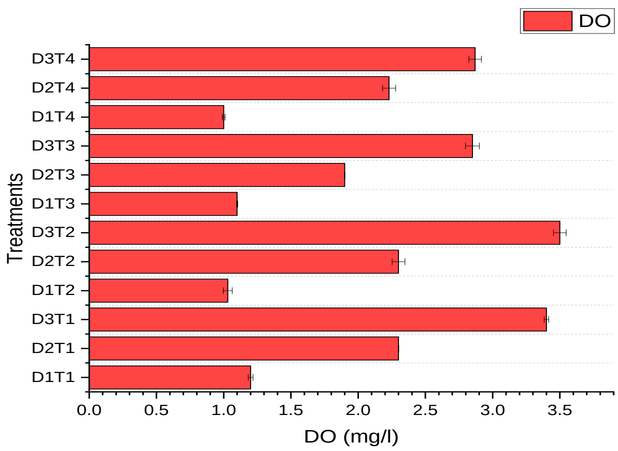

Fig. 2. Effect of Vetiver Floating Wetlands in Dyeing effluents over Dissolved Oxygen

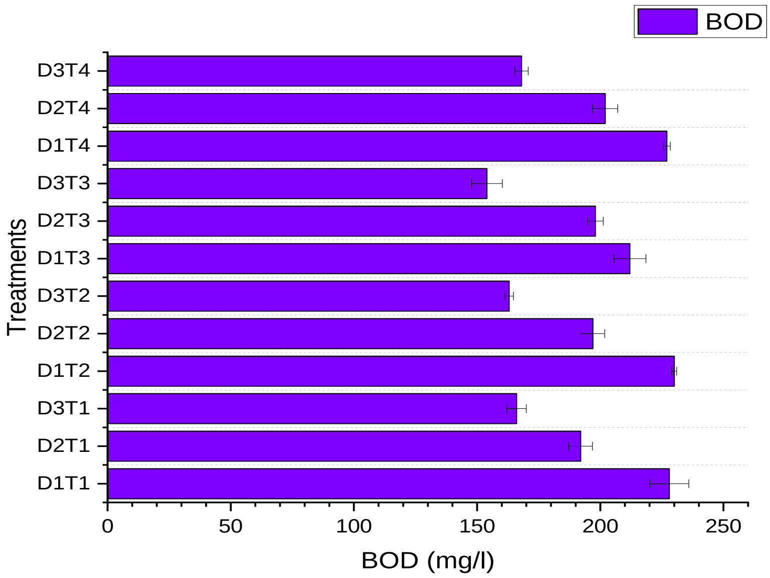

Fig. 3. Effect of Vetiver Floating Wetlands in Dyeing effluents over Biological Oxygen Demand

Table 3. Removal efficiency of Vetiver Floating Wetlands in Dyeing effluent

Parameters	T1	T2	T3	T4
pH	0.67%	1.27%	0.50%	0.61%
Electrical Conductivity	12.56%	10.93%	15.24%	15.16%
Total Solids	21.26%	22.79%	15.38%	22.11%
Hardness	58.18%	28.57%	52.5%	57.14%
Dissolved Oxygen	64.71%	70.57%	61.4%	65.16%
Biological Oxygen Demand	27.19%	30.93%	27.36%	25.99%

3.1.1.6 Effect of Vetiver on Biological Oxygen Demand

Biological Oxygen Demand was reduced greatly by T_2 with 30.93% followed by T_3 with 27.36% and T_1 with 27.19%. The same scenario was observed in case of [15] that the concentration of 50% showed greater reduction in BOD. [29] observed around 47–73% of efficiency in brewery wastewater. 67.47% of BOD was removed by [21] in Sewage wastewater.

3.1.1.7 Removal efficiency of Vetiver Floating Wetlands in Dyeing effluent

Reduction efficiencies of treatment system were calculated based on the following form:

Percentage removal efficiency = $\frac{Cini-C\,fin}{Cini}$ X 100%

where C_{inf} is initial parameter concentration and C_{fin} is final parameter concentration.

All parameters examined in the effluent had concentrations at the conclusion of the 30th day that were lower than those at the beginning of the day, showing that these parameters had been reduced in the system. Studies employing various types of wastewater and created wetland systems have shown that pollutants are reduced [28]. The degree of wastewater remediation is uniform with time. Despite the data originating from a variety of wastewater medium, plant density, pH, and retention period across several climatic zones, the removal efficiency for BOD and COD has proved to be reliable.

In this study the pH value ranged from 7.43-8.20. Electrical Conductivity ranged from 2.23 – 2.77 dS/m. Total solids ranged from 2540- 2953 mg/l. [29] also observed a similar range of Total Solis from 2500 -3000 mg/l. Hardness ranged from 350- 550 mg/l. Dissolved Oxygen increased from 1.0 to 3.4 mg/l. [30] observed DO range from 1.2-2.3 mg/l and Biological Oxygen Demand ranged between 168- 228 mg/l. [24] also observed a similar BOD range of 250 mg/l in his study.

30 days of remediation using Vetiver Floating wetlands revealed that average removal efficiencies of 61-70% for Dissolved Oxygen, 28-58% for Total Hardness, 25-30% for Biological Oxygen Demand, 15-22% for Total Solids, [24] showed an efficiency of 43% in Total Solids. 24-27% for Electrical Conductivity and pH the efficiency was up to 1.27% in Dyeing effluent. [18] showed a reduction efficiency of 32% in pH which is quite similar to our study. The results demonstrated that the performance of phytoremediation has the ability to increase the water quality.

4. CONCLUSION

This study shows that Vetiver plants are resistant to the contaminants in polluted water and Vetiver Floating Wetlands show greater efficiency in the remediation of Dyeing effluents. This study confirmed that remediation of Dyeing effluent using vetiver grass under hydroponic conditions is a feasible complementary treatment method that can reduce the amounts of total solids, Dissolved Oxygen and Biological Oxygen Demand within 30 days. The treatment efficiencies of DO, BOD, TS and Hardness increased with the age of vetiver. In Dyeing effluent the concentration of 50% showed greater results over VFWs in the remediation of Total Solids, Dissolved Oxygen and Biological Oxygen Demand followed by the other concentrations like 25%, 75% and 100% respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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