

International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST  
- 2015)

## Effectiveness of Vetiver System for the Treatment of Wastewater from an Institutional Kitchen

Mini Mathew<sup>a,\*</sup>, Sr. Claramma Rosary<sup>b</sup>, Mathukutty Sebastian<sup>c</sup> & Sandra Maria Cherian<sup>d</sup>

<sup>a,b,c,d</sup> Department of Civil Engineering, Amal Jyothi College of Engineering, Kanirapally, Kottayam, Kerala, India

### Abstract

This paper investigates the potential of using Vetiver System (VS) for the treatment of wastewater generated from an Institutional kitchen. Vetiver grass is a perennial grass with deep root and has high biomass system. Researchers proved that Vetiver grass have extraordinary ability to with stand extreme environmental conditions such as elevated levels of salt, acidity, alkalinity, sodicity as well as whole range of heavy metals, nitrogen (N), and phosphorous (P). There are around 800 inmates in this institutional hostel; as a result large amount of wastewater have been produced everyday in campus kitchen wastewater outlet. A pilot experimental setup was made for the treatment of wastewater produced from the wastewater outlet and the capability of using VS for the treatment was studied. Experimental setup includes 5 drums of 130 liters capacity and is filled with soil, the Vetiver grass is planted in them and was connected in series using different pipe fittings. Each tank has outlet at the bottom of the tank and inlet provided at top with sufficient free board. The wastewater was supplied through the inlet of the 1<sup>st</sup> tank and was allowed to pass through the 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> tanks and the treated water was collected at the outlet of the 5<sup>th</sup> tank. The water quality parameters of wastewater and treated water were analysed and the effectiveness of using VS for the treatment was assessed. The various water quality parameters like pH, turbidity, acidity, alkalinity, BOD, COD, DO, Ecoli were analysed for the wastewater and treated water. It is observed that the wastewater treatment using VS has significant potential to reclaim the wastewater. The VS is able to remove 80 to 85 % of BOD, 85 to 90 % of COD, and 85 % of total Coliform. Most of the water quality parameters are within permissible limits as per IS 10550, 2012 and IS 2292, 1992.

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Peer-review under responsibility of the organizing committee of ICETEST – 2015

### 1. Keywords: Wastewater, Vetiver System, Water Quality Parameters

\*Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .

E-mail address: [author@institute.xxx](mailto:author@institute.xxx)

## 2. Introduction

There are many methods for wastewater treatment; more than half of the world population will be suffering from severe fresh water shortages. The water is the most important factor in food production and agriculture. The limited availability of water for agricultural production is increasing day to day and can be resorted by using treated wastewater for agricultural and domestic uses and the fresh water could be limited for drinking and emergent domestic needs such as cooking and washing.

Vetiver grass, a perennial grass with deep root system and has high biomass production and has unique morphological characteristics. It has the ability to resist adverse environmental condition, absorb and tolerate extreme levels of nutrients [1, 2, 5] and has been used effectively for wastewater treatment [1, 2]. The Vetiver grass also has unique characteristics suitable for environmental protection purposes [3, 4].

Vetiver grass is highly tolerant to adverse edaphic conditions such as high soil acidity and alkalinity, saline, sodic, magnesian, Aluminum and Manganese toxicities [6], and to elevated levels of all heavy metals [7]. The Vetiver grass is capable of withstanding extremely high N supply [5,6] and also it can absorb large amount of water [8, 9]. Vetiver was also effectively used as vegetative buffer or wetland plant species due to its extraordinary morphological and physiological features [10]. Wastewater which contains high concentrations of organic and inorganic pollutants, which is produced from the oil refinery of the Maoming Petro-Chemical Company, China, treated using different plant species, and observed that the performance of the VS is low at beginning and became stable as the plant is grown.

The floating platform techniques were performed [11, 12] to treat domestic wastewater with different Vetiver species and two wastewater strengths – high and low concentration wastewater. The results indicated that the treatment efficiencies of different concentrations of wastewater were significantly different and observed the ability of Vetiver to uptake heavy metals from industrial wastewater. From the literature it was observed that Vetiver grass has extraordinary ability to withstand highly adverse environmental conditions and consume large quantity of water during growth. The main objective of this paper is to study the effectiveness of using VS for treating wastewater which is generated in our campus wastewater outlet.

## 3. Materials and methodology

The wastewater for the experimental studies was collected from institutional hostel wastewater outlet in Amal Jyothi College of Engineering, Kanjirapally, Kottayam (latitude: 9° 31' 54.42" and Longitude: 76° 49' 12.5"), Kerala which is situated in southern part of India. There are around 800 inmates in the hostel; as a result large amount of wastewater is produced everyday in our campus wastewater outlet.

### 3.1 Experimental Setup

A pilot experimental setup was constructed to assess the potential of VS for treating wastewater generated in campus wastewater outlet. The experimental setup is shown in Fig. 1. Fig. 1a shows the setup immediately after the construction and Fig. 1b shows the Experimental setup 400 days after the Vetiver is planted. The setup includes 5 drums each contains 130 liters capacity and those are connected in series. The drums were filled with soil and Vetiver is planted in them. These drums are connected using PVC pipes with controlling valves and various pipe fittings. The heights of the drums are 85 cm and they are connected to each other using 1 inch diameter hose. Each tank has outlet and inlet. The inlet of 1<sup>st</sup> tank is 30 cm below from top and the outlet is



(a) Immediately after construction



(b) 400 days after the Vetiver is planted

Fig.1. Experimental setup

7.5 cm above from the bottom of the tank. The outlet from the 1<sup>st</sup> tank is connected to the inlet of the 2<sup>nd</sup> tank which is 30cm below from the top of the tank. Similarly the outlet of the 2<sup>nd</sup> tank is connected to the inlet of the 3<sup>rd</sup> tank, 3<sup>rd</sup> to the 4<sup>th</sup> and 4<sup>th</sup> to the 5<sup>th</sup>. The inlet of the 3<sup>rd</sup> tank is 35 cm below the top of the tank, the inlet of the 4<sup>th</sup> and 5<sup>th</sup> tanks are 40 cm from the top. This is provided a hydraulic gradient from inlet to outlet. The wastewater is supplied through the inlet of the 1<sup>st</sup> tank, and is allowed to pass through the 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> tanks, through the roots of the Vetiver grass and is collected at the outlet of the fifth tank. The treated water obtained from outlet and wastewater is analysed for various water quality parameters like pH, turbidity, acidity, alkalinity, BOD, DO etc.

#### 4. Results and discussion

The treated water and wastewater were analysed for various parameters such as pH, acidity, alkalinity, chloride, hardness, turbidity, BOD, COD, and Ecoli. As per IS 10500, 2012, the permissible limit of pH for drinking purpose is 6.5 to 8.5, and as per IS 2292, 1992 for domestic/irrigation purpose is 5.5 to 9.0. Table 1 shows the water quality parameters of wastewater and treated water. Fig. 2 shows the percentage increase in pH after the Vetiver is planted for varying period of time. From the experimental results, it was observed that, one day after Vetiver is planted; there is an increase in pH of 20.4%. After the third day the % increase in pH was 8.94, and then on 5<sup>th</sup> and 7<sup>th</sup> days, the increase in pH became 15.38 and 42.8 respectively. Table 1 show the pH of the raw and treated water, the pH values of treated water is within the permissible limits for domestic and drinking.

Table 1. Water quality parameters of raw water and treated water

Days after vetiver is planted	pH		NTU		DO (mg/l)		BOD (mg/l)		COD (mg/l)	
	Raw water	Treated water	Raw water	Treated water	Raw water	Treated water	Raw water	Treated water	Raw water	Treated water
1	5.53	6.66	285	106	0.1	1.1	740	472	1300	997
3	6.04	6.58	212	110	0.1	0.9	833	570	1789	1235
5	5.2	6	212	102	0.1	1.0	756	502	1820	1214
7	4.78	6.83	203	90	0.25	2.7	780	420	1928	1009
30	4.56	6.56	208	7	0.6	3.0	730	123	1270	220
330	4.7	6.8	320	7	0	3.5	762	100	1845	232
380	4.13	6.99	365	8	0	4.0	812	112	1700	222
400	4.2	7.2	374	5	0	4.2	745	112	1790	210

As per IS 10500:2012, the permissible limit of turbidity for drinking purpose is limited to 1 NTU. Three days after the Vetiver is planted, the percentage decrease in turbidity was 48.1. Then after 5th, 7th, 30th, 330th, 380, and 400 days it decreased to 51.9, 55.7, 97.8, 98.7, 97.8 and 98.7. Fig.3 shows the percentage removal of turbidity as the Vetiver is grown. The result show that as time increases, ie the plant is grown properly; the percentage turbidity removal also increases. This show that as the plant is grown properly, the turbidity of treated water is getting better and the treated water can be used for various domestic and irrigation uses.

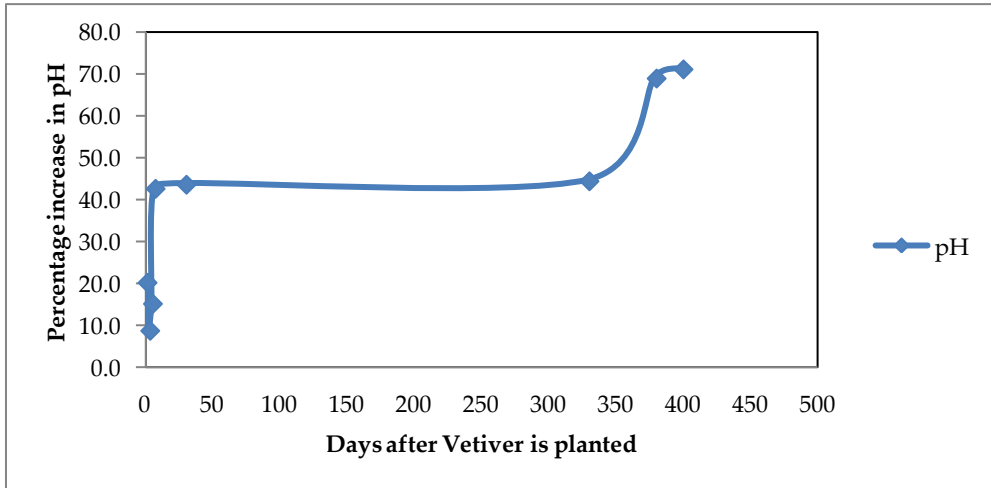


Fig. 2. Percentage Variation of pH after the Vetiver is planted

Fig. 3 also shows the variation of BOD and COD for varying period after the Vetiver is planted. These show that as the plant is grown properly the VS could be able to remove 85 % of BOD and 89 % of COD. Fig. 4 shows the variation of DO of raw water and treated water as the plant is grown, the VS system could remove 99% of DO 30 days after Vetiver is planted. As per IS 10500:1991, the permissible limit of DO for drinking purpose is 6 to 8 mg/l, and for aquatic life minimum 4 mg/l should be needed. The results show that properly grown plant could improve the DO levels of wastewater

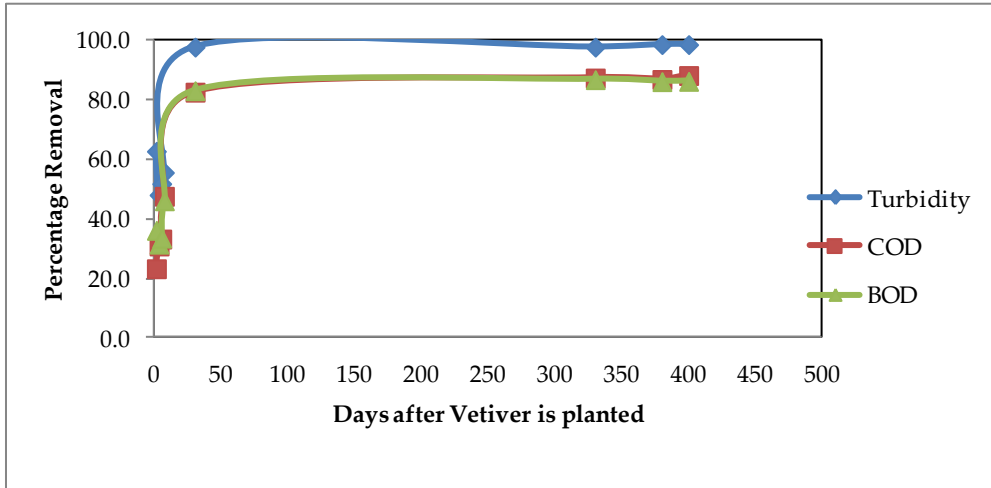


Fig. 3. Percentage Removal of COD, BOD and Turbidity after the Vetiver is planted

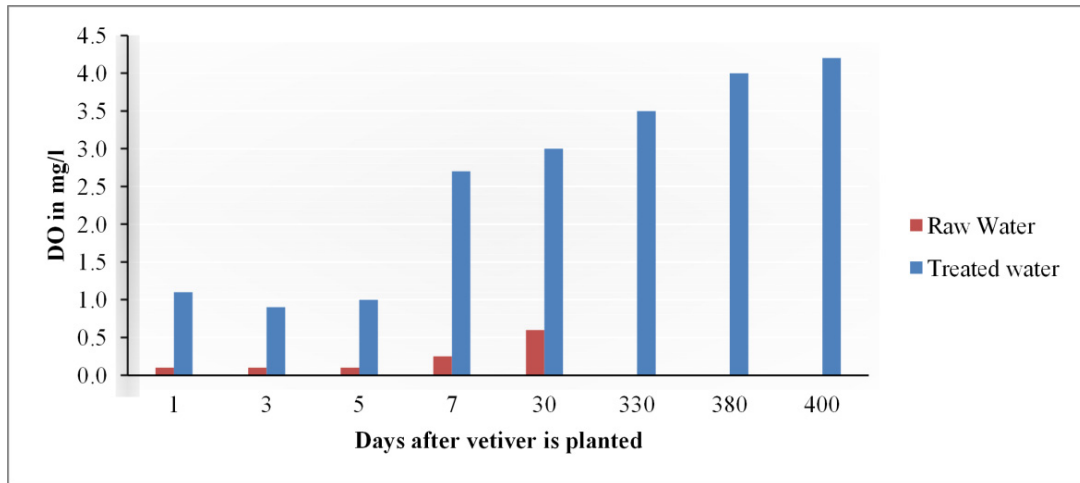


Fig. 4. Variation of DO before and after treatment

The microbiological properties of the water are also tested. Fig. 5 shows the percentage removal of total coliform MPN/ 100 ml. As the plant is grown properly, the VS could remove 85 % of Coliform.

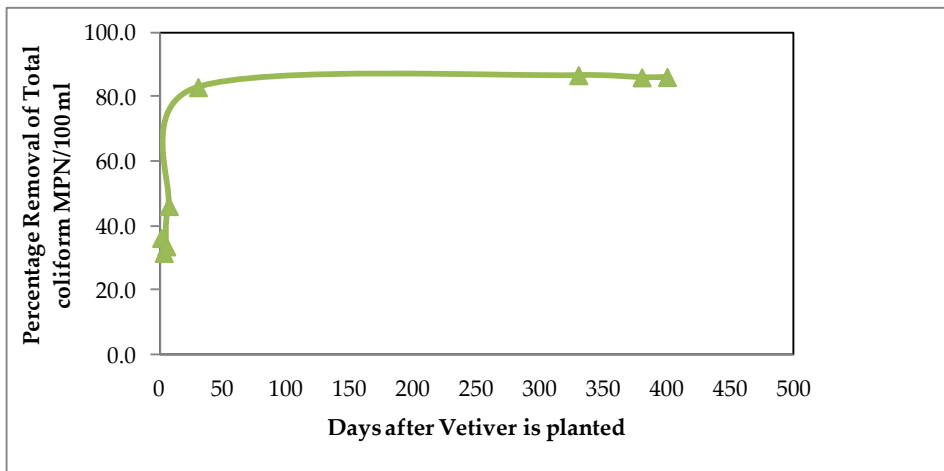


Fig. 5. Percentage Removal of Total coliform after the Vetiver is planted

### 5. Conclusion

The treatment of wastewater produced from wastewater outlet using VS was carried out. The water quality parameters of raw water and the treated water were analysed and compared with the permissible limits as per IS 10550, 2012 and IS 2292, 1992. From the results it is observed that most of the water quality parameters tested is within the permissible limits. The VS is able to remove 80 to 85 % of BOD, 85 to 90 % of COD, 85 % of total Coliform. The information presented above demonstrates that the VS are very efficient and low cost method for treatment of institutional wastewater.

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