The Study on Wastewater Treatment Capacity of Vetiver Grass in Hydroponic System

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Abstract- *Water is essential to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of good quality for domestic and economic activities. Application of the Vetiver system for wastewater treatment is a new and innovative phyto-remedial technology developed in Queensland, Australia by the Department of Natural Resources and Mines. It is a green and environmental friendly wastewater treatment technology. Biological wastewater treatment method using Vetiver is known as phyto-remediation of Vetiver grass. Present study aims to analyze the wastewater treatment capacity of vetiver grass in hydroponic system.To check the Vetiver grass growth in different wastewater samples using Hydroponic system and also check the biomass pH, BOD and COD of the Vetiver in the selected wastewater samples.*

Keywords- Vetiver, Three different wastewater samples Industrial water, Pool water, Home sewage water, Hydroponics.

I. INTRODUCTION

Water is our most precious resource as it is vital to all lives. Water is essential to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of good quality for domestic and economic activities. Clean water is becoming one of the scarcest and valuable resources in the twenty first century as its supply is finite and its traditional source is easily polluted by industries and population growth. But the water, available from different surface and groundwater sources are known to be clean and free from any contamination since the release of nutrient-rich wastewater into receiving open surface and subsurface along with river results in environmental and human health problems such as eutrophication in water bodies, i.e. undesirable growth of aquatic plants and algae (Morrison *et al*., 2001).

Phyto-remediation is one of the biological wastewater treatment methods which is low cost, consumes less energy, natural, practicable, effective and simple. Suitable plant species used for phyto-remediation should have high uptake of both organic and inorganic pollutants, grow well in polluted water and be easily controlled in quantitatively propagated dispersion. Vetiver grass (*Vetiveria zizanioides* (L.) Nash recently reclassified as *Chrysopogonzizanioides*(L.) Roberty) belongs to the Gramineae family and was first used for soil and water conservation purpose in all countries including Ethiopia. But in the last few years, due to its unique morphological and physiological characteristics and tolerance to high levels of heavy metals and adverse conditions, its role has been successfully extended to environmental protection, particularly in the field of wastewater treatment (Truong, 2003).

Application of the Vetiver system for wastewater treatment is a new and innovative phyto-remedial technology developed in Queensland, Australia by the Department of Natural Resources and Mines. It is a green and environmental friendly wastewater treatment technology as well as a natural recycling method (i.e. in the process of 'treatment', the Vetiver plant absorbs essential plant nutrients such as N, P and cations, and stores them for other uses). Its end-product has provided high nutrient material for animal feed, mulch for gardens, leaves and stalks for room cooling, handicrafts, roof thatching, extracting volatile oils for making perfume and aromatic ingredients in soaps, raw material for making pulp, paper, ropes, mats, hats, baskets, manure for organic farming and organic source for composting just to name a few (Smeal*et al*., 2003).

The vetiver grass system is a technology that employs the Vetiver grass (*Vetiveria zizanioides* (L.) Nash) for various environmental management applications. The unique morphological and physiological characteristics that make it tolerant to many adverse climatic and edaphic conditions. The vetiver grass exhibits both xerophytic and hydrophytic characteristics (Njau and Mlay, 2003), although it optimally thrives in waterlogged habitats (Boonsong and Chansiri, 2005). Studies with the use of Vetiver plants in the treatment of wastewater have been mainly done using either the hydroponics or the soil-based techniques of planting. Trials on vetiver by (Hart *et al*., 2004) indicated that on-site hydroponic vetiver treatment of domestic effluent had the potential of being more effective than other such treatments and more nitrogen and phosphorus are reduced by hydroponic Vetiver.

Positive characteristics of vetiver system for wastewater treatment process

- It is perennial and requires minimal maintenance.
- It is both xerophyte and hydrophyte. Once established, it can withstand drought, flood and long periods of water logging.
- It will grow in all types of soil regardless of fertility, pH or salinity.
- It is highly tolerant to toxic levels of aluminium, manganese, arsenic, cadmium, chromium, nickel, copper, mercury, lead, selenium and zinc.
- It will grow in a wide range of climates, survives in areas with average annual rainfall between 200 and 6000 millimeters and with temperatures ranging from 1 to 45 degree C.
- It is a climax plant and therefore even when all surrounding plants are destroyed by drought, flood, pests, diseases, fire or other adversity, vetiver will remain to protect the ground from the onslaught of the next rains.
- It has a strong fibrous root system that penetrates and binds the soil to a depth of three meters and can withstand the effects of tunneling and cracking.

II. MATERIALS AND METHODS

Taxonomic position

Kingdom - Plantae
Sub kingdom - Tracheobionta
Super division - Spermatophyta
Division - Magnoliophyta
Class - Liliopsida
Subclass - Commelinidae
Order - Cyperales
Family - Poaceae
Genus - Vetiveria
Species -*Vetiveria zizanioides* (L.) Nash

Fig 1. Vetiver grass (*Vetiveria zizanioides* (L.) Nash)

Vetiver grass comes under the Gramineae family. The vetiver is a unique tropical plant. It is tall and erect and it is native to India, and South-East Asia. It is found throughout the plains, lower hills of India especially on the river banks, in marshy soils and it is widely used in Karnataka, India. It is a herbaceous perennial plant with erect leaves and rather stiff. Its height ranges from 0.5 to 1.5 m. Its root system shows fast growth and it is deep and resistant. Due to its unique morphological characteristics and its tolerance of adverse environmental conditions, it has been used effectively for wastewater treatment (Troung, 2003).

V. zizanioides is not a hydrophyte but it prefers wet and waterlogged habitat where it can grow and develop even though a large portion of its shoots are submerged for relatively long period, normally in water. Many scientists have confirmed that Vetiver grass is powerful to remove nitrogen and phosphorus.

III. EXPERIMENTAL SET UP

The plant materials were collected from Peringottukurissi, Palakkad, Kerala. Vetiver grass was planted in the open field for two months. The leaves were cut 20 cm from the bottom of the plantlets and the length and number of roots and leaves etc., were noted. These plantlets are then grown hydroponically in three different water samples, Industrial water, Pool water and Home sewage water. From this, 1000 ml solution were taken and transferred to each cup ‘A’, ‘B’ and ‘C’. Then a thermocol is cut round and three holes of almost 1 cm diameter is made on the round shaped thermocol and fixed at the mouth of each 1000 ml flask. The vetiver plants are then inserted into these three holes thereby the roots are immersed in the water samples. The plants are allowed to grow for twenty days. The collected samples are tested, for nitrogen, phosphorus, pH, BOD and COD using APHA method before and after the experiment.

- Sample A - Industrial water
- Sample B - Pool water
- Sample C - Home sewage water

IV. RESULTS AND DISCUSSION

The present study was done to check the Vetiver grass growth in different wastewater samples using Hydroponic system. Biomass, Nitrate and Phosphate, BOD, COD and pH were analyzed. In number of leaves, the lowest number of new leaves were found in **sample A & B** and the highest number of new leaves were found in **sample C**. In leaf length, the lowest leaf length was found in **Sample A** and the highest leaf length was found in **Sample B.** In number of roots, the lowest number of new roots were found in **Sample A** and the highest number of new roots were found in **Sample B**. There is no major changes in root length in all samples.

Table – 1. Growth in biomass of Vetiver grass in 10 days in selected samples

Sample			Average no. of roots		Average root length (cm)		Average no. of shoots		Average shoots length (cm)	
			Initial	Final	Initial	Final	Initial	Final	Initial	Final
A	1		5	6	14.9	14	5	6	20	23.16
	2		5	5	9.2	10.7	6	6	20	21
	3		5	5	11.6	13.2	5	5	20	22
	4	Mean	**5**	**5.33**	**11.9**	**12.63**	**5.33**	**5.66**	**20**	**22.05**
	5	S D	**0**	**0.57**	**2.86**	**1.72**	**0.57**	**0.57**	**0**	**1.08**
B	1		2	4	13.5	10.5	4	2	20	20
	2		3	4	12.5	10.75	4	5	20	21.6
	3		13	14	8.67	10.73	5	7	20	23.85
	4	Mean	**6**	**7.33**	**11.55**	**10.66**	**4.33**	**4.66**	**20**	**21.81**
	5	S D	**6.08**	**5.77**	**2.54**	**0.13**	**0.57**	**2.51**	**0**	**1.93**
C	1		2	4	11	8.57	5	4	20	20
	2		5	6	13	13.41	6	4	20	20.5
	3		8	9	10.62	11.18	6	8	20	23.75
	4	Mean	**5**	**6.33**	**11.54**	**11.05**	**5.66**	**5.33**	**20**	**21.41**
	5	S D	**3**	**2.51**	**1.27**	**2.42**	**0.57**	**2.30**	**0**	**2.03**

Sample A: Industrial water, **Sample B**: Pool water **Sample C**: Home sewage water

Table - 2. Growth in biomass of Vetiver grass in 20 days in selected samples

Sample			Average no. of roots		Average root length (cm)		Average no. of shoots		Average shoot length (cm)	
			Initial	Final	Initial	Final	Initial	Final	Initial	Final
A	1		5	6	14.9	15.83	5	6	20	24.33
	2		5	6	9.2	12.2	6	8	20	23
	3		5	5	11.6	15.25.	5	4	20	21.75
	4	Mean	**5**	**5.66**	**11.9**	**11.83**	**5.33**	**6**	**20**	**23.02**
	5	S D	**0**	**0.57**	**2.86**	**3.99**	**0.57**	**2**	**0**	**1.29**
B	1		2	4	13.5	11.	4	5	20	20
	2		3	5	12.5	11.37	4	5	20	23.
	3		13	15	8.67	10.35	5	8	20	26.18
	4	Mean	**6**	**8**	**11.55**	**11.14**	**4.33**	**6**	**20**	**23.29**
	5	S D	**6.08**	**6.08**	**2.54**	**0.70**	**0.57**	**1.73**	**0**	**3.11**
C	1		2	4	11	9.75	5	5	20	20.5
	2		5	6	13	14.83	6	6	20	21.33
	3		8	11	10.62	10.81	6	8	20	27.37
	4	Mean	**5**	7	**11.54**	**11.79**	**5.66**	**6.33**	**20**	**23.06**
	5	S D	**3**	**3.60**	**1.27**	**2.67**	**0.57**	**1.52**	**0**	**3.74**

Sample A: Industrial water, **Sample B**: Pool water **Sample C**: Home sewage water

In **Sample A** the initial pH was **6.69** and the final pH was **7.34** after 20 days. **Sample B** the initial pH was **5.98** and the final pH was **7.40** after 20 days. **Sample C** the initial pH was **6.33** and the final pH was **7.35** after 20 days.

In **Sample A** the initial Nitrate concentration was **2.83mg/l**, the Nitrogen concentration was decreased to **2.56mg/l** in 20 days. in**Sample B** the initial Nitrate concentration was **1.74mg/l**, the Nitrogen concentration was decreased to **1.66mg/l** in 20 days. in**Sample C** the initial Nitrate concentration was **8.23mg/l**, the Nitrogen concentration was decreased to **5.63mg/l** in 20 days. The reduction of nitrogen in the wastewater might have occurred due to the assimilation by plants or the oxidation of ammonium into nitrite and nitrate by nitrifying bacteria (Metcalf and Eddy, 2003). In the present study phosphorus were found to be Below Detected Level (BDL) in all the samples.

In **Sample A** the concentrations of BOD5 (Table 3) were decreased from **6.0mg/l** at the beginning of experiment to **4.0mg/l** in 20 days. The COD concentrations were also reduced from **30.0mg/l** to **10.0mg/l** in 20 days. In Sample B the concentrations of BOD5 were decreased from **9.0mg/l** at the beginning of experiment to **4.0mg/l** in 20 days. The COD concentrations were also reduced from **67.0mg/l** to **20.0mg/l** in 20 days. In Sample B the concentrations of BOD5 were decreased from **16.0mg/l** at the beginning of experiment to **13.0mg/l** in 20 days. The COD concentrations were also reduced from **100.0mg/l** to **80.0mg/l** in 20 days. Moreover, during the entire time of analysis it could be depicted that the concentration of BOD5 and COD of experimental sets planted with Vetiver were reduced. This obviously indicates that the beneficial effect of vetiver in treating wastewater.

Table - 3.Major plant nutrient contents of the selected samples

Sl no.	Parameters	Sample A		Sample B		Sample C	
		Initial	Final	Initial	Final	Initial	Final
1	**pH**	6.69	7.34	5.98	7.40	6.33	7.35
2	**Nitrogen**	2.83mg/l	2.56mg/l	1.74mg/l	1.66mg/l	8.23mg/l	5.63mg/l
3	**Phosphorus**	BDL	BDL	BDL	BDL	BDL	BDL
4	**BOD**	6.0mg/l	4.0mg/l	9.0mg/l	4.0mg/l	16.0mg/l	13.0mg/l
5	**COD**	30.0mg/l	10.0mg/l	67.0mg/l	20.0mg/l	100.0mg/l	80.0mg/l

Sample A: Industrial water, **Sample B**: Pool water **Sample C**: Home sewage water

Fig 2.Vetiver grass in different selected samples

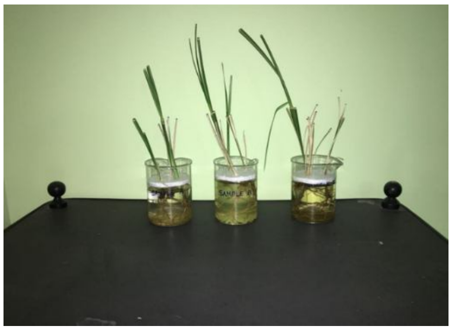
Fig 3.Vetiver grass in culture medium after 20 days

From the study, phosphorus is found to be BDL (below detected level) and the amount of nitrate was found to be decreasing in each sample. Presence of nitrogen in the medium helped for the growth of the plants. New leaves were arisen during the course of development. Also the amount of water used for hydroponic system was found to be decreasing. It indicates the absorbance of water by the plants. After 20 days of each experiment, there was a decrease of BOD and COD in contrast with the initial value. Initially the pH was acidic in all the samples but it become slightly alkaline or neutral after the treatment.

According to Mary (2005), in untreated wastewater, nitrogen exists in the forms of ammonia, nitrite, nitrate and organic nitrogen. Urea, protein and amino acids are the major forms of organic nitrogen along with the discharge of these nitrogen compounds in to the receiving environment would lead to several environmental and health risks. Nitrogen compounds, therefore, need to be removed from the wastewater. According to Mary (2005), when concentrations are too high, problems such as algal blooms, foul smelling, excessive weed growth and the loss of species diversity can occur.

The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. As acidity increases, most metals become more water soluble and more toxic. Ammonia, however, becomes more toxic with only a slight increase in pH. Elevated nutrient levels are some of the causes to acidity or alkalinity which cause excessive growth of algae and plants that will lift pH values. If extremely high or extremely low pH values occur, it would result in the death of all aquatic life (Shu*et al*., 2005).

The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to the environment. Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days. If effluent with high BOD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river (Ramesh *et al*., 2007).

V. CONCLUSION

Present study aims to analyse the wastewater treatment capacity of Vetiver grass in hydroponic system. The results from this present study using hydroponic technique, Vetiver showed a good potential to be used in situto treat domestic wastewater. The results of the study confirm that Vetiver is a useful tool in wastewater treatment. Hence, applying an appropriate technology with regard to the climate condition and social and economic features of the region is very important. The Vetiver system is low cost and extremely effective system for soil and water conservation, infrastructure stabilization, pollution control, waste water treatment, mitigation and prevention of storm damage and many other applications.

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