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Treatment of fertilizer industry effluent by using vetiver technology

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Abstract

The vetiver technology is now well accepted and used worldwide for numerous applications. Amongst these, environmental protection applications are the most popular due to its effectiveness, simplicity and low cost. Earlier research conducted to understand the role of the extraordinary physiological and morphological attributes of vetiver plant in soil and water conservation, discovered that vetiver plant also possesses some unique characteristics suitable for environmental protection purposes. Extensive research in Australia, China and Thailand and in other countries has established vetiver plant tolerance to elevated and sometimes toxic levels of salinity, acidity, alkalinity, sodicity as well as a whole range of heavy metals and agrochemicals. Latest research also shows its exceptional ability to absorb and to tolerate extreme levels of nutrients, to consume large quantities of water in the process of producing a massive growth. These attributes indicated that vetiver is highly suitable for treating polluted wastewater from industries as well as domestic discharges.

Keywords: Vetiver, Fertilizer, Wastewater, Water conservation.

Introduction

Wastewater treatment is virtually mandatory in the modern world to solve the problems of water scarcity and environmental degradation .water discharged into the environment must meet its acceptable quality standards. Since conventional treatment technologies are either ineffective or wasteful and costly . Many studies on phyto-remediation technologies are ongoing. Many plant species that have been widely studied, vetiver plant (*vetiveria zizanioides*) has been identified to be of significant potential (Alkorta and Garbisu, 2001). Vetiver constructed wetlands are hence the one of the best alternatives to the current wastewater treatment technologies (Smeal *et al.,* 2003; Smeal and Truong, 2006). Fertilizer industry is considered to be one among the major industries that contributes major water pollution. Presently India produce around 206 million tones food grains, but in future increase up to 380 million tons of food grain in 2025. As there is no scope for expansion of our agricultural land. Additional amount of food grain has to be obtain by using high quality and quantity of fertilizer. A major portion of the applied fertilizer is lost from soil-plant system by leaching, runoff, denitrification and volatilization and pollutes the soil, water and air. Fertilizers causes eutrophication of surface water, nitrate (NO_3) pollution of groundwater, heavy metal pollution of soil, atmospheric pollution etc. So effective treatment of fertilizer effluent is necessary. Conventional treatment methods are more costly, energy consuming and require adequate maintenance.

Phytoremediation: Phytoremediation is one of the biological wastewater treatment methods and is the concept of using plants-based systems and microbiological processes to eliminate contaminants in nature (Ash and Truong, 2003). The remediation techniques utilize specific planting arrangements, constructed wetlands (cw), floating-plant systems and numerous other configurations. The removal of wastewater constituents are achieved by different mechanisms like sedimentation, filtration, chemical precipitation, adsorption and microbial interactions, among which, the most effective technology is phytoremediation technology. These systems are generally cost effective, simple, environmentally non-disruptive, low maintenance cost and operation cost In phyto-remedial technology, the plants take up water soluble contaminants through their roots, and transport them through various plant tissues, where they can be metabolized or volatilized (Barbara *et al.,* 2010). They have identified various tolerant plants which are able to significantly reduce organic and inorganic pollutants in the wastewater and in the polluted soils and surface water. In phyto-remedial technology, the plants take up water soluble contaminants through their roots, and transport them through various plant tissues, where they can be metabolized or volatilized. The mechanism of phytoremediation are phyto-stabilization, phyto-extraction, phyto-volatilisation (Chomchalow, 2006).

Vetiver Technology: The vetiver technology is a technology that employs the vetiver plant(*Vetiveria zizanioides*) for various environmental management applications (Cull *et al.,* 2000). Vetiver have unique morphological and physiological characteristics that make it tolerant to many adverse climatic conditions. The plant exhibits both xerophytic and a hydrophytic characteristics. It has an exceptionally wide pH range, with the potential to grow in any type of soil, withstand extreme drought and thrive under temperatures as low as -9^{o} C (Davison *et al.,* 2005). Its ability to absorb and tolerate elevated levels of nitrogen and a high dry matter production rate is reported. The performance of Vetiver Constructed Wetlands (VCW) in wastewater treatment has been found to be commendable (Dudai *et al.,* 2006). Zheng *et al*. (1997), confirmed that the VCW is a good purifier of eutrophic water. It has been reported to reduce septic plant effluents' by 99% nitrogen, 85% phosphorous and 95% faecal coliforms reduction. Ash and Truong (2003) studies regarding the use of vetiver plants in the treatment of different types of wastewater have been mainly done using either the hydroponic or the soil-based techniques of planting, albeit with conflicting findings. Trials on vetiver by Barbara *et al. (*2010) indicated that on-site hydroponic vetiver treatment of domestic effluent had the potential of being more effective than other such treatments, and that hydroponic vetiver reduces far more nitrogen and phosphorous than any other plants. In contrast to this, studies by Mng'anya *et al.* (2001), Bonsoon and Chansiri (2006), Bonsoon and Chansiri (2008) and Headley and Tanner (2006) indicated that hydroponic techniques posted lower nitrogen and phosphorus removal efficiencies when compared with results from other studies which had soils as a growth medium (Lishenga *et al.,* 2015). This research aimed to evaluating the performance of vetiver across three distinct planting techniques, to treat wastewater

Materials and Methods

The main experimental materials used were vetiver plants, sandy soil from the locality and fertilizer industry effluent collected from FACT Ernakulum. The sandy type soil have porosity of 39% and void ratio 0.64. The vetiver plant tillers were obtained from the nearby locality.

Preparation of synthetic fertilizer industry effluent: One liter of distilled water was taken in a beaker for preparing of fertilizer industry effluent. Add 200mg Glucose, 40 mg Ammonium nitrate (NH_4NO_3), 28mg Monopotassium phosphate (KH_2PO_4) 20mg Dipotassium phosphate (K_2HPO_4) and 10ml Nutrient solution in to distilled water. Nutrient solution was prepared by mix all chemicals in 1L distilled water prescribed in Table (1).

Table (1): Synthetic waste water thoroughly mix to get uniform characteristics.

No.	Chemical	Composition (g/L)
1	Magnesium sulphate heptahydrate ($MgSO_4.7H_2O$)	90
2	Calcium Chloride dehydrate ($CaCl_2.2H_2O$)	6
3	Iron chloride hexahydrate ($FeCl_3.6H_2O$)	1.5
4	Manganese chloride tetrahydrate ($MnCl_2.4H_2O$)	6.5
5	Zinc sulphate heptahydrate($ZnSO_4.7H_2O$)	1.7
6	Cupper chloride dehydrate($CuCl_2.2H_2O$)	0.1
7	Cobalt chloride hexahydrate ($CoCl_2.6H_2O$)	1.9
8	Nickel sulphate($NiSO_4.6H_2O$)	6.5
9	Boric acid (H_3BO_3)	0.1
10	Sodium molybdate ($Na_2MoO_4$2H2O)	0.6
11	Yeast extract	1

Experimental setup: Vetiver experiments are conducted in continuous flow mode with high strength wastewater and low strength wastewater. In each strength wastewater 4, 8 , 12 and 16 plants are used. The effluent was collected at various hydraulic detention times such as 1 day, 2 days, 3days, 4 days, and 5 day. In floating vetiver system, vetiver plant was used for treating the fertilizer industry effluent. This experiment was conducted in a plastic container of size 38cm x 26cm x 8cm filled with low concentrated effluent. A thermo coal platform having holes was used to support the plants on the top of the water. Vetiver plants are fixed on this thermo coal platform. 4 to 16 number of plants were used in a single container. This experiment was conducted in 7 cm water depth. In constructed wetland method, tray is divided in to three parts by using thermo coal having 1 hole per1cm length. The influent, low concentrated wastewater is coming through the pipe to tray containing vetiver plants.

According to HRT effluent was collected at various detention times from 1 to 5 days. The combined method is a combination of floating vetiver system and constructed wetland system. The combined unit was constructed by partitioning the box into three halves using thermo coal. The first half was constructed wetland system. The combined unit was constructed by partitioning the box into three halves using thermo coal. The first half wasbplanted with 2 vetiver plants using the floating vetiver technique. Second part was filled with soil and planted with 2 vetivers. Third part was taken as out let zone. This set up was constructed for varied number of plants from 4 to 16. The collected effluent from combined unit are analysed for BOD, Sulphate, Phosphate, Chloride COD, pH and Nitrate according to standard method. Same experimental setup constructed for high concentrated effluent.

Results and Discussion

Below Figures shows the Percentage removal of BOD, COD, Chloride, Phosphate, Sulphate, Nitrate with 5 days HRT.

Table (2): Influent characteristics of synthetic waste water

Constituent	Low concentration	High concentration
Nitrate mg/l	52	126.5
Sulphate mg/l	74	89
COD mg/l	320	800
BOD_5 mg/l	24.6	72.64
Phosphate mg/l	70.2	232.6
Chloride mg/l	80	210.4

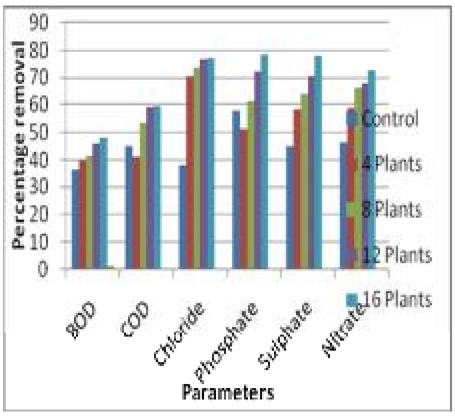

Figure (1): Percentage removal at 5days HRT for low concentrated effluent in floating method

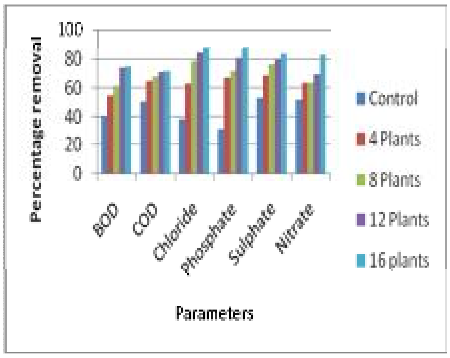

Figure (2): Percentage removal at 5days HRT for High concentrated effluent in floating method

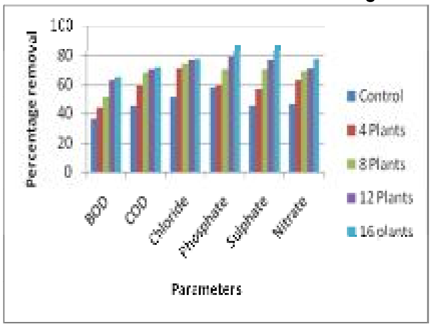

Figure (3): Percentage removal at 5days HRT for low concentrated effluent in Constructed wetland method

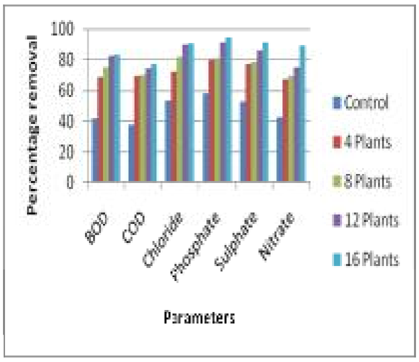

Figure (4): Percentage removal at 5days HRT for High concentrated effluent in Constructed wetland method

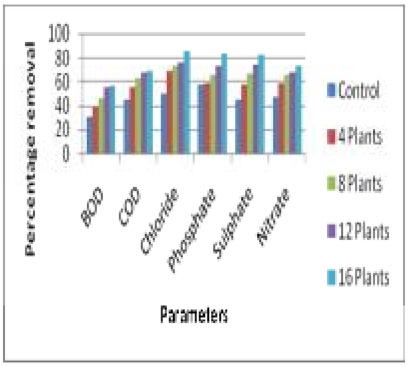

Figure (5): Percentage removal at 5days HRT for low concentrated effluent in Combined method

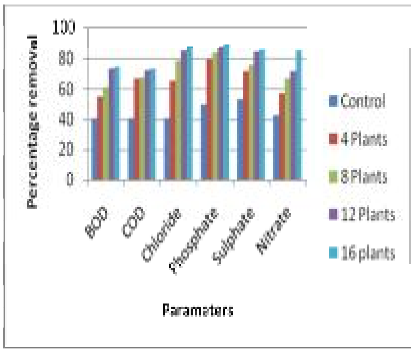

Figure (6): Percentage removal at 5 days HRT for high concentrated effluent in combined method

In the case of combined treatment method BOD, COD Chloride, Phosphate, Sulphate, Nitrate removal of 55.8%, 69.1%,85.5%, 83.0%, 82.7% respectively low concentrated fertilizer industry effluent. But in high concentrated fertilizer industry effluent, BOD, COD Chloride, Phosphate, Sulphate, Nitrate removal as74.8%, 73.38%, 88.27%, 89.29%, 86.15% respectively. Treatment efficiency is increased with increase in number of plants. It was also established that soil-based systems perform better in the treatment of wastewater than both the combined and the hydroponic. Growth rate of plants was more or less same. High growth rate was observed in high concentration waste water than the low concentration waste water. Vetiver is highly suitable for the treatment of industrial wastewater due to its extraordinary attributes such as very high level of tolerance and absorption of pollutants in wastewater, very high water use rate under wetland condition.

Conclusion

The results of the study show that vetiver technology is a useful tool in fertilizer effluent treatment. It is found that vetiver plants have high removal of BOD, COD, Phosphate, Sulphate and Nitrate. Vetiver plant has an excellent ability to grow in all conditions. Treatment efficiency is increased with increase in number of plants. It was also established that soil-based systems perform better in the treatment of wastewater than both the combined and the hydroponic. Growth rate of plants was more or less same. High growth rate was observed in high concentration waste water than the low concentration waste water.

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