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Study on the Filter Media for Constructed Wetlands

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ABSTRACT: The primary treated effluent was treated using constructed wetlands which is highly effective and eco friendly, it uses plants, microbes and gravity to transform wastewater into gardens and reuse water. They use rooted wetland plants (vetiver) and bio-filter to improve the water quality. Bio-filter was developed using organic and inorganic media. Inorganic media include sand and gravel. Organic media includes wood charcoal. Vetiver grass is a versatile hardy plant, deep, fast growing and fibrous root systems and shows good treatment efficiency for contaminants present in the effluent. The different properties of the filter aggregates was analysed and inferred with Environmental Protection Agency (EPA) water treatment manuals filtration. The filter aggregates have macro porosity and allow better regulation of water flow. The main aim of this study was to find out the properties of filter media and the effectiveness of vetiver grass (*Vetiveria zizanioides* L.Nash) in the treatment of wastewaters in constructed wetlands.

KEYWORDS: Primary treated effluent, vetiver, biofilter.

I. INTRODUCTION

About 71 % of the earth's surface is filled with water. But we still have a shortage of water as the amount of usable freshwater is only 1%. The main sources of fresh water are continental rainfall and ground water, but this is insufficient to support the entire world population which is increasing rapidly year by year. Thus the availability of usable freshwater per capita is decreasing day by day. Due to this apportion, the world population experience water stress and water scarcity during a large part of the year.

Along with the natural scarcity of fresh water, the quality of available freshwater is also deteriorating due to pollution from domestic, industrial and due to the disposal of harmful waste into natural waters. The failure of the current sanitation contributes as one of the reasons for water crisis. The use of surface and ground water as a sink for waste water has related in the increase of health hazards and environmental pollution. The major sources of pollutants in developing countries include untreated sewage, domestic wastewater from households and municipal sewage. These contain biodegradable organic matter, inorganic and organic chemicals, toxic substances and disease causing agents.

We need to purify our water sources because along with causing scarcity of drinking water, wastewater consumes oxygen leading to the death of aquatic animals. This wastewater contains nutrients that promote eutrophication by increasing the growth of algae and decreasing biodiversity. Wastewater has a bad odour, contains toxic chemicals and pathogens leading to water-borne diseases. High energy consumption, mechanical components that require heavy investment and high operating cost are the major drawbacks of conventional wastewater treatment plants. They are only suitable for large quantities of wastewater and also require skilled labour. They are mainly used in big cities and developed countries. They are not suitable for developing countries and small communities lacking skilled labour. The most sustainable solutions of wastewater recycling will be passive self-adaptive living systems. One such promising

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technology for wastewater treatment in constructed wetlands. Compared to conventional wastewater systems, constructed wetlands are low cost, easily operated and maintained. They enable the conversion of pollutants to essential nutrients which can be reused for other biological activities.

A constructed wetland is an artificial wetland specifically constructed for the purpose of pollution control and waste management at locations other than existing wetlands. The different components of a wetland include vegetation, hydric soil, substrate, water column, and living organisms. The major processes can occur are microbial activity, plant uptake, biodegradation, phytoaccumulation, photodegradation, cation exchange co-precipitation, sedimentation, sorption and settling. The use of constructed wetlands can be a cost-effective treatment alternative. Typically a constructed wetland should perform better than a natural wetland of equal area because the bottom is usually graded and the hydraulic regime in the system is controlled. Constructed wetlands are designed and constructed to imitate the function of a natural wetland using natural chemicals, physical and biological processes. They are used for the treatment of municipal industrial and agricultural wastewater as well as stormwater to remove pollutants and produce effluent of the quality suitable for reuse or for release into the environment.

II. LITERATURE REVIEW

Arushai Sheoran (2015): A serious problem facing the cities presently is the enormous volume of municipal wastewater discharged per day. Wetlands seem to be a good remedy to this threatening problem. There are two major types of constructed wastewater wetlands-water surface wetland (FWS) and Sub-Surface flow constructed treatment wetlands. The main components of the wetland are wetland vegetation, substrate or media, water and living organisms in the wetland.

Jaya S.Pillai, Vijayan N. (2013): Vertical flow constructed wetland systems planted with indigenous species such as Napier Bajra Hybrid grass and Guinea grass were developed for the treatment and utilization of Greywater for non-potable purposes. The performance of the control and experimental systems were analyzed and compared based on water quality parameters such as Turbidity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Nitrates, Phosphates, and Total Nitrogen (TN). For all the water quality parameters analyzed during the study period, the vertical flow constructed wetland system planted with Napier Bajra Hybrid grass achieved high removal efficiency.

Erina Rahmadyanti, Edy Wiyono (2013): This study helped to understand the efficiency of the use of constructed wetland as a wastewater treatment technology for flats. Plants used in the constructed wetland are often found in East Java, *Typha latifolia*, *Papyrus* and *Iris*. The results showed that all three types of plants have high efficiency in processing the wastewater is above 80 percent. Optimal plant density was 16 plants/m² for all kinds of variations of plants (*Typha latifolia*, *Papyrus*, and *Iris*) and optimal detention time was 5 days.

Madhukar M., Chethan G., Priyanka K. T., Ashwin R. S., Sowmya N. S., Surya (2012): The conventional method to remove the pollutants from water is to pass it through the porous filter media. The common porous media are sand, charcoal, anthracite, activated carbon, etc. The Laterite soil helps in the removal of pollutants with the help of its porous and permeable nature, adsorption and ion exchange capacity. Laterite media was efficient in reducing turbidity by 90% and 92% at 25mL/min flow rate respectively for residential pavement runoff water. Similarly, Total Hardness, Nitrate, Iron and Fluoride was also significantly reduced in both the runoff water.

Dhanya, G*. and Jaya, D.S. (2013): The main aim of the study was to find out the effectiveness of vetiver grass (*Vetiveria zizanioides* L. Nash) in the treatment of wastewaters in constructed wetlands. The results of the study show that more than 50% percentage removal of pollutants especially nutrients after 15 days treatment of wastewaters in constructed wetlands was observed and it showed the efficiency of the vetiver variety for improving the water quality. Even though that wastewater is highly polluted, the plants survived in the harsh environment and it indicated the high tolerance of vetiver grass against the waste water-induced stress. So from the present study, it was evident that vetiver grass is an ideal candidate for wastewater treatment using constructed wetland technology.

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III.METHODOLOGY

According to the hydraulic regime, free water surface wetland (FWS) and sub-surface flow(SSF) constructed wetland are the two types of constructed wastewater wetland. The FWS wetland consist of a basin or a channel with water at relatively shallow depth flowing over the soil and roots of vegetation. For SSF, the water is maintained below the surface of wetland bodies, usually it consists of gravel planted with emergent microphytes. This system can be further categorized into horizontal subsurface flow (HSF) and vertical subsurface flow (VSF). A saturated condition is created in HSF as the flow is usually continuous .while in VSF, the media is completely unsaturated due to intermittent feeding. According to Indian scenario, the availability of land for the treatment of wastewater generated is less, therefore the best suited would be VSF. We have constructed a prototype of VSF with a glass tank of size 0.9m x 0.6m x 0.76m, provided with a bottom slope of 2% for the collection of treated water. The major layer of the constructed wetlands includes wetland vegetation, substrate or media, water column & living organisms.

Wetland vegetation: The plants have an important role in wetlands. They should be able to adapt to waterlogged conditions, local climatic conditions, resistant to high pollutant minerals. They help in releasing oxygen by photosynthesis, reduce the velocity of inflow water thereby improving sedimentation of suspended solids, hydraulic conductivity of substrate and uptake of nutrients. In SSF wetlands, plants interact with wastewater at root zone only. The roots provide large surface area for the growth of microorganisms and bacterial colonies, forming a biofilm which is attached to the surface of substrate articles and roots. The hydraulic conductivity of the substrate is maintained by the root system. The common plants used are Common Reed, Cattail, Bullrush, Vetiver and Heliconia. Vetiver is a native medicinal plant of India. It has fibrous root system and has high resistance to polluted conditions. It has a unique property to grow in harsh conditions and absorb the contaminants leading to bioremediation.



Figure 1. Vetiver grass

Substrate: Substrates for wetlands include laterite soil, sand, gravel etc. Gravel is used as the substrate as it provides a large surface area for biochemical processes. It provide high conductivity which is required to stabilize hydraulic retention time of wetland. Sand is considered as the most suitable substrate in relation to hydraulic and organic loading which is a critical design parameter in SSF. Artificial products substrates like activated carbon are also used to increase the efficiency of wastewater treatment. We have provided 20 cm layers of gravel, sand and soil along with 5 cm of charcoal.

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Water column: Water acts as a medium of transport for organic solids, gases, nutrients etc and helps in the occurrence of biochemical reactions.

Living organisms: Microorganisms such as bacteria, fungi, protozoa play an important role in the treatment of wastewater, due to fixed film or free bacterial development. Biological processes allow the degradation of organic matter, nitrification in aerobic zones and de-nitrification in anaerobic zones.

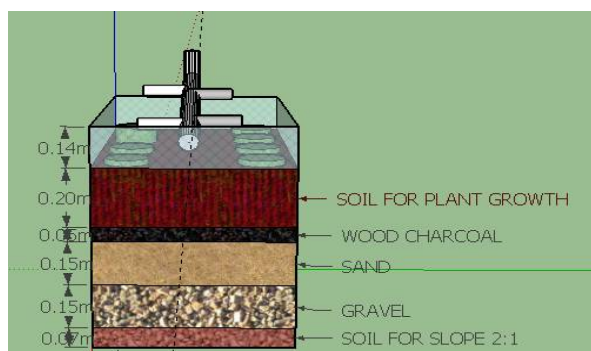


Figure 2.Design of constructed wetland prototype using sketch up software

IV. EXPERIMENTAL RESULTS

The wetland's extended detention hydraulic regime has a major influence on the establishment and persistence of macrophytes within the wetland and therefore play a major role in the sustainability of vegetation cover within the wetland and the ongoing water quality treatment performance of the wetland system. The tank dimensions were therefore designed so as to meet the bioload capacity and the need for greater filtration capacity. Bulk density test for filter media were therefore conducted. The bulk density for 10mm aggregate and 20mm aggregate was obtained as 1656 kg/m³ and 1618 kg/m³ respectively and the bulk density for sand was obtained as 1411 kg/m³. The gravel size in the range 10mm to 20mm was adopted. The vetiver grass was used for the vertical flow type in the treatment of wastewater. Laterite soil was used for the plant growth. Artificial products substrates like activated carbon are also used to increase the efficiency of vertical flow constructed wetlands.

To determine the efficiency of local natural substrates in the treatment of primary effluent, experiments were conducted and results were presented in the following table.

Table 1. Properties of the filter media in constructed wetlands

Sl.No	Test	Gravel	Sand	Inference
1.	Specific gravity	2.42	2.651	According to the EPA water treatment manuals filtration table 1, the specific gravity for gravel is 2.6 and for sand is 2.6. Specific gravity of our sample of gravel was 2.42 which is near to the specified value and for our sample of sand was 2.651 which is equal to the specified value
2.	Permeability (cm/s)	2.6×10^{-2}	7.54×10^{-3}	According to EPA water treatment manuals filtration, the filter media should have good hydraulic conditions (permeable). The hydraulic coefficient obtained for the above sample is 2.6×10^{-2} cm/s and 7.54×10^{-3} cm/s
3.	Sieve analysis		$D_{10}=0.317\text{mm}$	According to EPA water treatment manuals

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