WASTE WATER TREATMENT USING CONSTRUCTED WETLAND WITH COMMON REED

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Abstract

Constructed wetlands have gained much popularity for treating wastewater for small communities as a secondary treatment method for the onsite sanitation system. There are various design configurations that affect the treatment efficiency of constructed wetlands like, the type of vegetation, type of flow pattern and direction, Hydraulic Retention Time (HRT) and type of substrate and pretreatment provided. This study examines the effect/efficiency of different flow direction used in subsurface flow constructed wetland planted with common reed. The model was designed and the experiment was conducted on two subsurface flow reed beds; vertical flow bed, horizontal flow bed and hybrid system in an open-air laboratory receiving pre-treated domestic wastewater with a hydraulic residence time of 5days. The influent wastewater used were poorly treated wastewater which poses high risk to human and environment health. In the vertical flow reed bed, the removal efficiency of COD, BOD, TSS, and TP was 74.9%, 78% and 98% with a HRT of 5days. In the horizontal flow reed bed, the removal efficiency of COD, BOD, TSS, and TP was 67.9%, 74%, % and 97% with a HRT 5 days. It was found that in the hybrid flow system, the removal efficiency of COD, BOD, TSS, and TP was 76.5%, 85%, % and 100% with a HRT of 5days. The final effluent was found to be suitable for non-drinking purposes like crop irrigation and for direct disposal into the environment. The hybrid flow system under a 5-day HRT provided the highest pollution removal efficiency.

Keywords : *Reed plant, wastewater,vertical flow reed bed, horizontal flow reed bed,Hybrid flow system*

1. INTRODUCTION

Constructed wetland is an engineered structure, such as a shallow pond, that harnesses natural ecological processes to breakdown the organic matter present in the wastewater. They contain gravels and sands as the substrate, which are usually planted with aquatic plants like the emergent plant species or floating plant species. As the wastewater is fed to the wetland it passes through the filtering medium such as sand and gravels. This results in the growth of thin film of bacteria on the surface of the media particles and around the root systems of the aquatic plant and treatment by the various processes of sedimentation, filtration, oxidation, reduction, adsorption, precipitation, bacterial metabolism, nitrification, denitrification, and plant uptake (UN-HABITAT, 2008).

There are two basic types of constructed wetland namely; free water surface flow (FSF) constructed wetland in which the flow of water is above the sediment surface, and subsurface flow (SSF) con-structed wetland in which the flow of water is primarily below the sediment surface and emergent aquatic plants are planted on top of the media. Unlike surface flow wetland system this system is not exposed during the treatment process, minimizing the risk associated with human exposure to pathogenic organisms (Shrestha R., September, 2007). SSF constructed wetland are relatively low cost construction with high BOD and TSS performance for small and medium installation. SSF discourages odor and mosquitoes breeding (Reed & Brown, 1995).

The SSF constructed wetland is further classified into horizontal subsurface flow bed (HFB) and vertical subsurface flow bed (VFB). In HFBs the wastewater flows slowly through the porous medium under the surface of the bed in a horizontal path until it reaches the outlet zone. In VFBs wastewater is intermittently pumped onto the surface and then drains vertically down through the filter layer towards a drainage system at the bottom. Hybrid systems are a combination of both horizontal sub-surface flow and vertical sub-surface flow in order to achieve treatment efficiencies. The study investigated the efficiency of the aforementioned VFB, HFB and hybrid flow system planted with emergent plant, the common reed with a HRT of 5days.

2. MATERIALS AND METHODS

The laboratory scale constructed wetland with subsurface flow with common reeds (Phragmites Karka) were setup at the hydraulics lab under the Civil Engineering Department, College of Science and Technology. Reeds will grow best if the reed bed is situated in a sunny location (Households, 2003).

2.1 Construction of Reed Bed Models

The reed beds with horizontal and vertical subsurface flow filled with substrate enables the growth of reed plants and biofilm of micro-organisms. The wastewater in the root zone of constructed wetland undergo series of physical, chemical and biological process including sedimentation, filtration, biological degradation, adsorption and nutrient uptake. This process results in significant reduction in suspended solids, organic compounds (Brix,2004).

The network of roots and rhizomes maintain a high biological activity in the constructed wetland and the hollow vessels in the plant tissues enable oxygen to be transported from the leaves to the root zone and surrounding soil (Armstrong and Beckett, 1990). This allows the active microbial aerobic decomposition process and uptake of pollutants from the water system to take place. The size of media used in HF reed bed varies from 0.2mm to 30mm. The media in the outlet zones used were 40-80mm in diameter to minimize clogging and extended from the top to bottom of the system (Vymazal, 1997). For the VF reed bed the filter media used was sand (0 – 4 mm) as main substrate with d10>0.3 mm, d60/d10<4 and having permeability of 10-3 to 10-4 m/s with the retention time of 5 days.

In the vertical flow reed bed the larger aggregates of size 20-40mm were placed at the bottom of the bed with a thickness of 5cm. This was overlaid with 5-10mm aggregates with a layer thickness of 5cm and 1-4mm size sand over the aggregate layer. The thickness of the sand layer used was 20cm and the top layer was covered with

5-10mm sized aggregate of 5cm thickness as shown in Fig 1. The perforated pipes were used to distribute the sewage uniformly over the bed materials and the sewage travels from top to the bottom of the bed during the treatment process in the vertical flow.

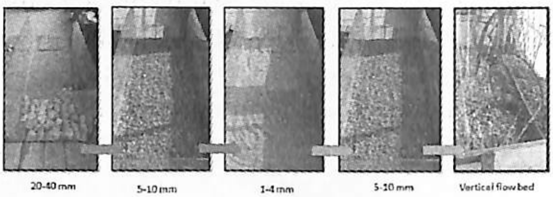

Fig. 1 Laying of substrate for vertical flow reed bed

In the horizontal bed the larger aggregates of size 40-80mm were placed at the two ends of the bed to 25cm thickness to reduce the clogging at the inlet and outlet. The extreme two sections cover a length of 15cm each from both the end. In between this two sections is the 5-10mm aggregate laid to a thickness of 25cm. The reed plants are planted within the middle portion of the bed within the 5-10mm aggregate as shown in Fig 2. During the experiment it was observed that the reed plants planted in these layers started wilting. Inorder to prevent further wilting, sand humps were laid around the reed plants to facilite its growth and observed better growth of the plants through such measures.For the horizontal reed bed the beds were inclined to facilitae the movement of the sewage. The raw sewage was introduced from the top end of the inlet and the sewage flow took place from top end to the other down end of the outlet.

Fig. 2 Laying of Substrate in horizontal flow reed bed

For the hybrid flow system both the vertical flow reed bed and the horizontal flow reed bed were used. In this system the wastewater was first passed through the vertical flow reed bed and then through the horizontal flow reed bed as shown in Fig 3.

Fig. 3 Arrangement of reed beds

3. RESULTS AND DISCUSSION

3.1 Influent Wastewater Characterization

The pre-treated domestic wastewater from the existing onsite sanitation system to the modeled reed beds was characterized as shown in Table 1.

Table 1. Influent Wastewater Characteristics

Sl. No	Parameter	Concentration in mg/l
1	BOD	100
2	COD	72.2
3	Suspended Solids (SS)	400
4	Phosphates	19.75

3.2 Performance level of different Reed Beds

The average Treatment Performance of different reed beds are given in Table 2 and Fig.4.

Table 2. Treatment performance of constructed wetlands

Sl. No	Parameter	Concentration in mg/l		
		Horizontal	Vertical	Hybrid
1	BOD	26	22	12
2	COD	23.142	18.062	16.92
3	SS	200	200	-
4	Phosphates	0.585	0.321	0.718

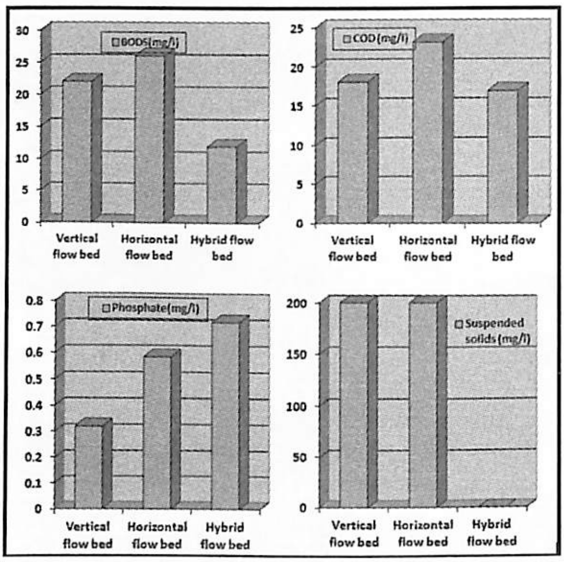

Fig. 4 Graphical performance represention of beds

From the above test results for HRT of 5 days the vertical flow reed bed indicated the removal effi-ciency of COD, BOD, TSS, and TP as 74.9%, 78%, % and 98%, the horizontal flow reed bed indicated the removal efficiency of COD, BOD, TSS, and TP as 67.9%, 74%, % and 97% respectively. Further the hybrid flow system indicated the removal efficiency of COD, BOD, TSS, and TP as 76.5%, 85%, % and 100%.

4. CONCLUSION

The subsurface flow constructed wetland planted with common reed was found to effectively remove BOD, COD, SS and TP if managed properly to reduce the risk of pollution and contamination of environment. Comparison between vertical and horizontal flow reed bed has indiacted both almost give the same results, However from the economic consideration and practical difficulties it was found it will be effective to install vertical flow reed bed Based on the result the hybrid flow system with the combined advantages of vertical and horizontal flow reed bed was observed to have highest pollution removal efficiency. The study indicated for effective treatment use of sewage from the septic tank provided results compared to the sewage sample before the septic tank therefore pretreated (effluent from septic tank) influent for the reed bed is recommended.

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