

PERFORMANCE STUDY OF CONSTRUCTED WETLANDS IN TREATING DOMESTIC WASTEWATER

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Introduction

Constructed wetland systems for wastewater treatment have been proven to be moderately efficient and have become a widely use technology recently in many parts of the world due to its advantages over the conventional systems such as low cost, low energy requirement and simplicity in operation & maintenance. Although it has a strong potential for application in developing countries in tropical regions it is not yet widely spread due to lack of information (Jinadasa et al., 2006).

This paper investigates the performance of vertical subsurface flow, horizontal subsurface flow and free surface flow constructed wetlands with varying hydraulic retention times in tropical condition. More attention is given to examine the fecal and total coliform removal efficiencies of the above three types of constructed wetlands.

Materials and Methodology

This study was carried out using three wetland models of size 5m x 1m x 0.6 m located in University of Peradeniya, Peradeniya. The system was modified to receive wastewater from Akbar hall of student residence. The first model was arranged as a free surface flow constructed wetland (FWFS), the second one was arranged as a vertical flow constructed wetland (VFS) and the third one was arranged as a

horizontal flow constructed wetland (HFS). 10 – 20 mm gravel was used as the wetland media of each system, and the plant bed was comprised with a surface layer (0.1m depth) of soil (<5mm particle size) to support the wetlands vegetation. All three wetland systems were planted with an emergent plant specie cattail (*typha angustifolia*) rhizomes. Wastewater was fed continuously to the models in a constant hydraulic retention time (HRT) for a three week period and then the flow was changed to a new hydraulic retention time (HRT). The samples were collected periodically from the influent and effluents of each wetland system at the start and the end of the each hydraulic retention time(HRT). All the samples were analyzed for five day Biochemical Oxygen Demand (BOD₅), Fecal Coliform and Total Coliform following standard methods of water and wastewater analysis.

Results

The concentrations (con) and removal efficiencies of BOD₅, fecal and total coliforms are tabulated in **Table 1**. The BOD₅ removal efficiencies are illustrated in the **Fig. 1**. The fecal coliform and total coliform removal efficiencies are illustrated in **Fig. 2** and **Fig. 3** respectively.

Table 1. Removal efficiencies of constructed wetland svstems

Parameter	HRT (day)	Influent		Effluents		Flow		free surface	
		Con.	RE%	Horizontal Flow constructed wetland	RE%	Vertical constructed wetland	RE%	flow constructed wetland	RE%
BOD ₅ (mg/L)	5.0	25.7		2.1	90.4	1.2	95.6	2.2	91.1
	2.0	14.7		5.8	60.4	2.2	84.8	4.8	67.2
Fecal coliform (10 ³ CFU/100ml)	5.0	469		226	56.3	144.5	72.4	83	84.0
	2.0	1069		63.7	90.5	125.3	79.4	49.7	91.2
Total coliform (10 ³ CFU/100ml)	5.0	706		304.5	57.6	139	65.2	287.5	58.6
	2.0	771.7		65	79.6	247	79.2	39	88.0

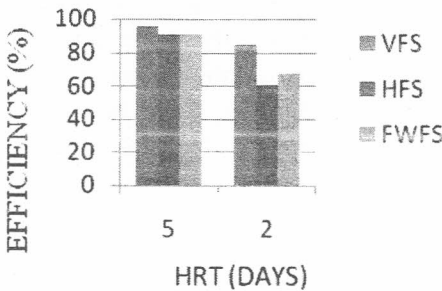


Fig. 1. Removal efficiency of BOD₅

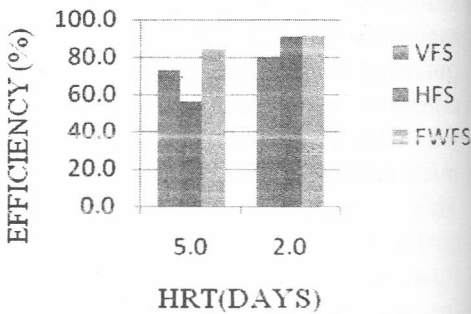


Fig.3 Removal efficiency of total coliform

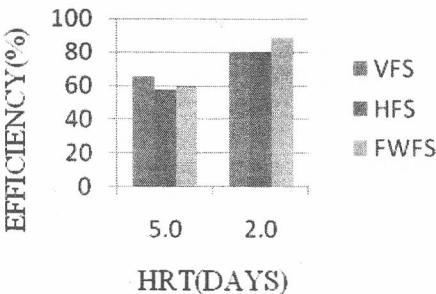


Fig. 2. Removal efficiency of fecal coliform

Discussion

Fig.1 shows, a higher removal of BOD₅ has taken place in vertical flow wetland model in both 5 and 2days HRT. The reason behind this might be due to the higher oxygen availability in the system as wastewater is applied to the vertical flow model by sprinkling and hence there is a higher possibility of adding oxygen to the wastewater. It is noted that the BOD₅ removal efficiency is higher with the five days HRT than the two days HRT in all three models. . It also satisfies the first order plug flow biokinetic model equation. The BOD₅

removal efficiencies of vertical subsurface flow, horizontal subsurface flow and free water surface flow wetland models are ranged between 60.6% – 95.6%.

The higher removal efficiency of fecal coliform is achieved by free water surface model at 5 days HRT and it is little less at 2 days HRT than VFS. The free water surface flow has the high potential to have ultra violet degradation (Sundaravadivel et al., 2001) and it might be the reason for the higher fecal removal in FWFS wetland model than other two systems. At 2 days retention time, both vertical subsurface flow and horizontal subsurface flow wetland models have given equal removal efficiencies, while at 5 days HRT vertical flow system shows better removal efficiency.

Higher total coliform removal efficiency is achieved in the FWF system at both 5 days and 2 days HRTs might be due to the same reasons as mentioned above. All the wetland models showed total coliform removal efficiencies between 56.1% and 91.6%. However, in contrast, the results show that there is a significant increase in both fecal coliform and total coliform removal efficiencies at 2 days HRT than 5 days HRT. This might happened with the maturity of the system.

Removal of fecal and total coliform levels indicates that all these systems are capable for about one- or two-log reduction with sufficient HRT. However, in most cases this reduction will not be sufficient to reach the commonly applied limit of 200/100 ml, so some form of final disinfection may be necessary to satisfy the effluent standard.

Conclusion

Wetland systems can treat domestic wastewater effectively at tropical conditions including total and fecal coliforms. Although the efficiencies were not much significant, vertical subsurface flow constructed wetlands perform better in BOD₅ removal compared to the horizontal subsurface flow or free surface flow constructed wetlands. However, the free surface flow system performs well in removing fecal and total coliforms.

References

- Sundaravadivel M. and Vigneswaran. S. "Constructed wetlands for wastewater treatment". *J. Critical Reviews in Environmental Science and Technology*, 31(4), 351 (2001).
- Jinadasa K. B. S. N., Tanaka N. , Mowjood M. I. M. and Werellagama D. R. I. B, "Free water surface constructed wetlands for domestic wastewater treatment: A tropical case study" *Chemistry and Ecology* Vol. 22, No. 3, June 2006, 181–191