Performance study on reed bed wastewater treatment units in Nepal

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Abstract

Constructed wetland, being simple in construction and maintenance and operation, is a biological system, which applies the interaction between media, plants, wastewater and microorganisms during the degradation of pollutants found in the wastewater. A subsurface horizontal bed followed by vertical bed system using with local reeds (Phragmites Karka spp) is popular. The current status of reed bed wastewater treatment units (RBWTUs) in Nepal consists of eleven such units with capacity ranging from 0.5 to 115 m^3/d in operation. This study was carried on two existing operating treatment plants, which have operated for 1 and 5 years. The objective of the study was to evaluate the removal performance of pollutants as TSS, organic matter, nutrients and faecal coliform. The organic matter removal performance was varied from 86 to 93 %, consisting the effluent Chemical Oxygen Demand (COD) concentrations of 20 to 38 mg/L depending on organic loading rate and age of wetland. Also nutrient removal efficiency was satisfactory. The removal performance of faecal coliform was 98.3 %.

Keywords: Performance study, constructed wetland, Nepal, reed bed, subsurface flow system

Introduction

One of the commonly found environmental problems in developing countries is water pollution caused by direct disposal of untreated wastewater. In Nepal, most of the centrally collected wastewater treatment plants are not functioning due to high cost of spare parts, chemical additives, utility bills and lack off trained human resources. These financial and managerial problems are common in every developing country.

Constructed wetland (CW) is a biological wastewater treatment technology designed to mimic processes found in natural wetland ecosystems. The basic mechanism of organic matter degradation in constructed wetlands is plant bacterial symbiotic reactions, in which gaseous oxygen photosynthetically produced or taken up for respiration by the plant is used by aerobic and facultative bacteria (Polprasert et al., 1998). Since the end of 1980, this system has been using widely in the world. In Europe, 5000 CWs are operating, designed for populations less than 500 (IWA, 2000, cited by Yoon, C. G. et al, 2001).

A subsurface horizontal bed followed by vertical bed system using local reeds (*Phragmites Karka spp)* is popular in Nepal. These systems are called reed bed wastewater treatment units (RBWTUs). The current status of RBWTUs in Nepal consists of eleven such units with a capacity of 0.5 to 115 m^3/d in operation and one system in the design phase (Shrestha, et.al. 2003). Further research study is becoming essential due to the rising trend of adopting constructed wetland for wastewater treatment. The objective of the study aimed to evaluate the removal performance of pollutants as TSS, organic matter, nutrients and faecal coliform.

Material and Methods

Description of constructed wetland units*:* The study was carried out on two full-scale domestic wastewater treatment units comprised of CWs owned by the Kathmandu University (KU) and Dhulikhel Hospital (DH). These treatment units of KU and DH were in operation for 7 months and 5 years, respectively. Both units consist of a settling tank and a combination of horizontal flow bed (HFB) and vertical flow bed (VFB) constructed wetlands. The details are presented in Table 1.

Table 1: Description of the treatment plant components

Component	Kathmandu University		Dhulikhel Hospital	
	Dimension L B W(m)	HRT (days)	Dimension L B W(m)	HRT (days)
Septic Tank	7.8 x 4.8 x1.2	2.2	3x1.5x2.75	0.29
Horizontal flow bed	27x8x0.6	1.03	20x7x0.6	0.44
Vertical flow bed	11x11x1.05	-	12x12x1.05	-

The porosity of supporting media in HFB was found to be 39 % and their construction detail is shown in Fig.1. The cross section of VFBs is made trapezoidal as HFB and support media consists of coarse sand with a porosity of 37 %.

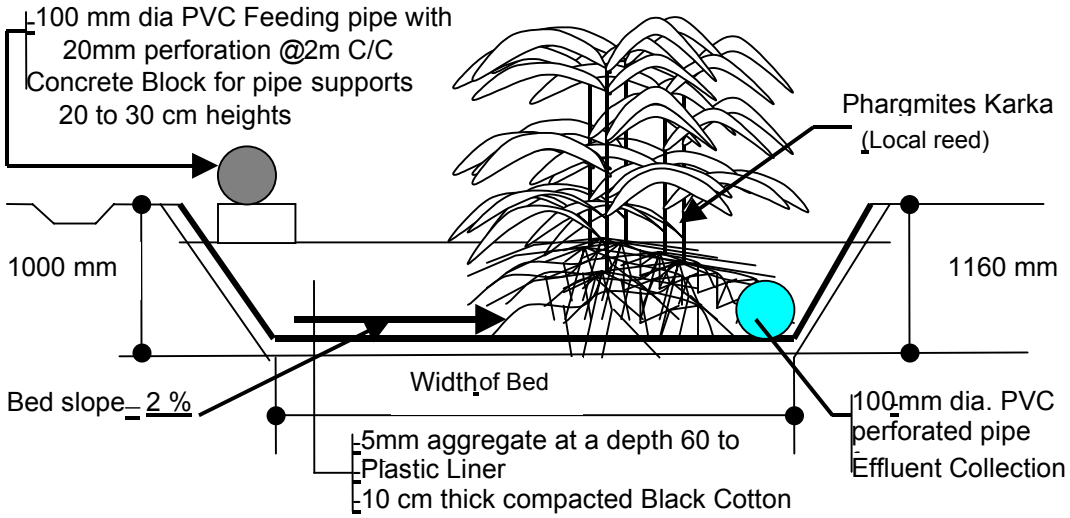

Fig. 1: Typical cross section of HFB

Operating conditions: The average value of the influent chemical oxygen demand (COD) in KU and DH were found to be 311 and 262 mg/L, respectively. Similarly, the average concentration of the influent ammonia-nitrogen in KU and DH were 33 and 42 mg/L, respectively. The average organic loading rate in KU and DH were 121 and 381 Kg. BOD_5/ha.d. The average flow of wastewater in KU and DH were 16 and 34 m^3/day, respectively.

Analytical procedure: The study was carried on four cycles for 7 months in two wetlands. The COD and ammonia were analyzed according to Standard Methods for the Examination of Water and Wastewater (APHA, AWWA and WPCF, 1993).

Results and Discussion

Efficiency of active media in HFB: Efficiency of active media volume in HFB of the DH was determined by measuring the depth of wastewater (WW) retained at different distance in HFB, which is shown in Fig. 2. WW retained volume of media was found to be 41.1 m^3, where the total media volume was 91.8 m^3 in HFB. The result showed that only 44 % of the media volume of HFB was used for pollutant degradation.

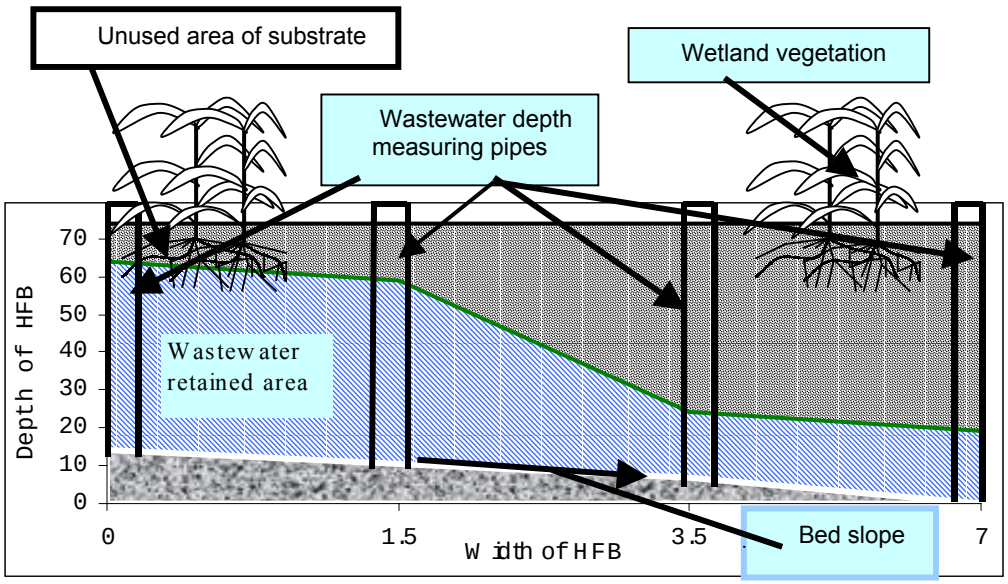

Fig. 2: Active media utilization in HFB wetland of the Dhulikhel Hospital

***Removal performance**:* The average concentrations of COD, ammonia-nitrogen (NH_3-N), total nitrogen (except organic form), orthophosphate- phosphorous (PO_4^{-3}), total suspended solid and faecal coliform in the inlet and outlet form the reed bed treatment units of KU and DH, are presented in Table 2. The average hydraulic loading rate of primary treated wastewater at wetlands of KU and DH was of 4.8 and 12 cm/day respectively. The mean organic matter removal efficiency in wetlands of DH and KU was observed to be 85 and 93 % respectively. These results are well supported by the findings of Juwarker et.al. (1985), who found 78 to 90 % organic matter removal in a reed bed.

Ammonia- nitrogen and total nitrogen removal efficiency in the reed beds of KU were found to be 86 and 58 % respectively. Similarly, in the wetland of DH, ammonia- nitrogen and total nitrogen removal efficiency were observed to be 61 and 33 % respectively. Gersberg et. al., (1986) reported nitrogen removal to the extent of 28 to 91 % in the constructed wetland. Total suspended solid (TSS) removal was excellent in the both wetlands. Orthophosphate-phosphorous concentration in the outlet of KU was reduced from 8 to 2 mg/L.

Table 2: Removal performance of pollutants

Parameters	Kathmandu University			Dhulikhel Hospital		
	Influent (mg/L)	Effluent (mg/L)	Efficiency (%)	Influent (mg/L)	Effluent (mg/L)	Efficiency (%)
COD	258	20	93	244	38	85
NH_3-N	42	6	86	33	13	61
Nitrogen	43	18	58	36	24	33
PO_4^{-3}-P	8	2	75	-	-	-
TSS	108	4	96	91	5	95
Faecal Coliform	-	-	-	179+5E (no.cell/100 mL)	3+5E (no.cell/100 mL)	98.3

Conclusion

The experimental data revealed that the actual substrate utilization volume of HFB of DH was observed to be 44 % by the lack off appropriate position of inlets and outlets.

The result showed that reed beds had high tolerating capacity on the hydraulic loading rate with respect to the age of wetlands and produced an effluent with COD, ammonia-nitrogen, total nitrogen, orthophosphate-phosphorous and TSS content of 38 to 20 mg/L, 6 to 13 mg/L, 18 to 24 mg/L and 4 to 5 mg/L respectively. The constructed wetland, being simple in construction, maintenance and operation and efficient removal performance of pollutants can be adopted in small towns, institutions, individual household and villages.

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