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TERTIARY TREATMENT IN A VERTICAL FLOW REED BED SYSTEM

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Key words :

ABSTRACT

A constructed wetland having vertical flow bed reed bed system (Gravel/sand) was chosen as a treatment plant for tertiary treatment of domestic waste. The surface of the vertical flow pilot plant amounts to 0. 60 m^2 and depth of bed is about 0.60 m. The application of the conventional plant effluent is carried out in intermittent flushes. Final nitrification and partial de-nitrification and elimination of phosphorus are the main goals to be achieved. In the framework of the present research work the efficiency and operational reliability will be determined by loading the different kind of secondary effluent. Results, of the study indicate that NH_4-N removal efficiency of 97% to 99%, COD removal efficiency of 50 – 60 % and phosphate removal efficiency of 60 - 73 % can be achieved using the constructed wetland.

INTRODUCTION

Constructed wetlands in combination with a conventional treatment plant represent a combined system which should guarantee a final purification of nutrients especially to satisfy stringent effluent standards with respect to small receiving watercourses. However, with the increasing use of constructed wetlands in a commercial environment, questions of reliability have become of great importance as constructed wetlands are compared to competing technologies. Reliable performance has been a key requirement of reed bed systems, especially in the tertiary treatment applications where tight standards have been imposed. Especially vertical flow system require careful construction and media selection (Brix, 1994). The research work aims at investigating the process performance and reliability of vertical flow reed bed constructed wetlands in polishing the secondary effluent from the conventional treatment plants.

MATERIALS AND METHODS

Experimental : Laboratory scale unit with an area of 0.6 m^2 (1.0m X 0.6m) and total height of 0.6m was used for the experiments. The unit was filled with several gravel layers (listed fro the bottom layer to the top one respectively): 3 cm of particle size : 1.0 - 2.5 cm, 10 cm of particle size of 0.4 - 0.6 cm, 10 cm of particle size of ; 0.25-0.4 cm followed by 10 cm of coarse sand at the top of the unit. A drainage pipe with control valve is provided at the bottom of the tank.

Feeding solution : The experimental unit was fed with

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secondary effluents from different units (1- from an activated sludge unit of milk processing plant, 2- from an activated sludge unit of hospital, 3- from a trickling filter unit of hospital, and 4- from a bio-filter unit of canteen). Inflow flow rate varied between 10 to 40 $l/m^2/h$

The application of the conventional plant effluent on the bed is carried out in intermittent flushes. The distribution system consists of high-grade PVC pipes with down sided holes which lie some 15 cm above ground. The pattern of the distribution points is designed symmetrically and proportionally to get an even distribution over the whole area. Dashed plates in the outlet zones are supposed to avoid erosion of the filter material. The drainage of the wetland system is constructed as a gravel layer over the whole bottom area. The effluent discharges by drainage pipes.

The operating efficiency of the vertical flow bed system mainly depends on the volume available for the organic metabolism process and on the retention and aeration time. Final nitrification and subsequently de-nitrification as well as the elimination of phosphorous are the goals to be achieved.

Analysis : All analyses were carried out as per standard procedures reported by APHA (APHA, 1989).

RESULTS AND DICUSSION

BOD_5 and COD- Removal : Although both BOD_5 and COD were measured, the removal of COD is described because the low basic influent reported to have a BOD_5 concentration in the range of 2 - 9 mg/L only. The influent COD level varied between 40 to 235 mg/L. The COD removal efficiency of about 50 - 60 % was achieved. As an overview, the average effluent values of different waste were compared. A slight decrease in COD removal efficiency is noted for the sample having higher NH_4- N. This may be due to the competition of O_2 for nitrification and oxidization.

Ammonium(NH4-N) removal : The predominant removal mechanism for ammonium in vertical flow wetlands is nitrification to nitrite (NO_2) and nitrate (NO_3) and subsequent de-nitrification of NO3 to nitrogenous gas products (Brix, 1993 ; Reed, 1993).

NH_4-N Concentration in the conventional plant effluent was low. The corresponding effluent concentrations of the vertical flow bed showed a very constant trend which is almost zero mg/L (Table 2). Due to the low basic inflow concentrations it was not possible to find out any influence of the vertical flow bed on the NH_4-N removal rate.

Table 1 Average COD Removal Efficiency

Source of secondary effluent	Influent(mg/L)	Effluent(mg/L)	Removal efficiency (%)
Milk processing unit.	41.63	16.3	60.85
Hospital[activated sludge process]	71.5	28.7	59.87
Hospital{trickling filter}	174.3	85.93	51.85
Canteen	233.00	99.56	57.27

Table 2 Average NH4-N Removal Efficiency

Source of secondary effluent	Influent (mg/L)	Effluent (mg/L)	Removal efficiency (%)
Milk processing unit.	7.3	0.2	97.26
Hospital[activated sludge process]	4.5	0.03	99.33
Hospital{trickling filter}	8.5	0.2	97.65
Canteen	33	0.84	97.45

Table 3. Average PO_4-P removal efficiency

Source of secondary effluent	Influent (mg/L)	Effluent(mg/L)	Removal efficiency (%)
Milk processing unit.	2.3	0.9	60.86
Hospital(activated sludge process)	1.18	0.31	73.76
Hospital{trickling filter}	1.12	0.36	67.87
Canteen	2.7	0.94	65.18

The effect of unsaturated zone is an important component in the enhancement of ammonium removal in this pilot-scale study. The unsaturated zone is effective at passively introducing oxygen in to gravel substratum and in to waste supporting nitrifier activity (this effect is studied in the process of nitrification in constructed wetlands having vertical flow).

Phosphate (PO_4-P) removal: In all the secondary effluents (feeding solutions) the phosphate concentrations were between .06 to 0.86 mg/L. In this operation a PO_4-P removal efficiency of about 60 to 73% was achieved.

In general, in a constructed wetland phosphorus accumulates in plants and sediments, until both are saturated. Reduction of more than 60 % have been reported by Perfler and Haberl (1992) and more than 90% by Willadsen *et al*. (1990). Instance of apparent increase in phosphate have also been reported (Willadsen *et al*. 1990). These discrepancies are indicative of the difficulties in ensuring phosphate reduction. Unlike total nitrogen reduction where gaseous nitrogen is lost from the system the phosphate is stored within the bed media or the reeds. Although release of phosphate cannot increase the overall phosphate in the effluent compared to the influent in long terms, at any given time the phosphate in the effluent can be greater than in the influent (Paul Cooper, *et al*. 1997). The ultimate capacity of the reed beds to store phosphate is limited not only by the concentration of suitable metal ions but also by the available surface area (Combes and Collett, 1995).

CONCLUSION

A study was conducted to on the application of the constructed wetland having a vertical flow reed bed system on treating residual COD, nitrogen and phosphorus. COD was effectively removed with removal efficiency ranging from 50 to 60 % in tertiary treatment system. The ammonium removal efficiency was determined to be in the range of 97 to 99 %: and PO_4-P reduction was found to be 60 to 73 %. The results of the study indicate that, the removal process can be significantly accelerated in vertical flow systems. In the present investigation, the hydraulic loading rates and time interval of intermittent flushes were kept constant. The hydraulic loading rate was fixed at 1 litre/minute/m2 and time interval of flushing was 2 hours. The effect of the hydraulic loading rate and time interval of flushing to an even more economical level will be further investigated.

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