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Variations of Chemical Pollutant Indexes in Constructed Wetlands of Different Hydraulic Loading Rates

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The secondary effluent of wastewater treatment plants in Tangshan area was used for this study. Constructed wetland was carried out for treatment. Hydraulic loading rate was the parameters for analyzing the removal efficiency of pollutants from the secondary effluent of wastewater treatment plant. Zeolite and limestone wetlands showed different behaviors for nitrogen and phosphorus removals. Meanwhile, the optimum hydraulic loading rate was testified as 0.093m^3/(m^{2}d).

Key Words: Constructed wetland, Hydraulic loading rate, Zeolite and limestone, Nitrogen and phosphorus removals.

INTRODUCTION

Secondary effluent of wastewater treatment plants is further treated exiguously. In most instances, the effluent is direct discharge to rivers and it will bring about river pollutions marginally. Thus, the secondary effluent of wastewater treatment plants is necessary to be treated to reduce any possible impacts on rivers.

Constructed wetlands (CWs) for wastewater treatment have been extensively applied in many fields, including municipal wastewater[1], ground surface polluted water[2], farm dairy wastewater[3], oilfield drainage[4] and eutrophic aquaculture wastewater[5]. Constructed wetlands is an aquatic ecosystem mainly composed of plants, microbes and substrate. With the coordination of these components, the constructed wetlands can work smoothly and achieve optimum purification capability[6-11]. Hydraulic loading rate, a key operational condition of constructed wetlands, has a significant effect on chemical pollutant removals. This study focuses on using horizontal subsurface flow constructed wetlands for treating mico-polluted water on the variations of chemical pollutant concentration with the hydraulic loading rates.

EXPERIMENTAL

Experimental system: The experiment took place in a laboratory with a controlled environment in Tangshan of P.R. China. The experimental system consisted of two 1 m^2 wetland mesocosms (1.6 m long × 0.6 m large × 0.6 m deep). Gravel, a particle diameter of 15-25 mm, was laid at the bottom of system and the depth was 0.10 m. Zeolite and limestone were laid at the middle layer, respectively. Both of particle diameters were 6-10 mm and and the depth was 0.20 m. The upper beds were consisted of lytag of a depth of 0.15 m and the particle diameter was 3-5 mm. The sieving soils were laid at the uppermost layer and the depth was 0.05 m. Phragmites and reed mace were planted in the soils. In the meanwhile, the interplanting ratio of plants was 1:1. Meanwhile, the zeolite wetland and limestone wetland would be represented by ZW and LW, respectively. The schematic diagram of main apparatus is shown in Fig. 1.

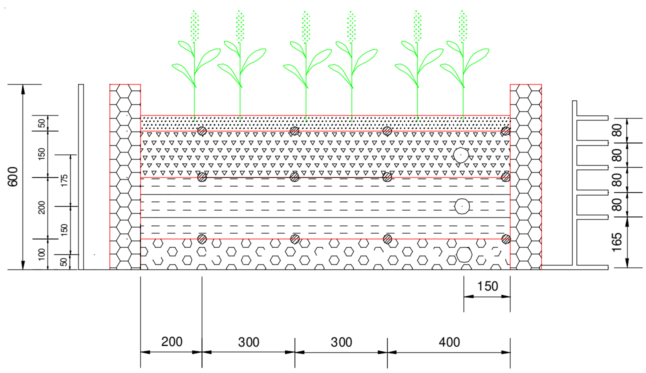

Fig. 1. Schematic diagram of the constructed wetland

Analytical methods: Parameters such as soluble NH_3-N, total nitrogen (TN), PO_4^{3-}-P and total phosphorus (TP) pH were monitored. Samples were collected once everyday when steady state conditions were achieved. In this experiment, intermittent flow was adapted in both of the systems and they continuously run for 25 days and 5 days is one cycle, namely, the hydraulic loading rates were 0.278, 0.139, 0.093, 0.070 $m^3/(m^2d)$ and 0.056 $m^3/(m^2$ d), respectively. In addition, the optimum hydraulic loading was ensured according to the average removals of nitrogen and phosphorus under different hydraulic loading rates.

Influent quality: The raw wastewater, secondary effluent of wastewater treatment plants, was collected from wastewater treatment plant in Tangshan. The composition of the influent used in all experiments is shown in Table-1.

TABLE-1
CHARACTERISTICS OF THE WASTEWATER SAMPLE USED IN THE EXPERIMENTS

Parameter	Concentration
pH	6.5-8.0
Ammonia nitrogen (NH_3-N) (mg L^{-1})	24.5-32.7
Total nitrogen (TN) (mg L^{-1})	37.7-45.1
Orthophosphate (PO_4^{3-}-P) (mg L^{-1})	4.2-4.7
Total phosphorus (TP) (mg L^{-1})	4.5-5.0

RESULTS AND DISCUSSION

Removal of nitrogen: Fig. 2 shows the removals of ammonia nitrogen *versus* hydraulic loading at various constructed wetlands. The removals of ammonia nitrogen in zeolite and limestone wetlands were obvious under the different hydraulic loading rates. The effluent average concentration of zeolite wetland was 2.5 mg/L and the removal rate was more than 90 %. The zeolite wetland indicated the better removal effect than limestone wetland on an equal footing. Under the continuous running, the removals of ammonia nitrogen decreased slightly while the hydraulic loading was 0.093 m/d.

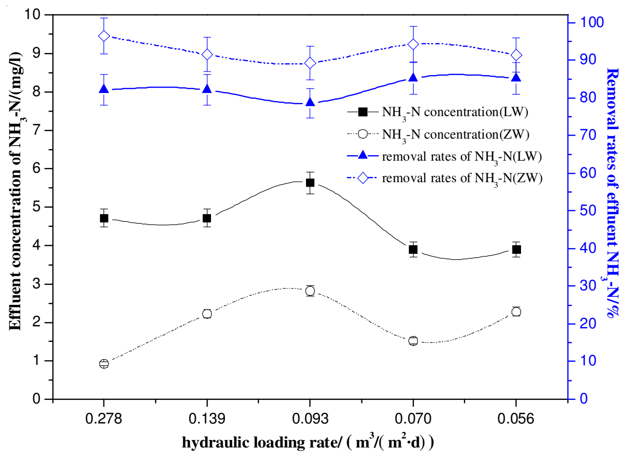

Fig. 2. Removal effect on ammonia nitrogen in every wetland under various hydraulic loading

Fig. 3, shows the removals of total nitrogen *versus* hydraulic loading at various constructed wetlands. The removals of zeolite wetland decreased generally with the hydraulic loading. The maximum concentration of effluent was 9.58 mg/L while the minimum 1.56 mg/L. And the range of removal rates was 66.1 %-94.5 %. On the contrary the removals of limestone wetland increased generally with the hydraulic loading, when the hydraulic loading decreased to 0.093 m/d, the removal rates increased slightly. And the range of effluent concentration was 4.31-10.96 mg/L, the range of removal rates was 61.2 %-84.7 %.

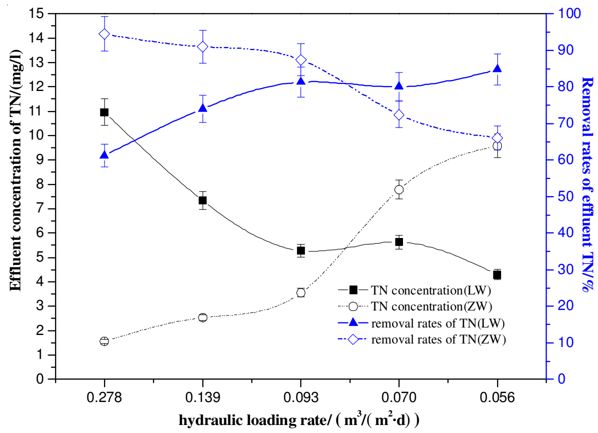

Fig. 3. Removal effect on total nitrogen in every wetland under various hydraulic loading

Removal of phosphorus: As shown in Fig. 4 and Fig. 5, the phosphorus removals of zeolite and limestone wetlands were poor, the range of PO_4^{3-}-P removal rates was 10.8-40.2 % while total phosphorus 20-43.2 %. Moreover, under the continuous running, both the wetland showed the character that the removal rates were increased at first and decreased subsequently. Namely, the phosphorus removal effects of two wetlands were optimum when the hydraulic loading was 0.093 m/d.

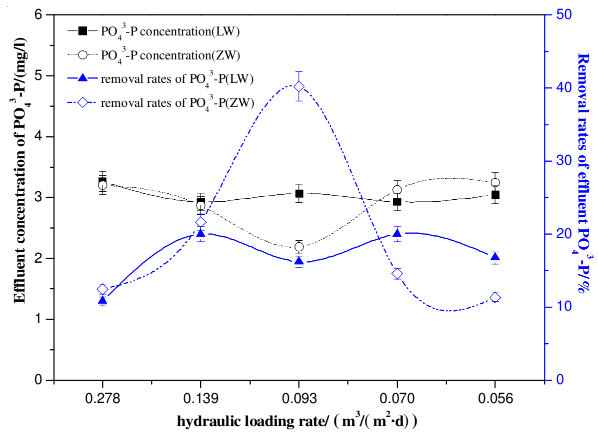

Fig. 4. Removal effect on orthophosphates in every wetland under various hydraulic loading

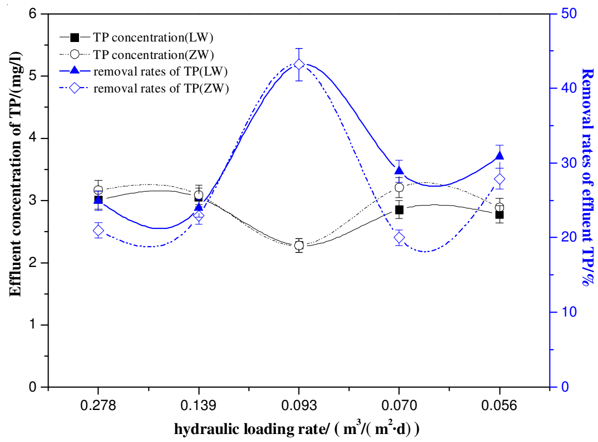

Fig. 5. Removal effect on total phosphorus in every wetland under various hydraulic loading

Conclusion

According to the above-mentioned results, when system inffluent was secondary effluent of wastewater treatment plants, the zeolite and limestone wetlands showed different behaviors for nitrogen and phosphorus removals. In addition, the optimum hydraulic loading rate was testified as 0.093 $m^3/(m^2d)$.

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