Asian Journal of Chemistry; Vol. 25, No. 5 (2013), 2703-2705

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2013.13693

Effect of Vertical Subsurface Wetlands in Removing Chemical Nitrogen and Phosphorus from Secondary Effluent of Wastewater Treatment Plant

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(*Received*: 7 March 2012; *Accepted*: 19 November 2012) AJC-12433

The secondary effluent of wastewater treatment plants in Tangshan area was used for this study. Two vertical subsurface constructed wetlands were carried out treating it. The chemical pollutant indexes of ammonia nitrogen (NH_3-N), total nitrogen (TN) and total phosphorus (TP) were analyzed for evaluating the removal efficiency of pollutants from the secondary effluent of wastewater treatment plant. The vertical zeolite subsurface wetland and vertical modified zeolite subsurface wetland showed different behaviours for nitrogen and phosphorus removals. Meanwhile, vertical modified zeolite subsurface wetland exhibited more remarkable removal effects on NH_3-N, total nitrogen and total phosphorus.

Key Words: Vertical zeolite subsurface wetland, Vertical modified zeolite subsurface wetland, Nitrogen, Phosphorus.

INTRODUCTION

Constructed wetland is an artificial construction and regulation system. The optimized combination of physical, chemical and biological processes in eco-system is applied to wastewater treatment[1,2]. The method has the effect of water stability, low running costs, operation safe and convenient, *etc*. According to water flow patterns, constructed wetland can be divided into two basic types which include flow constructed wetlands (FWS) and subsurface flow constructed wetlands (SF)[3-5]. Subsurface flow constructed wetland can be explained that sewage flows under soil surface. Meanwhile, subsurface constructed wetland mainly relys on substrate filtration, surfacial biofilm adsorption and degradation to purify sewage[6-11]. Subsurface flow constructed wetlands is divided into horizontal subsurface flow constructed wetlands and vertical subsurface flow constructed wetlands as perpendicular to the direction of flow. Due to its good bearing load capacities, vertical subsurface flow constructed wetland is used widely in various sewage treatment.This study focuses on using vertical subsurface flow constructed wetlands for treating secondary effluent of wastewater treatment plants on the variations of chemical pollutant concentration for a space.

EXPERIMENTAL

As shown in Fig. 1, two vertical subsurface constructed wetland systems was constructed, the main parts of the filled were four layers, substrate filter (from bottom): 10 cm gravel (particle size 15 to 25 mm); 20 cm zeolite or modified zeolite (particle size 6-10 mm); 15 cm lytag (particle size 3-5 mm); 5 cm soil (with 10 mesh sieve mixed soil). Reeds and cattails were planted on soil layer. The wetland equipment was made of plexiglass, a single wetland specification for length × width × height = 60 cm × 50 cm × 60 cm. The wetland is divided into water distribution buffers and main areas of wetlands.

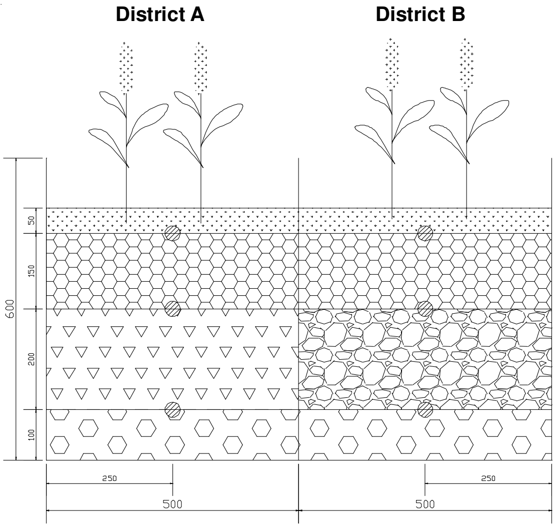

Fig. 1. Schematic diagram of horizontal subsurface wetland

Substrate zeolite modified contrast to the experiment

Pretreatment: A and B district washed 2 times with clean water, respectively. In order to reduce experimental errors as substrate background values, control the water level to the zeolite upper contact layer every time. A district was injected with water, and B district injected 0.5 mol/l NaCl solution, then soaked 2d; After 2d, the two districts were drained, then added clean water, B district changed to 0.5 % $KMnO_4$ solution, then soaked; The two district were drained, injected the preparation sewage, the system started. A district was represented by vertical zeolite subsurface wetland and B district was represented by vertical modified zeolite subsurface wetland.

Analytical methods: Parameters such as soluble NH_3-N, total nitrogen, total phosphorus and pH were monitored. Samples were collected once everyday when steady state conditions were achieved. In this experiment, intermittent flow was adapted in both the systems, and they continuously run for 135 days and 5 days is one cycle.

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	Unit	Concentration
pH	-	6.5-8.0
Ammonia nitrogen (NH_3-N)	mgL^{-1}	24.5-32.7
Total nitrogen (TN)	mgL^{-1}	37.7-45.1
Total phosphorus (TP)	mgL^{-1}	4.5-5.0

RESULTS AND DISCUSSION

Nitrogen removal: As shown in Fig. 2, vertical wetland exhibited well removal effect on ammonia nitrogen under some hydraulic loading rate. The concentration of effluent kept under 4.90 mg/L, while removal rates above 80 %. However, after the system run more than a month, the NH_3-N removal efficiency of vertical subsurface constructed wetland rapidly decreased and stabilized at around 85 %. At the end of this stage, the NH_3-N removal of two wetlands slightly rebounded. Compared with vertical zeolite wetland, vertical modified zeolite wetland performance a higher treatment effect of NH_3-N in the pilot phase, and differences are significant ($p < 0.05$). This is possible that the modified zeolite's surface properties have had the benign change to enable this wetland system to react nitration more easier, thus achieve the better removal effect on NH_3-N.

As shown in Fig. 3, vertical wetland exhibited well removal effect on total nitrogen under the same hydraulic loading rate. The concentration of effluent kept under 16.06mg/l, while removal rates above 60 %. However, after the system run for some time, the total nitrogen removal efficiency of vertical subsurface constructed wetland rapidly decreased and stabilized gradually. The total nitrogen removal rate of vertical modified zeolite subsurface wetland achieved more than 67 %. Compared with the vertical zeolite subsurface wetland, vertical modified zeolite zeolite subsurface wetland exhibited the higher treatment effect on total nitrogen, but no significant difference ($p > 0.05$).

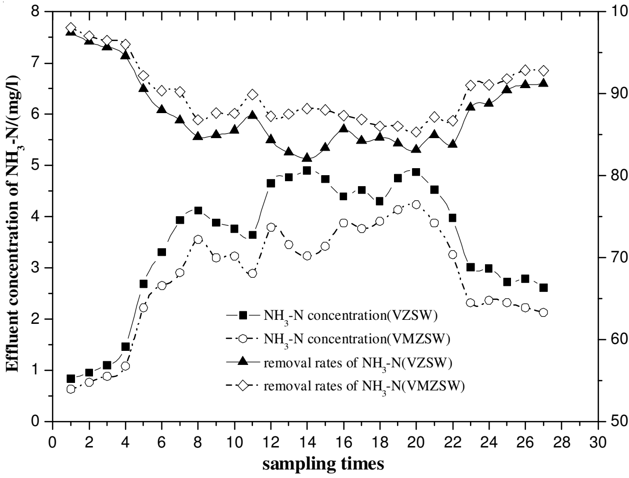

Fig. 2. Removal effect on ammonia nitrogen in every wetland under optimal hydraulic loading

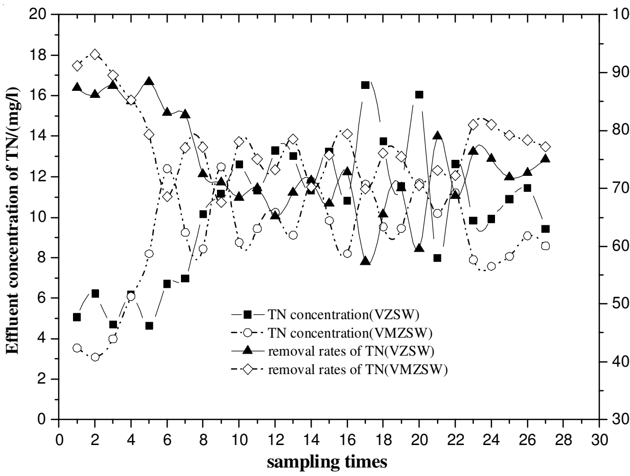

Fig. 3. Removal effect on total nitrogen in every wetland under optimal hydraulic loading

Phosphorus removal: It can be seen from Fig. 4 that total phosphorus removal efficiency showed a high similarity in two wetlands. Initially, the effluent concentration range of two wetland systems removal efficiency for total phosphorus in the wastewater are basically stable at 0.88-2.25 mg/L, the removal rate range would remain at 53.2 % to 81.2 %. Wetland system on the total phosphorus removal has been running steadily after some time. Compared with the vertical zeolite subsurface wetland, vertical modified zeolite zeolite subsurface wetland exhibited the higher treatment effect on total phosphorus, but no significant difference ($p > 0.05$).

Conclusion

According to the above-mentioned results, when system influent was secondary effluent of wastewater treatment plants, the vertical zeolite subsurface wetland and vertical modified zeolite subsurface wetland showed different behaviours for nitrogen and phosphorus removals, and vertical modified zeolite subsurface wetland exhibited more remarkable removal effects on NH_3-N, total nitrogen and total phosphorus.

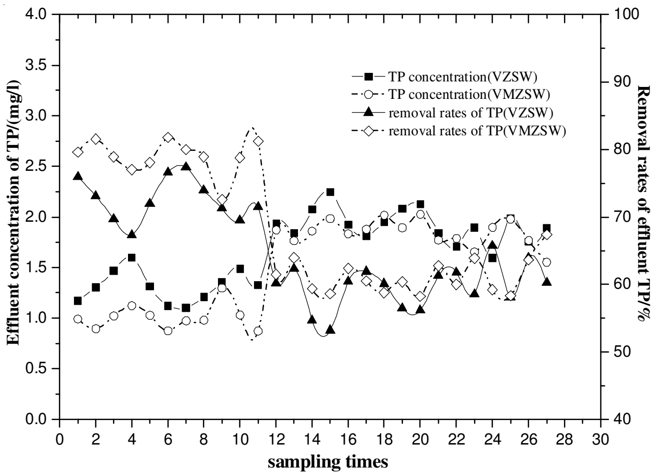

Fig. 4. Removal effect on total phosphorus in every wetland under optimal hydraulic loading

ACKNOWLEDGEMENTS

The financial support of this research by Water Pollution Control and Treatment of National Science and Technology major project (2008ZX07209-003-07) and Tangshan Foundation for development of Science and Technology, P.R. China (2011-111302007b) gratefully acknowledged.

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