Pretreatment effects of the Micro-polluted Water Supply in the Reservoirs by Subsurface Constructed Wetland

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Abstract: In order to improve water quality of the source of drinking water and mitigate load of drinking water treatment plant，A pilot test was conducted with integrated horizontal flow constructed wetland to pre-treat the Water Supply in the reservoirs of the Yellow Rive. Experiment was carried on in Yuqing Lake Reservoir in Ji'nan city and the water of it comes from Reservoirs of the Yellow River。Results show that under hydraulic loading rate a load of 2 $m^3 \cdot d^{-1}$, the average removal rates of chemical oxygen demand(COD), total nitrogen(TN), ammoniacal nitrogen(NH_4^+-N), nitrate Nitrogen (NO_3^--N) , and Total phosphorus (TP) in the horizontal flow constructed wetland were 49.21%%,52.04%, 47.20%、53.65% and 49.09%, respectively. This show horizontal flow constructed wetland may effectively pretreated with the micro-polluted Water Supply in the Reservoirs. [Nature and Science. 2008;6(2):53-58]. ISSN: 1545-0740.

Key words: Constructed wetland; micro-polluted Water Supply in the Reservoirs; Pretreatment

Yuqing Lake Reservoir, which takes raw water from Yellow River, is the most important project for water supply of Ji'nan city. After pretreatment to remove sand and other solid particles due to a long stay in the reservoir, water was transported to Yuqing drinking water treatment plant for further purify. With more and more discharge of domestic sewage and industrial wastewater into Yellow River, the water quality is becoming more and more deteriorated in recent years. The raw water was mainly micro- polluted by organism, nitrogen and phosphorus, with COD around 40 mg/L, TN around 4 mg/L and TP around 0.05 mg/L.

Constructed wetlands, as a lower cost, lower energy, lower technical-demanding sewage treatment method, have aroused more interests around the world. Constructed wetlands have been applied for various wastewater treatments, such as sewage wastewater(Winthrop et al.,2002), industrial wastewater(Ji G D,et al.,2002), rainstorm runoff in cities(Scholes L et al.,1998), wastewater out of farms(Kem J et al.,1999), lake pollution(Sakadevan K et al.,1999). But with our best knowledge, constructed wetland is rarely used for the pretreatment of micro-polluted Water Supply in the Reservoirs, either inland or outland.

This study therefore intends to investigate the feasibility of pretreatment of micro-polluted Water Supply in the Reservoirs by constructed wetland and also to provide the operation parameters for a full scale constructed wetlands to improve the quality of influent water to Yuqing Lake Reservoir.

1. Materials and Methods

1.1 Description of the constructed wetland system

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The subsurface constructed wetland system for the experiment is built in No.2 pumping station of Yuqing Lake Reservoir. The system is a reed beds with hydraulic characteristics of a horizontal flow. Dimension of unit is 6m×1.5 m×0.6m (L×W×D) and base slope is 1% .The wetlands beds are filled orderly with bigger gravels (average diameter 52mm, height 300mm), smaller gravels (average diameter 20mm, height 300mm) and local soils (height 150mm). The local common bulrush were planted in the wetland with the density of 20 plants/m².The wetland bottoms are plastered by concrete ， with brick built up in layers and mortar plastered. The water level of effluent is adjustable. Bottom of catchment area install a porous catchment pipe which was connected with a exterior vertical pipe. Vertical pipe was installed outlets to regulate water level in different height with 4m，8m，12m，16m. The regulation of the water level of effluent water can boost the growth of the roots of the plants and domesticate the super microorganism of the different depths.

1.2 Running of the system

The system began to run at the middle of May, 2005, with a load of 2 $m^3 \cdot d^{-1}$ and the hydraulic retention time of 1.35 days.

1.3 Sampling and testing

Water samples were collected both from the influent and effluent at regular, short intervals. Temperature ,pH, chemical oxygen demand (COD), total nitrogen(TN), total phosphorus (TP), ammonium-nitrogen (NH_4^+-N), nitrate–nitrogen (NO_3^--N) and nitrite–nitrogen（NO_2^--N） were measured according to the methods of the EPA of China (1993). COD, TN, TP , NH_4^+-N , NO_3^--N ,pH, NO_2^--N, and Temperature were measured 6-8 per month From May3, 2006 to November 27, 2006.

COD was determined by titrimetric method. Determination of NH_4^+-N, NO_3^--N, NO_2^-—N,TN and TP were performed using a segmented flow analysis (Skalar San^{++} Automated Wet Chemistry Analyzer, the Netherlands). The physico-chemical water parameters, such as water temperature, redox-potential (Eh), pH, and dissolved oxygen (DO) were measured in situ. DO was assayed using an Orion Dissolved Oxygen Probe (Model 862Aplus, USA). Water temperature and Eh were recorded with an Orion 250Aplus ORP Field Kit, and water pH with an Orion Portable pH Meter (Model 250Aplus, USA). All the parameters mentioned above were determined according to the method as described in the Standard Method for Examination of Water and Wastewater (Standard Method for the Examination of Water and Wastewater Editorial Board, 1993) and all analyses were completed within 24 h of sample collection.

2. Results and discussion

2.1 Removal of COD

Fig.1 show the variations of influent and effluent COD concentrations and COD removal rate for the raw water treatment by constructed wetlands. Concentrations in those figures are the testing results for month average value of samples. Under the operation conditions with a inflow COD of 19~35mg/L and the load of 2 $m^3 \cdot d^{-1}$, the removal rate of COD in raw water by horizontal flow constructed wetland is between 40%~60%,. The average COD concentrations of the effluent are 14.90 mg/L. According to other literatures, the removal rate of organic contaminations in sewage and other wastewater treatment by constructed water is normally 80%~90%. But in our current research, the organic contamination in the raw water is more hardly to be removed due to the lower concentration. Also, the hydraulic retention time of this system is only 1.35 days, shorter than the common HRT of 5~30 days, resulting a little low COD removal. But the effluent COD is less than 20mg/L, which can meet the China standard for surface water resources (GB3838-2002), i.e. 20mg/L for water resource of drinking water treatment plant.

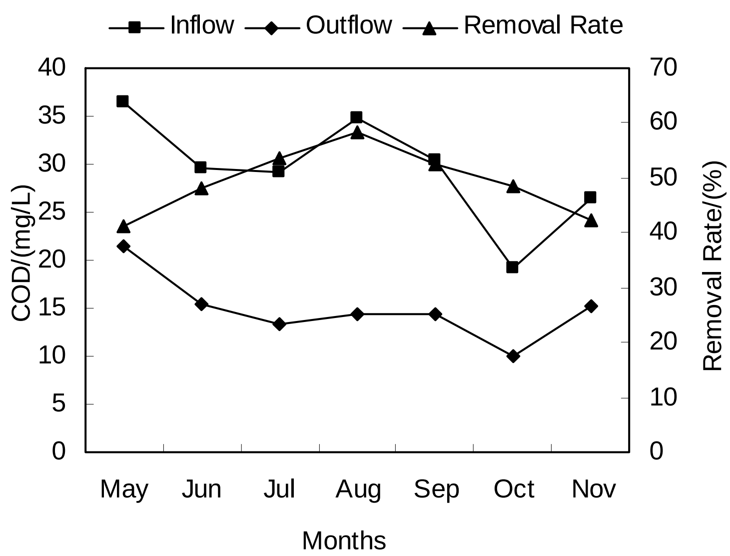

Fig.1The removal efficiency of COD by horizontal flow constructed wetland

2.2 Removal of TN

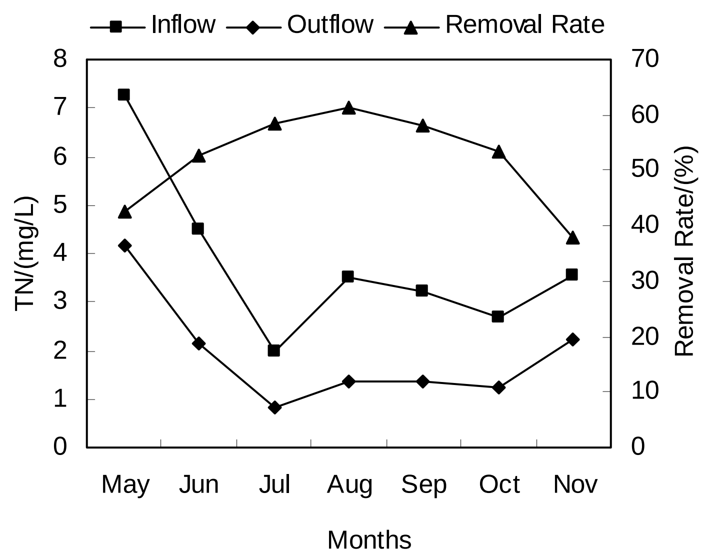

Fig.2 The removal efficiency of TN by horizontal flow constructed wetland

Fig.2 illustrate the variations of influent and effluent TN concentrations of the constructed wetlands. The figures show The removal rates of TN in the horizontal flow constructed wetland were 52.04%. According to the China standard for surface water resources (GB3838-2002), Mean influent TN were Grade Ⅲ, inferior Grade V. After the disposal of the constructed surface wetlands. Mean effluent TN can nearly reach Grade V.

The figures also show that, from July to the first half of October, TN concentration in the effluent is kept at a lower level, normally around 1mg/L, while the air temperature was high and the system ran steadily. It implies that the constructed wetland is a natural, biological treatment system, which entirely depends on natural energy inputs such as sunlight and wind. Temperature has a major impact on micro-biological process rates and obviously on plant growth as well, resulting in an effect on the higher removal rate of contaminations. The removal of nitrogen in wetlands depends on nitrification and denitrification of micro-organisms, the absorption of foliages and fillings and the volatilization of NH_4^+-N. Normally, the nitrification and denitrification of micro-organisms are important in the constructed wetlands. If there are lots of nitrobacteria, denitrobacteria, and also compatible situations, most of nitrogen will be removed.

2.2.1 Nitrogen species

The average concentrations of TN、NH_4^+-N、NO_3^--N、NO_2^--N from influents and effluents are showed in Table 1.

It is showed in Table 1 that most nitrogen (above 80%) from influents and effluents is in the form of NO_3^--N due to its stability. Concentrations of NH_4^+-N and NO_2^--N in the effluents can meet the nearly second standard of GB3838-2002. little NH_4^+-N and NO_2^--N be removed. The first reason is that the hydraulic retention time is short and the second is that the concentrations of contaminations are very low.

Table 1. The average concentration of nitrogen species in influents and effluents

	TN/（mg/L）	NH_4^+-N/（mg/L）	NO_3^--N/（mg/L）	NO_2^--N/（mg/L）
Influents	3.8087	0.4514	2.9474	0.03725
effluents	1.8979	0.2407	1.4017	0.01581

2.2.2 Removal of NO_3^--N

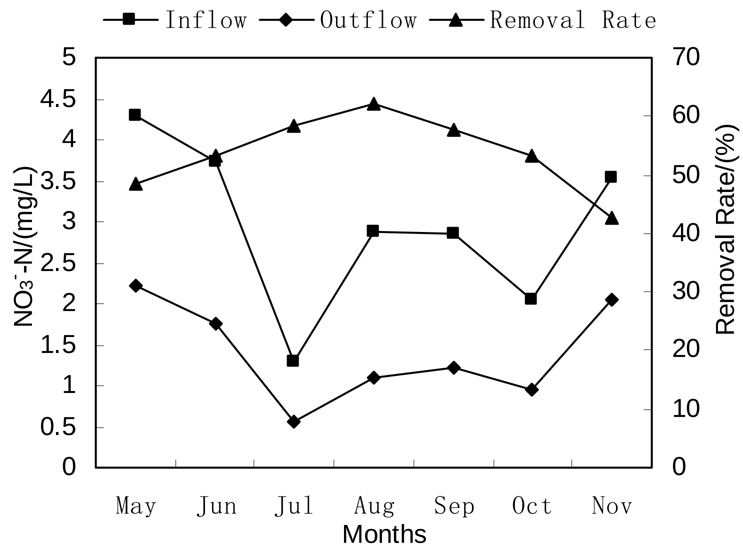

Fig.3 The removal efficiency of NO_3^--N by horizontal flow constructed wetland

Fig.3 show the removal efficiency of NO_3^--N from the raw water by constructed wetlands. It's so similar to that of TN, due to that most nitrogen is in the form of NO_3^--N as mentioned above.

2.3 Removal of TP

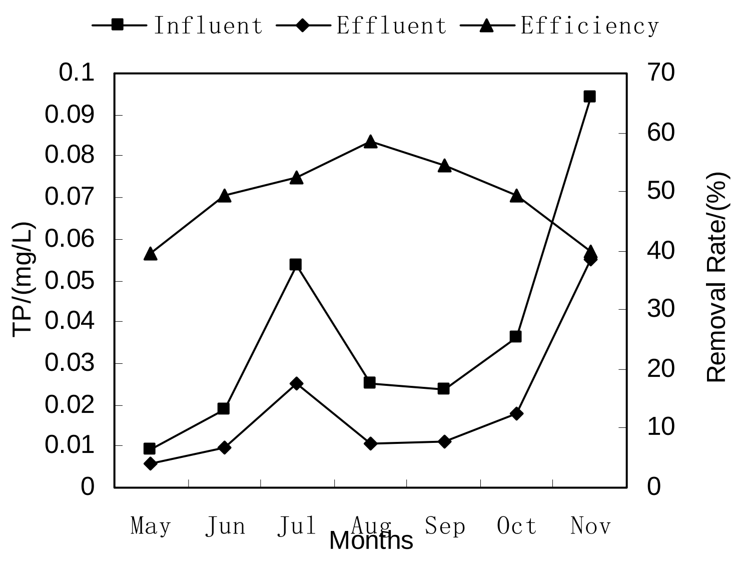

Fig.4 The removal efficiency of TP by horizontal flow constructed wetland

Fig.4 show the removal efficiency of TP from the raw water by horizontal flow constructed wetland. Usually, the removal of TP in wetlands depends on adsorption, replacement and sedimentation(Verhoeven J T A et al.,1999) The main removal mechanisms are adsorption to the filter and/or soil particles, adsorption to the detritus layer and precipitation with certain metals such as Fe, Al, Ca and Mg. When there is a saturation of sorption sites or the depletion of complication ligands, According to the China standard for surface water resources (GB3838-2002).By treatment function of the system Mean effluent TP from Grade Ⅱinto close to Grade I .Data finally suggest a substantial effect of temperature, with better removal efficiencies during the growing season. The most probable explanations are plant uptake on the one hand and P-leaching from decaying detritus on the other hand.

3. Conclusions

The results show horizontal flow constructed wetland effectively pretreated with the micro-polluted Water Supply in the Reservoirs. , the average removal rates of chemical oxygen demand(COD), total nitrogen(TN), ammoniacal nitrogen(NH_4^+-N), nitrate Nitrogen (NO_3^--N) , and Total phosphorus (TP) in the horizontal flow constructed wetland were 49.21%%,52.04%, 47.20%、53.65% and 49.09%, respectively. Temperature has a positive effect on the contamination removal. A higher removal rate can be obtained when the water temperature is higher.

Because of the low feeding load, the wiped function of system can't be fully exerted. Therefore, future experiment should enhance the feeding load so that the effects of system can be adequately exhibited.

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