Study on Purification Efficiency of Sewage in Constructed Wetlands with Different Plants

[1]Guang Sun, Yongsheng Ma*, Ran Zhao
1. College of Water Conservancy and Civil Engineering, Northeast Agricultural University, Harbin, Heilongjiang, China
ysma66@126.com

Abstract This article through the test research of subsurface flow constructed wetland, which plants reeds、cattail and respectively, analyzed effect of three plants on the purifying the sewage, and different Hydraulic Retention Time (HRT) under the law changes. The results show that in the best operating conditions, COD, TN, and TP in the removal rate of 50%, 75% and 65%. Three plants contrast test presents that cattail purifying effect is significantly better than the reeds and acorus calamus. The COD, TN and TP removal rate reached to 67.2%, 89.7%, and 88.9% by cattail.
[World Rural Observations 2009;1(2): 35-39]. ISSN: 1944-6543 (print); ISSN: 1944-6551 (online).

Keywords Wetland plants; Constructed wetlands; Sewage purification; HRT

1. INTRODUCTION

Constructed wetlands technology has been widely applied for sewage treatment, pollution control and environmental improvements in worldwide. Comparing with traditional chemical and biological sewage treatment，this technology has the characteristics of low construction cost, low operation cost, good treatment effect, ecological restoration function and building ecological landscape etc. In sewage treatment and environment pollution control, the constructed wetland played a very important role. However, constructed wetlands as a new sewage treatment technology is studied in very short time in China, the choice of wetland plants is in the lack of relevant experience, especially in Northeast China，has significant different region conditions, climate, vegetation and other features than southern regions. Therefore, in the northeast of China, wetland plants selection and configuration technology research for the development of constructed wetlands has an important significance. Construction of the test through subsurface flow wetland system with three different plants to study the wetlands in different Hydraulic Retention Time (HRT) on the COD, TN, TP removal effect for the construction of constructed wetlands provide a theoretical basis.

2. MATERIALS AND METHODS

2.1 Design of the Constructed Wetland Test System

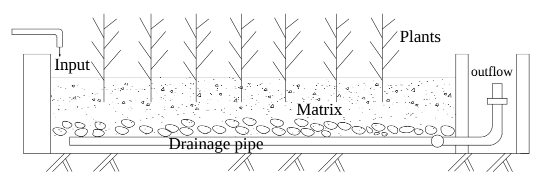

Fig.1 The structure of subsurface constructed wetland

In 2006, a pilot model of constructed wetland test system using subsurface flow constructed wetland system has been built in open-air experimental site of Northeast Agricultural University, as shown in Figure 1. The model composed 4 units. Each unit has inlet section、plant bed and outlet section. The size of each bed is 4 m (length) ×1.7 m (width) ×1.0 m (depth). On the bottom of the plant bed, lay two drainage pipes and filled within 10 cm rubble in 4mm-8mm diameter, the upper covered 10 cm sand layer and 40 cm soil layer.

2.2 The Plants in Constructed Wetlands

Selection of aquatic plants must follow the principle that tolerance against pollution, high decontamination efficiency, fit for local conditions， developed root system, strong anti-pest, and those have aesthetic and economic values. The capacity of wetland plants uptake for nutrients varies with the species of plants, sewage quality, the local climate and soil properties, the growth and depth of roots, also the wetland plants on the soil of oxygen carrying capacity and root functions of water conduction related to the development of root system(Chunchang Liu et al, 2007).

In April 2006, the wetland plants - Reeds, cattails and acorus calamus were collected and planted in the wetlands test system. For preventing the rapid growth of weeds inhibit Reed, cattail and acorus calamus growth, the weeds in beds were regulated in early stage of plant growth. At the end of June, the wetland plants have become dominant species and covered with fine whole pool.

2.3 Quality of Input Test Water

According to paddy field drainage water index, in Qinjia Irrigation Experiment Station in Suihua county, the input sewage water quality for testing was made using chemical fertilizers (diammonium phosphate - DAP) to simulate ratio, mainly contain with nitrogen in ammonia form, phosphorus in phosphate PO_4^{3-}form, as shown on table 1.

Table 1 The water quality of constructed wetland inlet

COD (mg . L^{-1})	NH4+-N (mg . L^{-1})	TN (mg . L^{-1})	TP (mg . L^{-1})	PH
76-128	44.6-81.2	47.6-80.0	32.7-52.9	7.2-8.2

Analysis Method

The analysis method is followed the guideline of Luo Weibang ET99731 microelectronic multi-parameter COD / TOC Analyzer of Germany:

NH_4^+-N: Salicylic acid method

TN: Potassium Per-sulfate Oxidation- UV spectrophotometer

TP: Molydenum – antimony – D – iso – ascorbie – acid - colorimetry (MADAC)

COD: Potassium Dichromate Method

Testing Instrument: Luo Weibang ET99731 microelectronic multi-parameter COD / TOC Analyzer of Germany

3. RESULTS AND ANALYSIS

3.1 The COD removal effect in sewage wetlands of three plants

The COD removal of constructed wetlands is mainly relying on microbiological degradation of the matrix attached to and the plant roots (Yang LIU et al, 2006). Experimental Study was done on three constructed wetland, which plants reeds, cattail and acorus calamus. With the running time, the time series curves of COD removal rate of constructed wetland are obtained, as shown in Figure 2.

This Research shows that each plant in constructed wetland on the removal rate of COD_{cr} increased with the HRT prolonging, the plants to the removal of the COD_{cr} play a certain role. The COD_{cr} removal rate of each plant was best on the third day, the removal rate was all over 54.9%, and the effect was significantly. On the fourth and fifth day removal rate began to decrease. Comparing the different plants, the cattail has higher removal ability (see figure 2).

3.2 The NH4+-N and TN removal effect of three plants

The nitrogen removal of constructed wetlands system is relying on nitrification – de-nitrification reaction, plant absorption and ammonia nitrogen volatilization (Xia Wang, 2007). The comparisons of the NH_4^+-N and TN removal effects in the reeds, cattail and acorus calamus wetlands are shown in figure 3 and figure 4.

The NH_4^+-N also is an important index of sewage treatment effect. The NH_4^+-N removal mainly depends on oxygen supply capability of plants. The results show that the NH_4^+-N removal effects in constructed wetlands with the test plants do not in direct proportion to HRT. The best removal effect is in the third day, and removal rates are 54.8％－90.0％.

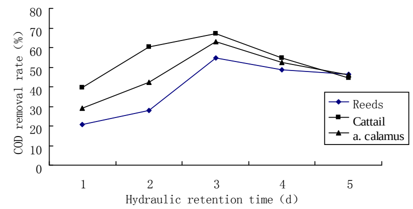

Fig.2 the COD removal efficiency of the three constructed wetlands with plants

Removal effect of the cattail wetland is the best, removal rate has reached 90.0%, and more obviously than reeds and acorus calamus wetlands, as shown in Figure 3.

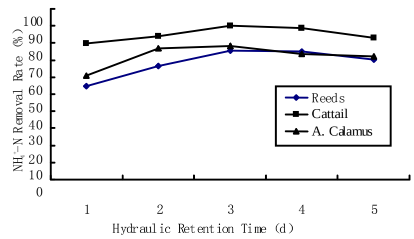

Fig.3 The NH_4^+-N removal efficiency of the three constructed wetlands with plants

Figure 4 presents that similar trend between the TN removal and NH_4^+-N removal. The TN removal rate first increased with the increase of HRT, and reached to Maximum on the third day, thereafter began to decrease, and the removal rate was 61.3%-89.7%. The analysis shows that the matrix as a part of the absorption of nitrogen in a longer stay time will release to the

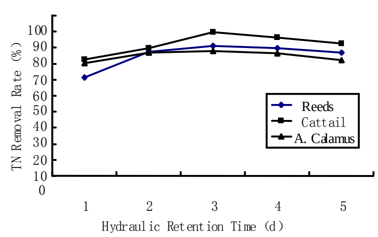

Fig.4 the TN removal efficiency of the constructed wetlands with three plants

system again, as well as the additional organic nutrients in the matrix components can also release a part of nitrogen nutrients. A longer HRT led to aggravation of anoxic conditions, suppressed transformation of ammonia nitrogen to nitrate nitrogen by the main procedure of nitrogen removal de-nitrification reaction**s,** and resulted in lower removal effect in system.

3.2 The TP removal effect in sewage of three plants

The TP removal of constructed wetlands System is a synthetically process including three aspects synergistic effects of plants absorption, microbial accumulation and physical-chemical effect of matrix. The TP removal effects of three plants of wetland are shown in Figure 5.

The figure 5 shows that the constructed wetland system has a better ability to remove phosphorus in different plants wetlands. The removal rate of TP is from 35.5% up to 88.9%. The phosphorus in farmland drainage is mainly in the form of the PO_4^{3-} , and phosphorus loads in the wetlands is transported in the form of particles and mainly deposit on the soil. Therefore, control sewage remain time in the wetlands can achieve the purpose of withhold Phosphorus. However, such withhold course is reversible, because some soil absorption may release a part of phosphorus into the water, or may flow into the wetlands by the impact of disturbance. As a result, the long remain time, as well as a greater flow of water may cause adverse effects of phosphorus removal. The figure 5 presents that the best HRT of Phosphorus removal is 5 days. To select the strong phosphorus absorption plants and better adsorption matrix, can have positive effects for phosphorus removal.

4. CONCLUTIONS

Among three tested plants, the removal effect of the cattail was the most obviously, which related closely to the growth of three plants. The growth of the cattail was the most vigorous and the larger coverage, the growth condition and coverage of reeds and acorus calamus were basically same. Nitrogen removal in system is mainly through the absorption and utilization of plant and microbial nitrification and de-nitrification reaction, root system micro-organic quantitative difference, due to the different conditions of plant growth, and the effect of the root added oxygen, lead to the difference of removal effects. In addition, owing

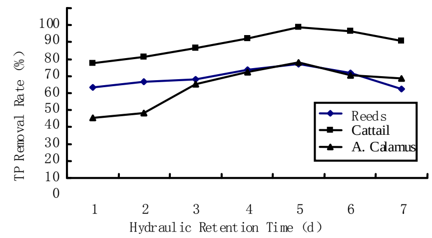

Fig.5 the TP removal efficiency of the constructed wetlands with three plants

to the intensity of the plant is not same; the interception effect of sewage in Cattail wetlands is more than reeds and acorus calamus, so the results appear in graph.

With the different HRT, the COD, N and P removal effect curves for sewage present a trend of removal rate rise up first and fall down later. The COD, N, P removal effects are more obviously. In wetland system, the best HRT of nitrogen purification is 3 days, the COD、NH_4^+-N and TN removal reached the highest level, 67.2%、90.0% and 89.7% respectively. The test presents the best HRT of Phosphorus removal is 5 days. Generally, the sewage removal effects in constructed wetlands are commonly influenced by the factors of wetland structure, operation mode**,** pollutant removal mechanism.

ACKNOWLEDGEMENTS

This research was supported by Program for Innovative Research Team of Northeast Agricultural University, **"IRTNEAU"** (CXZ009) and The Science and technology planning program of Heilongjiang province

(GB06B106-2); the key Scientific Research and Development project of Heilongjiang Province water conservancy engineering bureau (No.HSKY2007-05).

REFERENCES

[1] Quan-jin Wang, Li LI, Jiang Liu, Xiaoyan Zhan (2006). Study on Nitrogen and Phosphorus Removal Effect of Substrate in Subsurface Constructed Wetland [J]. Journal of East China Jiaotong University, 23(5):1.

[2] Xiaodong Chen, Wenyue Chang, (2007), Application Study and Engineering Demonstration of Northern Constructed Wetlands Wastewater Disposal Process [J]. Sciences of Environmental Protection, 23 (2):25.

[3] Jianqiang Wu, Ling Ding (2006). Study on treatment of polluted river water using pilot-scale surface flow constructed wetlands system [J]. Environmental Pollution and Control, 28（6）: 433.

[4] Chunchang Liu, Shuqing An et al, (2007). Effects of several plants species in their growth on the treatment of constructed wetlands [J]. Ecology and Environment, 16(3): 860-865.

[5] Yang LIU, Shihe WANG et al, (2006). Study on constructed wetlands for longtime running [J]. Ecology and Environment, 15 (6): 1156.

[6] Xia Wang (2007). Progress on the nitrogen removal mechanism in surface flow constructed wetland [J]. Electric Power Environmental Protection, 23(2):47.

6/8/2009