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**Research Article**

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# Under different conditions of the vertical flow constructed wetland nitrogen vertical distribution

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**ABSTRACT**

*The research of different conditions, various forms of nitrogen in vertical flow constructed wetland filling to the vertical concentration distribution at different depth, by measuring the nitrogen removal effect, so as to determine the effective height of packing. Using zeolite and ceramic filler, lythrum salicaria consists of wetland plants of four units of vertical flow constructed wet land system. Setting the 1#: ceramic, planting, no aeration; 2#: zeolite, no plants, no aeration; 3#: zeolite, planting, no aeration; 4#: zeolite, planting, aeration. The depth of the four device at various nitrogen concentration and conversion rate was determined. The 4 processing unit average conversion rates of $NH_4^+$-N were 87%, 89%, 89.8%, 91.6%; $NO_3^-$-N system does not reduce, but the accumulation. The 1#-4# processing unit and the average removal rates of TN were 27.9%, 25.3%, 35.1%, 19.6%. Four unit in the packing depth is 20-30cm DO decreased rapidly, to 50cm when the DO reaches the minimum, respectively 1.55mg/L, 0.71mg/L, 0.68mg/L, 5.39mg/L. The simulation system, 3# conditions on the nitrogen removal effect is best. Transformation and TN 3# unit of $NH_4^+$-N removal in the depth reached the maximum at 30cm, so the artificial wetland effective depth of zeolite filler for 30cm. Higher concentration of $NO_3^-$-N in the four unit, the main reason is the lack of carbon source, denitrification was weaker, caused the accumulation of $NO_3^-$-N, appropriate supplementary carbon source is in favor of the denitrification reaction.*

**Keywords:** vertical flow constructed wetland; simulation system; nitrogen vertical ; zeolite; distribution; nitrogen removal

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## INTRODUCTION

With the rapid development of social economy development and the city development, a large number of sewage produced, most of them are not standard treatment on the direct emissions, resulting in the deterioration of water environment . According to the survey ,in the 200 Rivers National seven rivers and inland river water quality assessment, section ratio of IV class -V and class V water quality deterioration at 24.2% and 20.8%. 1/3 above the river are subject to different degrees of pollution, more than 90% of the city water pollution, urban water source on nearly 50% does not meet the drinking water standard, has serious harm to human health. Therefore, constructing the safety of water environment has become an urgent task facing. Nitrogen is the key index caused by the pollution, so the control of eutrophication must focus on nitrogen removal.

Artificial wetland is an integrated ecosystem, has good economic benefit and ecological benefit, has low investment, high efficiency, good effluent quality, strong anti impact force, improve and beautify the environment, maintenance and operation has the advantages of low cost [1-2]. Suitable for the national conditions of our country, especially for the rural areas, sewage treatment of small and medium-sized city, with the prospect of application of [3] wide.
The artificial wetland is the surface flow constructed wetland, horizontal flow constructed wetland and vertical flow constructed wetland is three [5]. The vertical flow constructed wetland in three in the denitrification effect relative prominence. Filling is an important group of artificial wetland system, its adsorption function can greatly improve the wetland treatment effect of [6]. The research results show, zeolite and ceramic adsorption effect of $NH_4$+-N good.

The comparison study of nitrogen at the same conditions of vertical distribution. Remove the path of vertical flow wetland nitrogen mainly for nitrification denitrification reaction [7-8]. Study on vertical flow constructed wetland using zeolite and ceramic filler, Lythrum salicaria as nitrogen vertical system of wetland plants to the distribution of concentration and proportion, in order to explore the effective depth of filler, effect of DO concentration on the reaction of microbial nitrification and denitrification. Improve the nitrogen removal efficiency and investment economy, the more efficient removal of sewage nitrogen has practical significance is worthy of popularization.

## MATERIALS AND METHODS

### 2.1 Experimental Design

**Experimental materials:** ceramic, zeolite, air pump, water tank (made of organic glass, divided into 4 units, filling test filler. Each cell are arranged perpendicular to the 5 sampling port. The unit size is 80cmx50cmx70cm).

**Test conditions:** this device uses a continuous operation mode, the parallel operation of HRT unit, 2d, hydraulic loading is $7.24\times10^{-3}m^3/m^2.h$. Control of aeration unit 4 in the 100ml/min, the intermittent aeration mode, aeration 1h, suspended 5h.The room temperature is 25℃, humidity 70%, carbon dioxide concentration is 385ppm, daytime light intensity was 1000-5000 lux. Set the S1-S5 five sample level, before the start of the experiment, the first collection of plants on the experimentation area domesticated l0d, then transplanted into the test device.

Setting: the water tank is arranged in the device above the water, the system is controlled by a valve velocity evenly to each unit. Flow from top to bottom vertical flow into the bottom, bottom of the device and a water outlet overflow pipe. Research on simulation system for vertical to the water quality change along, ceramsite filler No. 1 unit, diameter and height of 20mm (50cm); No.2-4 units are packed with zeolite filler, zeolite particle size and height of 35mm (0-20cm), 20mm (20-30cm), 30mm (30-50cm). Each unit filling the total height is 50cm, three units selected No. 2 for the control group, no plants, no treatment, other units are plant Lythrum salicaria, while No.4 unit increase in artificial aeration conditions, by connecting the gas meter to control ventilation.

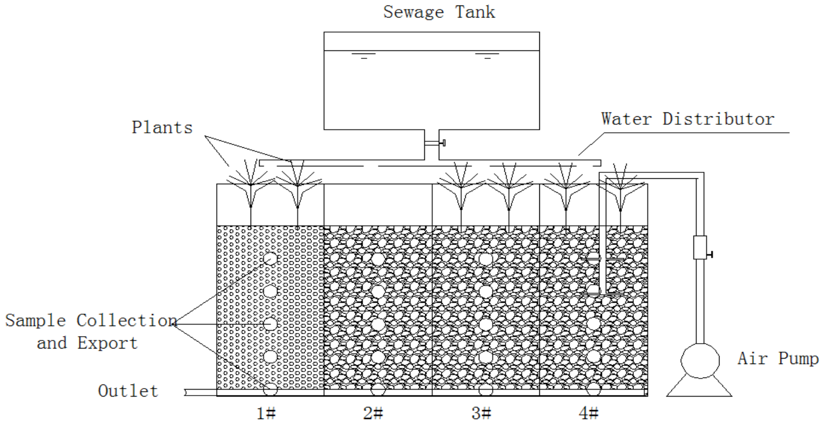



**Figure1. device unit**

### 2.2 Water Index

The device from a water inlet Hunhe River mouth, the main quality index table.

**Table 2 Water quality indicators**

| Water Index | DO（mg/L） | TN（mg/L） | $NH_4^+$.N（mg/L） | $NO_3^-$.N（mg/L） | $NO_2^-$-N（mg/L） | pH |
|---|---|---|---|---|---|---|
| **Mean ±standard deviation** | 2.54±1.42 | 13.37±1.84 | 5.92±0.81 | 6.77±0.7 | 0.32±0.14 | 7.5±0.3 |

### 2.3 Sample Collection and Analysis Method

Each sample in the morning 8 points, the siphon method of collecting water samples, water samples in plastic sample bottles, volume 500mL. After the acquisition, placed in 4℃ refrigerator to be determined.

**Table 3 monitoring indicators and analytical methods**

| Water Index | Analysis Method |
|---|---|
| TN | Alkaline potassium persulfate digestion UV spectrophotometric method |
| $NH_4^+$-N | Nessler'sreagent spectrophotometric method |
| $NO_3^-$-N | Phenol two sulfonic acid spectrophotometry |
| $NO_2^-$-N | N-(1-naphthyl)ethylenediamine dihydrochloride spectrophotometric method |
| DO | Membrane method |
| pH | The glass electrode method |

## RESULTS AND DISCUSSION

### 3.1 DO vertical distribution

Each processing unit of vertical distribution of DO is shown in figure 2. 4 processing unit due to the increase of the aeration device, so the highest concentration of DO, concentration of DO filler bottom still reached 4.89mg/L. The filler height at 10cm DO was the highest, reached 7.32mg/L, followed by the 1 processing unit, the content of DO decreased from 6.56mg/L to 1.39mg/L, DO distribution of No.3 and No.2 processing unit is the most close, filling the depth 50cm, basically reach the anoxic condition.

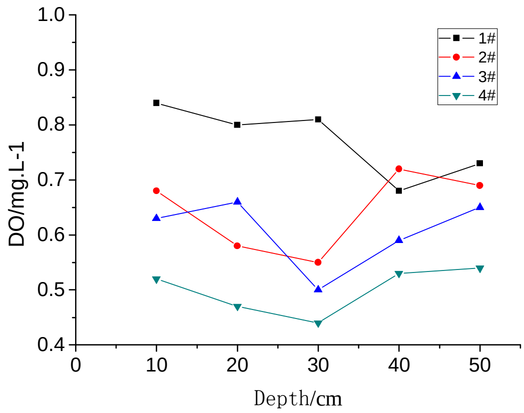



**Figure 2. vertical flow constructed wetland system Simulation of vertical DOdistribution curve**

2.2 different forms of nitrogen concentration and the vertical distribution

Below are $NH_4$+-N, $NO_3^-$-N, $NO_2^-$-N concentration vertical distribution map. We can see from Figure 3,four processing units in the packing depth is 10cm when the $NH_4$+-Nconcentration is composed of a water inlet $NH_4$+-N average concentration of 5.90mg/L to 0.45-0.90mg/L,$NH_4$+-N.1,-4 removal rate reached 87.80%, respectively, 88.47%, 89.32%, 91.19%. Visible in the filling depth of about 10cm when the processing unit $NH_4$+-N has most been removed, depth is reached the lowest level in the lowest concentration of No. 2 -4 processing unit of the 30cm, then increased to a certain extent, No. 1 unit in the packing depth is 40cm when $NH_4$+-N concentration reached to the lowest level.

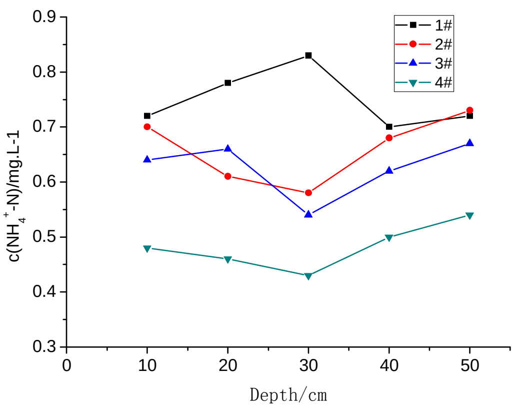



**Figure 3. vertical flow constructed wetland system simulation Curve changes to the $NH_4$+-N concentration**

We can see from Figure 4, No.1-3 processing unit, in the filling depth is 10cm, the concentration of $NO_2^-$-N decreased from 0.32mg/L to 0.07mg/L-0.3mg/L, removal rate. The No. 1 unit of $NO_2^-$-N have not been removed, but there is a certain degree of accumulation. In the filling depth is 40cm, the concentration of $NO_2^-$-N reached the maximum. Then dropped to 0.28mg/L, which may be due to the ceramic filler 1 processing unit filling contains more CaO to make the surrounding water environment is alkaline, influence microbial activity, made from $NO_2^-$-N to $NO_3^-$-N transformation has certain difficulty, leading to the accumulation of $NO_2^-$-N.

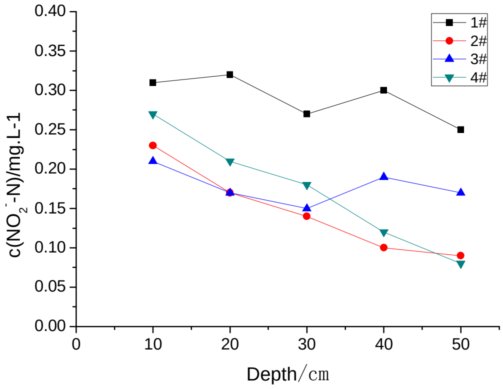



**Figure 4. vertical flow constructed wetland system simulation Curve changes to the $NO_2^-$-N concentration**

We can see from Figure 5, the four processing unit of $NO_3^-$-N vertical distribution is basically the same, in the filling depth is 10cm, No. 1-4 unit on the $NO_3^-$-N removal rate is larger, filling depth is more than 10cm after $NO_3^-$-N began to accumulate.

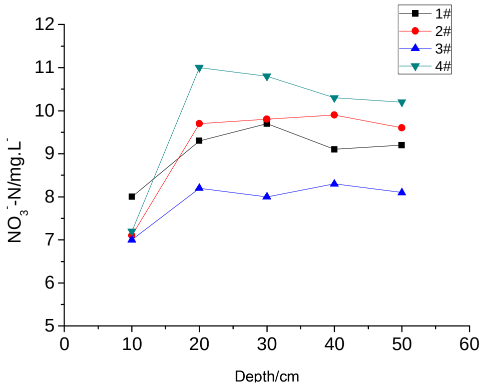
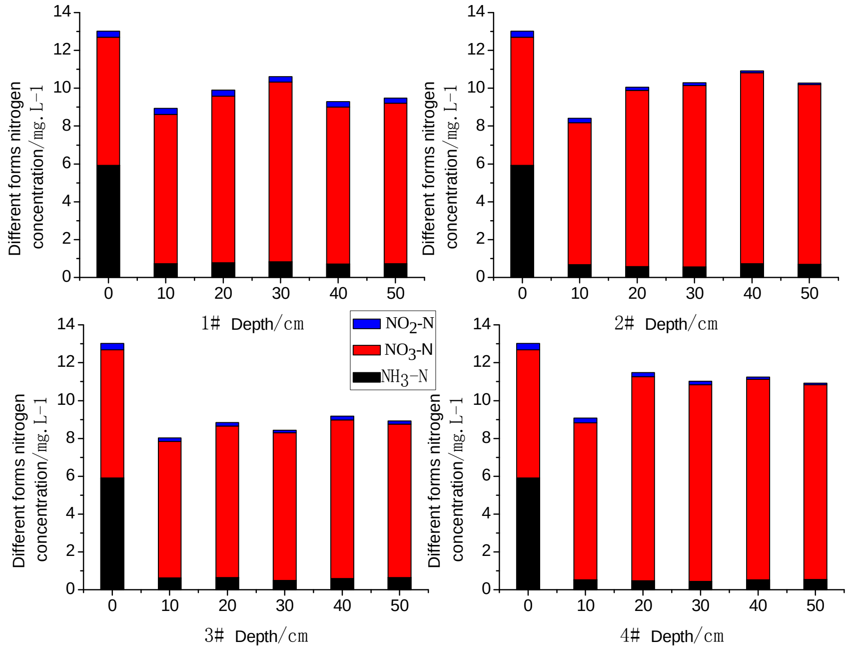



**Figure 5. vertical flow constructed wetland system simulation Curve changes to the $NO_3^-$-N concentration**

2.3 different ratios of nitrogen vertical distribution

From the figure, No.1-4 processing unit nitrogen vertical distribution situation as shown below. The water content of $NH_4^+$-N four processing units accounted for 46.66%, $NO_3^-$-N accounted for 52.23%, $NO_2^-$-N accounted for 1.11%, packing depth at about 10cm most of $NH_4^+$-N was converted to $NO_3^-$-N, there are a small part of $NO_2^-$-N. The four processing unit along the NO3--N content reached more than 90%, and the 1 processing unit of $NO_2^-$-N also appeared to accumulate. The whole system is not the denitrification process obviously, the main reason is lack of carbon source, especially the 1 processing unit increased aeration device, can not achieve the hypoxic environment at the bottom, so the number 1 processing unit of the $NO_3^-$-N account for the largest proportion.




**Figre 6. units at different vertical depth of the nitrogen distribution ratio diagram**

## CONCLUSION

4 processing unit of the system on the $NH_4^+$-N conversion is higher, the average conversion rate were 87.80%, 88.47%, 89.32%, 91.19%, but $NO_3^-$-N accumulation. No.1-4 processing unit and the average removal rates of TN were 27.9%, 25.3%, 35.1%, 19.6%.1#-4# processing unit in the packing depth is 20-30cm DO decreased rapidly, to 50cm when the DO reaches the minimum, respectively 1.55mg/L, 0.71mg/L, 0.68mg/L, 5.39mg/L. System in the packing depth is 10cm most of $NH_4$+-N into $NO_3^-$-N, $NO_3^-$-N denitrification produces weak, accumulate in the system. Mainly because of the lack of carbon source, can not meet the denitrification reaction conditions, so the removal efficiency of TN system is not ideal.

1# and 4# comparison, 1# average removal rate of TN is lower than that of 4#. Under the same conditions, the adsorption effect of zeolite, microbial nitrification and denitrification reaction is better than ceramic; 2#, 3# contrast, planting more conducive to the removal of pollutants; 3#, 4#, aeration can make the conversion of $NH_4^+$-N was slightly higher than that of natural conditions, but the removal efficiency of TN don't like 3#.

In general, using zeolite as substrates in constructed wetland, the best nitrogen removal efficiency for 3#, suggest that under natural conditions on the conversion of most microbial nitrogen and removal can achieve good status. Comprehensive comparison, in the 3# unit operating conditions, transformation and $NO_3^-$-N ,$NH_4^+$-N removal in the depth reached the maximum at 30cm, the effective depth of the filler for 30cm. In the surface 10-20cm range appropriate to increase the dissolved oxygen can accelerate the nitrification of microorganisms, but the increase of dissolved oxygen and inhibit denitrification, is not conducive to the removal of TN.

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