Comparison of nitrogen and phosphorus purification effects of different wetland plants on eutrophic water

Junzhong Yang[1], Yong Qi[2], Hongyuan Li[3], and Guangyao Xu [3]

[1]College of Environmental Science and Engineering, Nankai University, 300350, China

[2]Tianjin LVYIN Landscape and Ecology Construction Co., Ltd, 300384 China

Abstract. Using hydroponic, 13 plants were selected from 2 type（aquatic plants, hygrophytes）of new varieties and common varieties of wetland plants in Tianjin to explore the differences of purification effect of nitrogen and phosphorus in water. The result shows that the plants on the removal rate of total nitrogen was significantly higher than control group, but the differences were small. Among them, yellow iris, Siberia iris, Cyperus alternifolius, aquatic Canna and Miscanthus sinensis had the best effect on TN, and the removal rate was above 99%;The removal rates of total phosphorus in plants were significantly higher than those in control group (except for M.sinensis cv.'Variegatus'), and the differences among the groups were relatively significant. Among them, Irispseudoacorus, Cyperus alternifolius, iris pseudacorus, Scirpus tabernaemontani, Iris siberian，C.glauca and M.sinensis cv.'Gracillimus' had the best effect on TP, and the removal rate was more than 70%. Therefore, Irispseudoacorus, Cyperus alternifolius, iris pseudacorus, Scirpus tabernaemontani, Iris siberian, C.glauca and M.sinensis cv.'Gracillimus' can be used as an alternative plant for eutrophic, wetlands or landscape water.

1. Introduction

Water eutrophication is one of the important causes of water pollution[1], and it is also a hot and difficult problem in water pollution control[2]. Water eutrophication further deteriorates water quality, seriously affecting the ecological environment and human life, restricting the sustainable development of the national economy[3]. At present, there are many ways to manage eutrophic water at home and abroad, whether it is to reduce the source of exogenous nutrition or take various measures to eliminate algae can not achieve lasting and ideal results[4]. Through a lot of practice, ecological restoration has become the best way to manage water eutrophication. plants as the core of ecological restoration from the water can absorb nitrogen, phosphorus and other nutrients and provide a suitable environment for microbial degradation of pollutants[5]， which not only had less investment, low energy consumption, no secondary pollution risk, but also can restore original function of the aquatic ecology system, to create a good landscape effect. Due to different plants between the nitrogen and phosphorus absorption capacity are different, and different types of plants between the growth characteristics of the differences. At present, although there are many studies on the management of eutrophic water bodies [6-7], most of them focus on several indigenous and common plant studies, and few studies on the combination of large numbers of new varieties and local common plants for nitrogen and phosphorus adsorption to optimizate plants.

In this study, 13 wetland plants from 2 types （aquatic plants, hygrophytes） were selected. The effects of different wetland plants on the removal of nitrogen and phosphorus were studied by means of indoor hydroponics, and the best new varieties were selected. So as to provide a theoretical basis for the application of new varieties of aquatic plants and the application of common varieties in engineering and eutrophic water.

2. Materials and methods

2.1. plant materials
Through the field collection and purchase of plant seedlings suitable for growth in wetlands, thirteen kinds of wetland plants with a certain landscape value were selected from six kinds of aquaticplants (Pontederia cordata(PC),Arundo donax var.versicolor(ADV),iris pseudacorus(IP),Cyperus alternifolius(CA),Scirpus tabernaemontani(ST),Cortaderia selloana(CS)) and seven kinds of hygrophytes (Irispseudoacorus(I),Iris Siberian(IS),L.salicaria cv.white flower(LSW),Lythrum salicariaL. (LS) ,M.sinensis cv.'Variegatus'(MSV),M.sinensis cv.'Gracillimus'(MSG),C.glauca(CG)). All plants were transferred to the configured nutrient solution for one week before the experiment began,and then one by one into the artificial allocation of sewage ,which TN concentration was 9.558mg/L, TP concentration was 1.005mg/L in the actual, to cultivate.

2.2. Experimental design
The experiment was conducted in the greenhouse of the Nankai University in May 2017. Experiments were carried out by using foam floating plate as carrier. Each plant was cultivated according to its growth characteristics and consistent growth. The diameter of the plastic bucket was 30cm and the height was 22cm, and the plastic bucket was into water 8L. Each plant was grouped with 3 replicates and 1 set of blank controls. Each group of plastic barrels according to the amount of water added to determine the standard water level, Water level is added to the tick mark before each water sample. The experimental period is 35 days and the water sample is taken once a week.

2.3. Experimental methods and data process
To avoid the sampling error, each sampling time is 9: 00-10: 00AM. The water samples were taken and measured within two days. Taking into account the latest monitoring methods of the State Environmental Protection Administration, the total nitrogen (TN) was determined by ammonium persulfate digestion ultraviolet spectrophotometry (GB11894-89) and the total phosphorus (TP) was determined by ammonium molybdate spectrophotometry (GB11893-89).

Excel 2007 is used for data processing and mapping. Spss20.0 is used to calculate the mean and standard deviation of each index.

3. Results

3.1. Removal of Total Nitrogen (TN) by Different wetland Plants

3.1.1. TN removal rate
all kinds of wetland plants had promote the removal of total nitrogen in water, but the difference of tot al nitrogen removal rate among different wetland plants is small(Table 1). In general, the order of total nitrogen removal of 13 species was as follows: M.sinensis cv.'Gracillimus'>Cyperus alternifolius>Iris pseudoacorus> Iris siberian >C.glauca>Cortaderia selloana>Scirpus tabernaemontani=Lythrum salicar iaL.>Nymphaea tetragona=Arundo donax var.versicolor>iris pseudacorus>Pontederia cordata>M.sine nsis cv.'Variegatus'>L.salicaria cv.white flower>control group. Among them, M.sinensis cv.'Variegatu s', Cyperus alternifolius , iris pseudacorus , Iris siberian and C.glauca on total nitrogen removal rates r espectively were 99.61%, 99.38%, 99.24%, 99.11%, 99.06%, which were 28.3%, 28.07%, 27.93%, 27. 80%, 27.75% higher than control group. The worst of the total nitrogen removal effect is L.salicaria c v.white flower, but it also reached 93.44% which is significantly different from that of control group (P <0.05). As the experimental process will regularly clean up the part of the plant aging, and the experim

IOP Conf. Series: Earth and Environmental Science **113** (2018) 012042 doi:10.1088/1755-1315/113/1/012042

ental site is indoor, so the total nitrogen and total phosphorus in water is basically a plant on the eutrop hication of water purification effect.

Table 1 Removal of Total Nitrogen (TN) and Total phosphorus (TP) by Different Aquatic Plants

species	Removal of TN (%)	Removal of TP (%)
CK	71.31±3.26c	19.65±0.77g
Pontederia cordata	98.16±1.49a	51.82±4.12d
Irispseudoacorus	99.24±0.49a	74.14±1.37ab
Arundo donax var.versicolor	98.58±0.45a	68.32±4.12bc
L.salicaria cv.white flower	93.44±0.48b	41.62±0.69e
M.sinensis cv.'Variegatus'	97.40±0.04a	25.13±2.06g
Cyperus alternifolius	99.38±0.30a	71.23±2.75abc
iris pseudacorus	98.43±0.82a	72.20±0.00ab
Scirpus tabernaemontani	98.69±1.04a	74.14±5.49ab
Iris siberian	99.11±1.12a	77.54±3.43a
Lythrum salicariaL.	98.69±0.30a	64.44±2.74c
Cortaderia selloana	98.74±0.07a	34.35±1.37f
C.glauca	99.06±0.15a	71.72±3.43ab
M.sinensis cv.'Gracillimus'	99.61±0.26a	71.72±4.80ab

Different letters indicate significant differences among cultivars (P<0.05).

3.1.2. TN removal rate changes over time

Figure.1 shows the curve of TN removal rate in the aquatic plants groups with time. As shown in Figure 1, compared with control group, each group on the total nitrogen in water have a good removal effect. During the first week of experiment, the removal rate of total nitrogen was the highest, reaching more than 90%. The removal rate of total nitrogen was almost flat after the end of the second week.

Figure. 2 shows the curve of TN removal rate in hygrophyte groups with time. It can be seen from Figure. 2 that the removal of total nitrogen in the water was significantly improved compared with control group. Similar to the emerged plant, the removal efficiency of total nitrogen was the highest in the first week of the experiment, with the exception of L.salicaria cv.white flower, the other groups reaching more than 90%. However, the removal rate of total nitrogen was more obvious after the end of the second week of the experiment, which may be related to the growth characteristics of hygrophyte, and the part of plant leaf abscission could easily fall into the water, leading to the recovery of total nitrogen concentration.

Figure 1. TN removal rate in the aquatic plant groups with time

Figure 2. TN removal rate in hygrophyte groups with time

3.2. Removal of Total phosphorus (TP) by Different wetland Plants

3.2.1. TP removal rate

all kinds of wetland plants had promoted the removal of total phosphorus in water, and the difference of total phosphorus removal rate between different wetland plants is quite different (Table 1) . In general, the order of total phosphorus removal of 13 species was as follows: Iris siberian>Irispseudoacorus>Scirpus tabernaemontani>Iris Siberian>C.glauca=M.sinensis cv.'Gracillimus'>Cyperus alternifolius>Arundo donax var.versicolor>Lythrum salicariaL.>Pontederia cordata>L.salicaria cv.white flower>Nymphaea tetragona>Cortaderia selloana>M.sinensis cv.'Variegatus'>control group. Among them, Irispseudoacorus, Cyperus alternifolius , iris pseudacorus , Scirpus tabernaemontani ,Iris Siberian, C.glauca and M.sinensis cv.'Gracillimus'on total phosphorus removal rates respectively were 74.14%、71.23%、72.20%、74.14%、77.54%、71.72%、71.72%, which were 54.49%、51.58%、52.55%、54.49%、57.89%、52.07% higher than control group, and the removal rate was significantly higher than that of the control group ($P<0.05$). The worst of the total phosphorus removal effect is M.sinensis cv. 'Variegatus', only 25.13%, which was not significantly different from that of control group ($P> 0.05$). Removal of total phosphorus in water In addition to the plant's own absorption, there are plant roots provide a good habitat for the growth and reproduction of polyphosphate bacteria, and promote the removal of phosphorus in water [8]. There is a difference in the removal of total phosphorus between different aquatic plants, which may be related to plant growth to phosphorus requirement and root oxygen capacity [9].

3.2.2. TP removal rate changes over time

It can be seen from Figure. 3 that the total phosphorus removal rate of each group was significantly higher than that of control group. In addition to Pontederia cordata and Cortaderia selloana, the other groups of total phosphorus removal rate of more than 60%. And the effect of total phosphorus removal was significant in the first three weeks of the experiment, and then became gentle.

It can be seen from Figure. 4 that compared with the control group, in addition to M.sinensis cv.'Variegatus', the other groups of plants on the removal of total phosphorus in water were significantly improved. Reaching the third week of the experiment, the removal rate of total phosphorus reached the maximum and then fluctuated slightly. The removal rate of total phosphorus between different plants was different. The highest removal rate was Iris siberian, which was 77.54%; the lowest removal rate was M.sinensis cv.'Variegatus', only 25.13%.

In all, the aquatic plants are similar to hygrophyte to phosphorus removal in water, and there is no significant difference. This indicates that under the existing culture conditions, the plant roots provide a good environment for microorganisms such as polyphosphate bacteria, and promote the transformation of phosphorus in water [10].

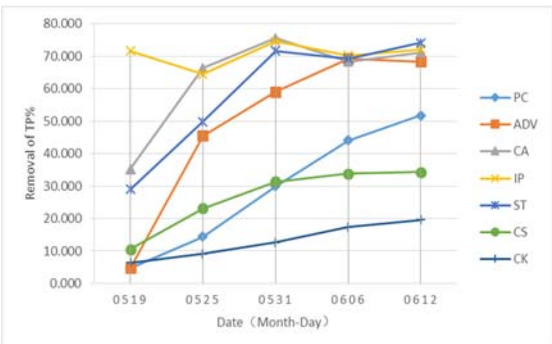

Figure 3. TP removal rate in the aquatic plant groups with time

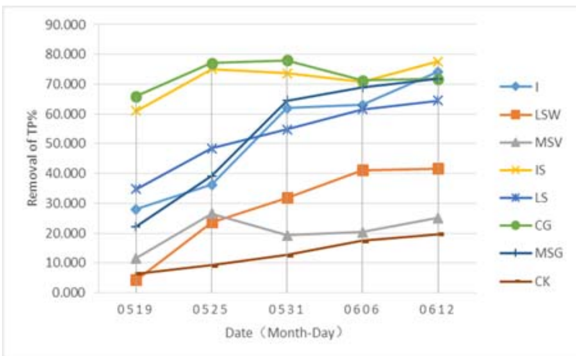

Figure 4. TP removal rate in hygrophyte groups with time

4. Conclusions

(1) The removal rate of total nitrogen in different wetland plants was significantly higher than that in control group, but the difference among the groups was small. Removal effect of Irispseudoacorus, Iris siberian, Cyperus alternifolius, C.glauca and M.sinensis cv.'Gracillimus' are better, and the removal rate of them are more than 99%.

(2) The removal rate of total phosphorus in different wetland plants was significantly higher than that in control group, and the difference was significant. Removal of the better effect are Irispseudoacorus, Cyperus alternifolius, iris pseudacorus, Scirpus tabernaemontani, Iris Siberian, C.glauca and M.sinensis cv.'Gracillimus', and the removal rate of them are more than 70%.

(3) Considering the efficiency of Wetland Plant on TN and TP removal, Irispseudoacorus, Cyperus alternifolius, iris pseudacorus, Scirpus tabernaemontani, Iris Siberian, C.glauca and M.sinensis cv.'Gracillimus'can be used as an alternative to eutrophic water, wetlands or landscape water.

Acknowledgements

This work was financially supported by the National Natural Science Foundation (31370700).

References

[1] Dai Shan，Li Qingwei: Removal Efficiency of Eight Plants in Two Different Eutrophic Water, *Journal of Northeast Forestry University*, 2016, 44(7): 80－83．

[2] Quan weimin, Shen xinqiang, Yan lijiao: Advances in research of biological purification of eutrophic water body, *Chin. J. Appl. Ecol*., 2003, 14(11): 2057～2061.

[3] Zhu guangwei: Eutrophic status and causing factors for a large, shallow and subtropical Lake Taihu,China,J.*Lake Sci*.,2008,20(1):21-26.

[4] Liu chunguang, Wang chunsheng, Li he, et al: Removal Efficiency for Nitrogen and Phosphoyus in Eutrophic Waterbody by Macrophytes, *Journal of Agro-Environment Science*, 2006, 25:635-638.

[5] Ji xiaomei, Xu lin, Xie Yanfeng, et al: Effects of Hydrophytes on Removal of Nitrogen and Phosphorus in Different Levels of Eutrophic Water, *Southwest China Journal of Agricultural Sciences*, 2015, 28: 809-814.

[6] Fang Yanxin, He Chiquan, Liang Xia, et al: The Purifying Effect of Polluted Water by the Aquatic Plants, *Journal of Hydroecology*, 2010, 3: 36-40.

[7] Sun Ruilian, Zhang Jian, Wang Wenxing: Effect on polluted water purification by eight emergent plants, *Journal of Shandong University* (Natural Science), 2009, 44: 12-17.

[8] Hu Xiao, Cai Hui, Chen Gang, et al: Purification Efficiencies of Three Types of Aquatic Plants and Combination of Them to Chromium, Nitrogen and Phosphorus in Wastewater, *Technology of water treatment*, 2012, 38: 45-49.

[9] Yi Naikang, Peng Kaiming, Lu lijun, et al: Research Advances on the Influence Mechanism of Wetland Plants on Microbial Activity in Nitrogen Removal, *Technology of water treatment*, 2016, 42:12-16.

[10] Liang Wei, Wu Zhenbin, Research Advances on Removal Mechanism of Nitrogen and Phosphorus in Sewage by Constructed Wetland, *Environmental Science Trends*, 2000, 3: 32-37.