Nitrogen and Phosphorus Removal Performance by Several Planted Floats in Eutrophic Water in Winter

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Abstract: The floating plate basin cultivation techniques was used to study the purification effects of the local xerophyte--*Trifolium repens* Linn and *Erigeron annuus* (L.) Pers on the total nitrogen (TN) and total phosphorus (TP) in the eutrophic lake landscape in winter, and compared that to the aquatic plant --*Eichhornia crassipes* Mart as well as the control water sample, in which only floating plates are added. The result of the study shows that after water cultivation, *Trifolium repens* and *Erigeron annuus* (L.) have some removing effect toward the TN and TP in the eutrophic water body landscape, and respectively, the removal percentages in TN are 21%,22% and the percentages in TP are 82%,21%. The test to paired samples shows that the purification effect of these two xerophyte towards TN and TP is obviously better than that of the control water sample（TN:15.6%，TP:-6%） and the difference was significant($P<0.05$). Compared the purification effect of these two terrestrial plants with that of *Eichhornia crassipes*（TN 20%，TP 53%）, the difference on purification effect to TN was not obvious while that to TP is significant. Between these two terrestrial plants, *Trifolium repens* has far better purification effect than *Eichhornia crassipes*,and the difference was particularly significant. *Erigeron annuus* (L.), however, had less purification effect than *Eichhornia crassipes*. and the difference was also significant. The results of this study provide new plant resources to ecological restoration of the eutrophic water bodies in winter, especially those polluted by phosphorus.

Keywords: Entrophication; Planted floats; TN; TP; Purification effect

1 Introduction

With the acceleration of urbanization, water pollution is getting more and more serious. The China Environment State Bulletin in 2008 shows that among 28 state key control lakes (reservoir), 78.6% cannot reach the III water standard. Among the 26 lakes (reservoirs), in the status of nutritional monitoring, 3.8% are seriously eutrophic, 19.2% are moderately eutrophic, 23.0% are mild eutrophic[1]. The nitrogen (N) and phosphorus (P) are the main pollution indicators[1,2], so the removal of N and P in eutrophic waters is always the focus of water environment problems[3,4,5,6,7]. At the moment among all the techniques aiming at Eutrophication control, the ecological restoration technique is the most advantageous and promising one, in which the core technique is the phytoremediation[8,9,10]. removing nitrogen and phosphorus by plant metabolism with solar energy, which has the advantage of low investment, low risk, and no secondary pollution, and in favour of establishing a rational aquatic circulatory system. This technique is the hot spot in the research field of water environment, and our country has gained great achievement on phytoremediation[11,12,13,14]. As the plant resource which not only has good removing effect but also can go through the winter safe is scarce, that is not good to annual purification using plant ecological technique towards eutrophic waters, choosing the plant that can ecologically restoring the eutrophic waters in winter has important practical significance. The study shows that a lot of terrestrial plant has potential adjusting power towards water cultivation conditions, which provide new ideas and methods in the adjustment of terrestrial plants to water and the study on control of polluted water[15,16,17]. In this research, we focus on the study of suitable xerophytes, using floating aquatic cultivation plate. After initial domestication, *Trifolium repens* Linn. and (*Erigeron annuus* (L.) Pers, which alive at normal level on the floating aquatic cultivation plate through winter, are selected, study their performance on removing nitrogen and phosphorus in winter landscape water, and compare with the water samples by transplanting *Eichhornia crassipes* Mart. and bare flouting late.

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2 Materials and methods

2.1 Test materials

The natural water of XiChi Lake in Chengdu World Park, which has reached the level of eutrophication, was cho-

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sen as the culture water sample for experiment. The concentrations of total nitrogen and total phosphorus in waters were 6.717mg/L, 2.935 mg/L, respectively.

The plants in experimental group are local xerophyte-*Trifolium repens* and *Erigeron annuus* (L.) The plant in the control group is *Eichhornia crassipes.* and a separate control water sample with floating board added is set.

2.2 Test methods

The plants will be transplanted into the XiChi Lake for two-week artificial domestication, then choose the plants which grow well for experiment. Plant roots will be carefully washed before the experiment to avoid bringing other substances. The step is first select a roof, which not only prevents rain, but also has good ventilation and lighting. Then choose plastic barrels with the volume of 25L, each will be injected into 20L of test water in which the dross is filtered through double gauze, and the foam floating plate cultivation methods are applied. These procedures will be repeated to each plant for 3 times, the average transplanting volumes of *Eichhornia crassipes*, *Trifolium repens*., *Erigeron annuus* (L.) are respectively 60, 25 and 16 g. In the end, the blank control water with no plants transplanted but only foam floating board added are furthermore displayed

2.3 Determination

The experiment was conducted during November-December, 2008, which lasted for 48 days. About every 7 days the concentration of TN and TP were determined and the height, tillering, root length, etc. of the plants were observed. The water sample was removed and the medium was filled with raw water, the evaporation was filled with distilled water, the weights of the plants when stayed dry and wet were respectively measured, the water content and growth rate were calculated. Potassium persulfate digestion and UV spectrophotometric molybdenum antimony resistance[18] are respectively applied as the test method of TN and TP; the quality of the plants without dripping was wet weight while the quality gained after 2-hour 105℃ drying was dry weight; the heights from the surface of floating board substrate to leaf surface of each plant were measured and the average value was chosen to be plant height; the height from the surface under floating plates to the place where the root system is most developed is measured as the length of the root. The growth rate and moisture content rate are calculated using formula (1) and (2) respectively.

$$\text{Growth rate}(\%) = \frac{G - G_0}{G_0} \times 100\% \qquad (1)$$

$$\text{Water content}(\%) = \frac{W - W_0}{W} \times 100\% \qquad (2)$$

G: measured after culture;
G_0: measured before culture;
W: wet weight(g);
W_0: dry weight(g).

2.4 Statistical Analysis

All data is the average value of repeated three times on average, Statistical analyses were done with the software SPSS at the level of significance at $P<0.05$ or 0.01. All data are reported as means ± S.D.

3 Results and Analysis

3.1 Comparison of plant growth in winter

The growth of water *Eichhornia crassipes*, *Trifolium repens* and *Erigeron annuus* (L.) in winter is shown in table 1. See from the growth rate of the three plants, they grow well in eutrophic water in winter except for *Eichhornia crassipes*,. After 48 days of cultivation, the plant height, root length and fresh weight all has a great increase. Among the three plants, the plant height, root length and biomass growth of *Trifolium repens* increase the most, over 50%. In particular, the root growth of it is the growing rapidly, the growth rate up to 73%, and has more growth of new roots and nodules, which indicates that *Trifolium repens* can grow well in the water floating board culture. The growth rate of indicators of *Erigeron annuus* (L.).the biomass growth rate is only 30%. And the *Eichhornia crassipes* is somewhat lower than the others except for the plant height item. Although has new tiller production, the increase of biomass is not obvious. The reason may be that *Eichhornia crassipes* belongs to aquatic plants which cannot stand cold, is difficult to grow in winter and has more death. Therefore, in terms of adaption to eutrophic water in winter, the order of these three plants from strong to weak is: *Trifolium repens*, *Erigeron annuus* (L.)and *Eichhornia crassipes*.

Table 1 Growth conditions of three kinds of plants

	before culture			after culture					Growth rate (%)			water content (%)
Growth status	height (cm)	root (cm)	fresh weight (g)	height (cm)	root (cm)	tiller	wet weight (g)	dry weight (g)	height	root	wet weight	-
Eichhornia crassipes	18.8	3.9	60	20.3	4.3	1	72	6.01	8	10.3	18	91
Trifolium repens	14.5	5.7	25	21.9	9.8	3-4	38.7	4.25	51	73.1	54.8	89
Erigeron annuus	17.3	5.2	10	18.4	7	1-2	20.7	2.36	6.4	34.6	30.2	89

Note: The data in the table for each species are average of three repeat samples

3.2 Removal of TN

Figure 1 shows that during the 48-day growth period, *Eichhornia crassipes*, *Trifolium repens* and *Erigeron annuus* (L.) all has some effect to remove TN in eutrophic water. The removal rates of TN are respectively 20%, 21% and 22%.The removal rates are positively correlated in plant biomass with correlation coefficients> 0.6; t test results of paired samples (Table 2) shows that there are significant differences of the removal effect to total nitrogen between transplanted plants water samples and control water samples (P <0.05), which has no significant difference compared with the removal effect to TN of transplanted hyacinth samples (P> 0.05). This indicates the existence of these types of plants can significantly improve the system removal capacity to TN, yet the difference on removal of TN between the plants is not significant.

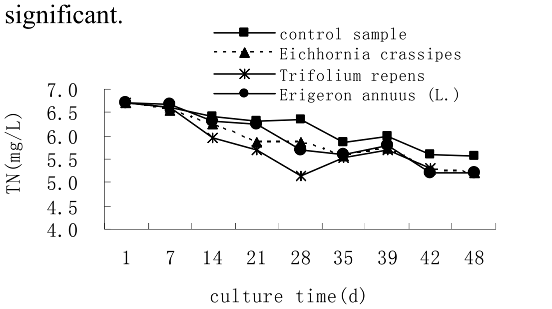

Fig. 1 Comparison of removal effects on TN in eutrophic water bodies between selected plants and *Eichhornia crassipes* Mart.

Table 2 TN Paired Samples Test

	Paired Differences					t		
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	df	Sig. (2-tailed)
Trifolium – control	-.4557	.38161	.1442	-.8086	-.1027	-3.16	6	.020
Erigeron - control	-.3185	.22960	.0867	-.5309	-.1062	-3.67	6	.010
Trifolium Eichhornia	-.0985	.12720	.0480	-.2162	.01907	-2.05	6	.086
Erigeron - Eichhornia	.03857	.17344	.0655	-.1218	.19898	.588	6	.578

3.3 Removal of TP

The removal effects of *Eichhornia crassipes*, *Trifolium repens* and *Erigeron annuus* (L.) to TP in eutrophic water are shown in figure 2.

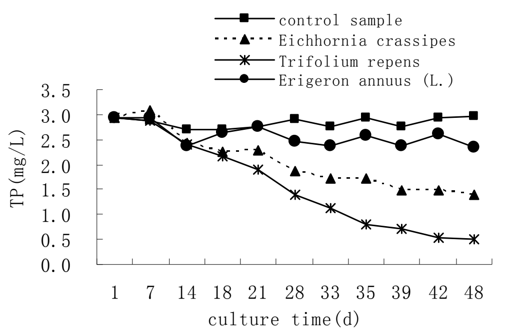

Fig.2 Comparison of removal effects on TP in eutrophic water bodies between selected plants and *Eichhornia crassipes* Mart.

Some Studies showed that high concentration nutrient salt could promote plant's growth and absorbing & accumulation of phosphorus, but due to the different species and physiological characteristics, a greater degree of difference still exists. As shown in figure 3, in the eutrophic water with high nitrogen and phosphorus contents of 6.717mg / L and 2.935 mg / L, during 48 days -growth period, *Trifolium repens*, *Erigeron annuus (L.)*. and *Eichhornia crassipes*. have all-right removal rates of TP, the removal rate are 53%, 82% and 21%, respectively. Especially, during 1-35 days, *Trifolium repens* and *Eichhornia crassipes* remove TP obviously. The figure 3 indicts the Linear fitting curve and regression equation of TP removal in water during 1-35 days and 35-48 days. During 1-35 days, TP removal curve slope was significantly higher than that of 35-48 days. And in 1-35 days, *Trifolium repens* had a better TP removal effect than *Eichhornia crassipes* Mart., but in 35-38 days, the TP removal effect tended to the same.

Figure 3 is the linear curve fitting and regression equation of total phosphorus removal state in water during 1-35 and 35-48mdays, and it's obvious to see that during 1-35 days the slope of P removal curve was significantly higher than that of 35-48 days. The removal efficiency on the total phosphorus of *Trifolium repens* is better than that of *Eichhornia crassipes*, and the purification trend of *Trifolium repens* was consistent with *Eichhornia crassipes* in 35-48 days.

The results show that changes in plant biomass are positively related to the removal efficiency of total phosphorus, and TP correlation coefficient of *Trifolium repens Eichhornia crassipes* biomass is >0.9, and the correlation coefficient of *Erigeron annuus* is 0.4. See from the combination of growth characteristics of several plant, as most one year Punta grow on slopes, beside roads and in the fields, its demands little for phosphorus, so its purifying effect of phosphorus is also poor. On the

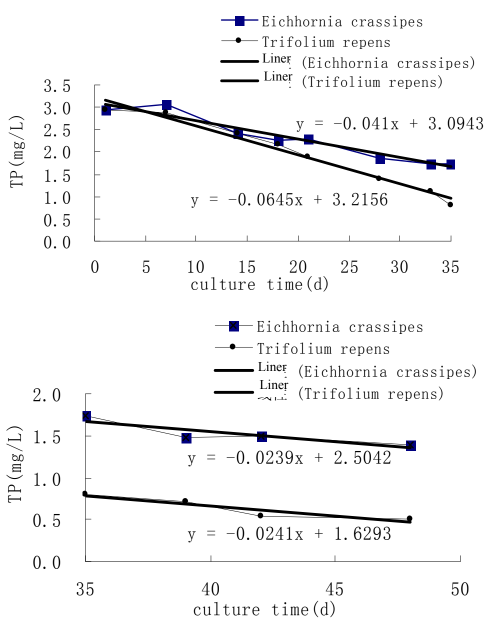

Figure3. Curve: system result of standard experiment

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contrary, *Trifolium repens* and *Eichhornia crassipes* demand high for phosphorus, so their purifying effect of phosphorus is also better than *Erigeron annuus*.

The removal efficiency to TP of some plants and that of the control group (paired t test showed (Table 3) is significantly different ($P < 0.01$), while difference between the sample of transplanting terrestrial plants and that of *Eichhornia crassipes* is extremely significant ($P < 0.01$), just the purification capacity of *Trifolium repens* is better than *Eichhornia crassipes*, and that of *Eichhornia crassipes* is better than year Punta. This shows that the presence of plants can significantly increase the removal capacity of TP in the system, and there exists big difference of removal capability to TP between different plants. The removal capacity to TP of these 3 plants in eutrophic water in winter, from strong to weak, is as follows, 3 species of phosphorus: *Trifolium repens*, *Eichhornia crassipes*, *Erigeron annuus*.

It can also be seen from Figure 3 that TP in control group water samples has increased by 6% during the trial period. After analyzing the causes, it may be due to the dust which brings part of phosphorus. In terms of the removal efficiency to TP in the water, *Trifolium repens* is the best. If take increase of the control value of total phosphorus in water samples into consideration, the removal efficiency of *Trifolium repens* to TP is nearly 90%, which can be used in the plants ecological restoration in winter eutrophic water.

Therefore, from the growth state of all plants, the removal efficiency to nitrogen and phosphorus, it is considered that the removal efficiency to total nitrogen of eutrophic water in winter, from strong to weak, is as follows: *Trifolium repens*, *Eichhornia crassipes* , *Erigeron annuus*.

4 Conclusion

This paper uses floating plate cultivation techniques, study on the purifying effect of total nitrogen and phosphorus in eutrophic landscape lake in winter of *Erigeron annuus* and *Trifolium repens*, the effect are compared with that of *Eichhornia crassipes* and blank water samples. Research suggests that in eutrophic water, all dry screening plant chosen can grow well. Compared with the *Eichhornia crassipes*, *Trifolium repens* grows faster, has more biomass, can adapt better to the eutrophic water better and its purification effect to TN and TP is obviously far better. Although there's no difference between the purifying effect to total nitrogen of one year Punta and *Eichhornia crassipes*, the removal effect of phosphorus is not good and the growth in biomass was not significant. Therefore, the *Trifolium repens* should be the first choice in the practical application. This paper suggests that *Trifolium repens* has the advantage on removing total nitrogen and phosphorus in eutrophic water bodies in winter. The result provides new plant resources for the treatment to eutrophic water bodies and certain scientific basis for further study of the terrestrial plant restoration in eutrophic water in winter.

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References

[1] Ministry of Environmental Protection of the People's Republic of China. China's environmental situation in the gazette[M]. Beijing: China Environmental Science Press China(in Chinese with English abstract)

[2] Jing Xiang-chan. The control and management technique Lake eutrophicated.[M]. Beijing: Chemical Industry Press China(in Chinese with English abstract)

[3] Saygin,Tomruk. Phosphate and nitrogen removal from wastewater by the plant paspallum paspalodes[J]. Fresenius Environ Bull.1992,l(11):695-699.

[4] Chang H.Q., Yang X., Fang. YY. In-situ nitrogen removal from the eutrophic water by microbial-plant integrated system[J]. Journal of Zhejiang University Science B, 2006, 7, 521-531.

[5] Miao Lia, Yue-Jin Wua, Zeng-Liang Yua et a1. Nitrogen removal from eutrophic water by floating-bed grown water spinach (*Ipomoea aquatica* Forsk.) with ion implantation[J]. Water Reserch. 2007 (41) 3152-3158.

[6] Stephen R, Carpenter,et a1. Biological control of entrophication in lakes. Environ Sci Technol, 1995,29(3):784-786.

[7] Wang D R, Cui S Z, Zhao J,et a1. Purification of nitrogen and phosphorus in secondary treatment effluent by aquatic plants. Environ Chem 1990,9(6):44-48.

[8] Wu Xiang. Genotvpic differences in effectiveness of phosphorus removal from eutrophic water under floating culture conditions and some mechanisms[D].Hang Zhou: Zhe Jiang University. 2008.8. (in Chinese with English abstract)

[9] WANG Guo-xiang, PU Pei-min, ZHANG Sheng-zhao.The purification ability of aquatic macrophytes for eutrophic lake water in winter[J]. China Environmental Science,1999,19 (2):106-109. (in Chinese with English abstract)

[10] GUO Pei-yong, ZHU Yin-mei, SONG Xiang-fu. Remediation of eutrophic water by terrestrial plant in enclosure:the purification effect and dynamics processes of Lolium multiflorum for removing TP[J]. Journal of Zhejiang University(Science Edition),2007,34(5):560-564. (in Chinese with English abstract)

[11] Chen Li, GUO Pei-young, LIN Yu.Effect of terrestrial plants with different planting patterns on phosphorus removal in eutrophic water[J]. Journal of Zhejiang University(Science Edition),2009,36(6):699-704. (in Chinese with English abstract)

[12] Ma Zhan-qing1, WEN Shu-yao.Removal of Nitrogen and Phosphorus in Eutrophic Water with Humulus scandens[J] Journal of Soil and Water Conservation,2009,23(3):53-57. (in Chinese with English abstract)

[13] Wei Fu-shen.shui he fei shui jian ce fen xi fang fa(IV)[M]. Beijing: China Environmental Science Press China (in Chinese)

[14] Chang H.Q., Yang X., Fang. YY. In-situ nitrogen removal from the eutrophic water by microbial-plant integrated system[J].

Journal of Zhejiang University Science B, 2006, 7, 521-531.
[15] Xie Y. H., Dan Y., Ren B. Effects of nitrogen and phosphorus availability on the decomposition of aquatic paints[J].Auqatic Botany.2004.80:29-37.
[16] Fang Yun-ying.Efficiency and Mechanism of Uptaking and Removing Nitrogen from Eutrophicated Water using Aquatic Macrophytes[D]. Hang Zhou: Zhe Jiang University. 2006. (in Chinese with English abstract)
[17] Zhou Xiao-Ping, Xu Xiao-Feng,Wang Jian-Guo. Nitrogen and phosphorus removal performance by three planted floats in eutrophic water bodies in winter.[J]. Chinese Journal of Eco-Agriculture.2007,15(4):102-104. (in Chinese with English abstract)
[18] Fang Jian-xin. Utilization about Escape Plant of *Erigeron annuus*(L.) Pers.[J]. Resource Development & Market 2006, 22(6)474-475. (in Chinese with English abstract)

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