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Removal Effects on Nitrogen, Phosphorus and COD in Water Body of Shanghu Lake Ecological Wetland in Taihu Lake Watershed

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Abstract

Shanghu ecological lake wetland is mostly made up of woody plants. So far, its removal effects on nitrogen and phosphorus are unknown. The removal effects on TN, TP, AmmN and COD in wastewater of Shanghu lake wetland were studied from July, 2008 to May, 2009. The relationship between removal effects on pollutants and temperatures of water body was studied too.192 samples were collected from input point, output point, and 6 points in water body. The results show that the wetland has always a good removal effect on TN, TP and AmmN under different water temperature, the water temperature has influence on removal effects to various extents. First report to removal effects on nitrogen and phosphorus of Shanghu lake wetland and woody plants wetland in China.

Keywords: Taihu Lake Watershed, Shanghu Lake Ecological Wetland, Nitrogen and Phosphorus, COD, Removal Effects

Introduction

With the acceleration of industrial growth and the increasing population, the natural environment is constantly deteriorating. The water pollution is becoming increasingly severe. Over 90 percent of the water body in ponds and lakes of city's parks in China is polluted to some degree, and most of the indexes of total nitrogen (TN), total phosphorus（TP） and ammonia nitrogen（NH_3-N） are beyond the environmental quality standards of level 4 for surface water [1,2]. Since 1970s, aquatic plants were given attention for searching high effect and low cost wastewater disposal technology. Aquatic plants not only have high ornamental value, but also provide purification to eutrophication water body via initiative absorption from the water body. So, the wastewater disposal function of aquatic plants and ecological wetland has been used and paid attention more and more.

The Shanghu lake ecological wetland is located at suburban district of Changshu city in Taihu lake

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watershed. It is important to local climate, such as temperature and humidity, for improving the city's ecological environment, and for purifying wastewater of Taihu lake watershed. There are no reports about the removal effects on non-point source wastewater of the Shanghu lake wetland and the wetland constructed by woody plants according to documentary sources until now. It is significance to study on removing nitrogen and phosphorus, which have been one of the key factors leading to the eutrophication of water bodies, of the Shanghu lake wetland.

Material and Methods

Testing location. The Shanghu lake ecological wetland, which is located at suburban district of Changshu city in Taihu lake watershed in East China, is one of the top ten city ecological parks and one of the most important ecological wetlands in Taihu lake watershed. Its territorial waters area is 800 ha. It has over 300000 woody plants of 173 families, mostly Pond Cypress (*Taxodium ascendens* Brongn.), Phragmites communis Trin. (*Phragmites* Trin.) and Cattall Pollen （*Typhaang ustifolia*），which formed a kind of particular Pond Cypress community forest wetland landscape.

Testing time. It lasted for nearly one whole year from July 2008 to May 2009; including every period when water temperature varies.

Sampling methods. The 192 samples were taken from water inlet, water outlet, and 6 fixed sampling points of lake body individually (Table 1).

Table 1 The sample points distribution in Shanghu lake

Number	1	2	3	4	5	6	7	8
Sample points	Inlet	lake body						Outlet
		East lake	Dazhai gate	West lake	Lajidui	Tanchun bridge	North lake	

Determining methods. COD（chemical oxygen demand）, pH, TN, NH_3-N and TP were determined according to *water and wastewater monitor analysis methods* (the 4th edition) [2]. COD: used Permanganate Index method to determine; pH: used pH meter method to determine; TN, NH_3-N and TP：used flow injection analysis method to determine; TN, NH_3-N, TP and COD removal rate statistical methods: TN(NH_3-N, TP or COD） removal rate =[inlet TN(NH_3-N, TP or COD）- outlet TN(NH_3-N, TP or COD）] /outlet TN(NH_3-N, TP or COD）×100%.

Results and Analysis

The removal rate under the different water temperature variables. TN, NH_3-N, TP, and water temperature were sampled and determined one time individually in July 2008, November 2008, and January 2009. The results are shown in Table-2, Table-3 and Table-4.

Tab. 2 The values of nitrogen and phosphorus from Shanghu lake wetland under 30℃ water temperature

Sample points	Water Temperature [℃]	pH	NH_3-N[mg.m^{-3}]	TN[mg.m^{-3}]	TP[mg.m^{-3}]
Water inlet	30.5	7.87	0.56	2.63	0.10
Average of water body	29.7	8.49	0.33	0.58	0.02
Water outlet	30.2	8.41	0.06	0.86	0.05

Tab. 3 The values of nitrogen and phosphorus from Shanghu lake wetland under 13℃ water temperature

Sample points	Water temperature [℃]	pH	NH_3-N[mg.m^{-3}]	TN[mg.m^{-3}]	TP[mg.m^{-3}]
Water inlet	16.4	7.54	1.38	2.63	0.10
Average of water body	13.5	8.40	0.04	0.33	0.05
Water outlet	13.8	8.24	0.10	0.66	0.04

Tab. 4 The values of nitrogen and phosphorus from Shanghu lake wetland under 5℃ water temperature

Sample points	Water temperature [℃]	pH	NH_3-N[mg.m^{-3}]	TN[mg.m^{-3}]	TP[mg.m^{-3}]
Water inlet	5.2	7.71	1.35	2.56	0.19
Average of water body	5.0	8.19	0.06	1.01	0.06
Water outlet	5.2	8.05	0.08	0.82	0.04

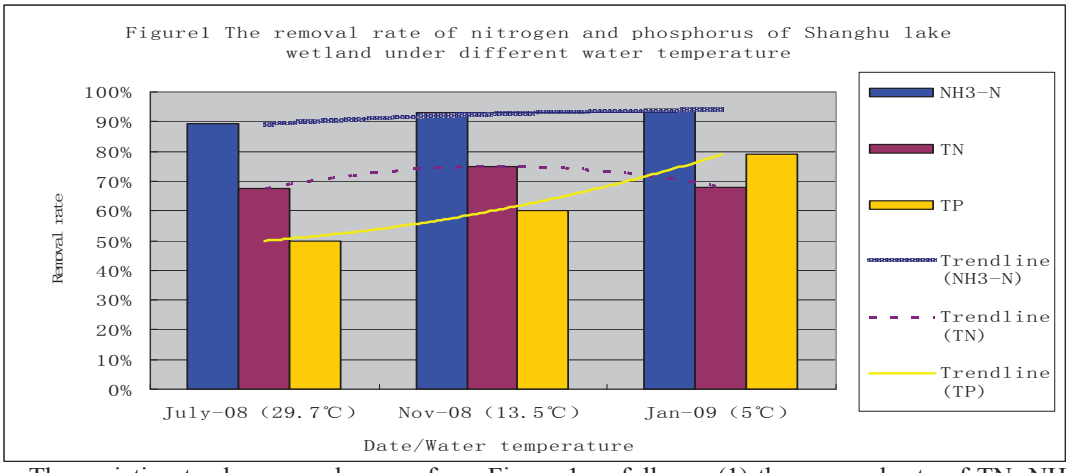
According to Table 2, Table 3, and Table 4, the removal rates of nitrogen and phosphorus of Shanghu lake wetland under varying water temperatures were statistically analyzed. The results are shown in Table 5 and Figure 1.

Shanghu lake ecological wetland has always a good effect on removal of the nitrogen and phosphorus in water body under different water temperatures (Table 5). There is an obvious purification effect when the surface runoff contained nitrogen and phosphorus into Shanghu lake ecological wetland, via contrast the water inlet indicators of TN, NH_3-N, and TP with water outlet, the removal rates of TN, NH_3-N, and TP are all beyond 50%.

Tab. 5 The removal rates of nitrogen and phosphorus of Shanghu lake wetland under different water temperature

Date of sample	Water temperature [℃]	Removal rate [%]		
		NH_3-N	TN	TP
July 2008	29.7	89.3%	67.3%	50.0%
November 2008	13.5	92.8%	74.9%	60.0%
January 2009	5.0	94.1%	68.0%	78.9%

The removal rate of NH_3-N is the highest, which is always beyond 89.3% under any water temperature, with the maximum removal rate 94.1%. The removal rate of TN is closest under different temperatures, which is between 67.3% and 74.9%. And the removal rate of TP is the lowest, which is between 50.0% and 78.9%, with the minimum removal rate50.0%.



The variation tendency can be seen from Figure 1 as follows: (1) the removal rate of TN, NH_3-N, and TP is different in the water body of Shanghu lake wetland, with the overall tendency of NH_3-N >

TN > TP; (2) when water temperature is reduced, the removal rate of NH_3-N and TP in the water body of Shanghu lake wetland is in a rising trend, which means that when the water temperature is lower, the removal rate of NH_3-N and TP in the water body of Shanghu lake wetland is higher, and the removal effects of NH_3-N and TP in the water body of Shanghu lake wetland is better, especially TP; (3) the removal rate of NH_3-N is always higher under any temperature comparing to TN and TP; (4) the removal rate of TP is related with water temperature to a certain extent, the moderate water temperature of a little more than 13℃ is optimal for the TP removal.

The relationship between the COD removal rate and the water temperatures. The results show that the COD value is reduced to varying extent through the purification of Shanghu lake wetland. The aquatic trees in Shanghu lake wetland have certain removal effects on COD (Table 6).

Tab. 6 The COD content in Shanghu lake ecological wetland under different water temperature

Sample points	Jan-09		Feb-09		Mar-09		Apr-09		May-09		Jul-08		Nov-08	
	w.t.	COD	w.t.	COD	w.t.	COD	w.t.	COD	w.t.	COD	w.t.	COD	w.t.	COD
Water inlet	5.2	19	5.2	18	9.2	19	14.1	20	19.1	19	30.5	21	16.4	22
Average of water body	5.0	15	5.1	15	9.2	15	14.6	19	19.6	18	29.7	13	13.5	20
Water outlet	5.2	11	5.0	10	9.4	11	14.3	16	19.5	14	30.2	13	13.8	18

Note: w.t. is short for water temperature; the COD unit is $mg.m^{-3}$; the water temperature unit is ℃.

The COD removal rate of Shanghu lake wetland under vary water temperature is statistically analyzed according to Table 6 (Table 7).

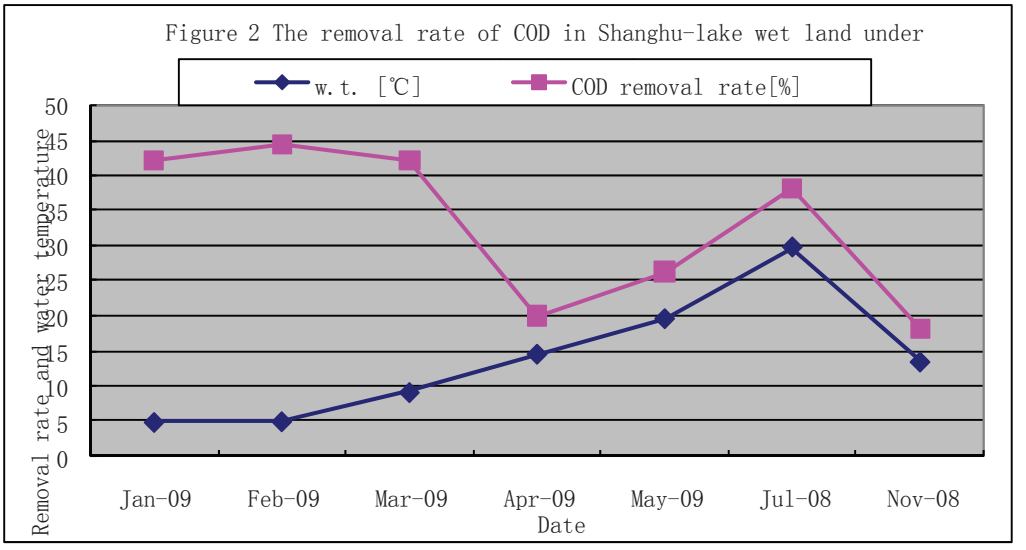
Tab. 7 The removal rate of COD in Shanghu lake wetland under vary water temperature

Projects	Date and results						
	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jul-08	Nov-08
w.t. [℃]	5.0	5.1	9.2	14.6	19.6	29.7	13.5
COD removal rate[%]	42.1	44.4	42.1	20.0	26.3	38.1	18.2

Note: w.t. is short for water temperature; the date is sample date.

The relationship of the removal rate of COD with water temperature is shown in Figure 2.

The research results show the significant correlation between the water temperature of Shanghu lake wetland and the removal rate of COD, shown in Table 7 and Figure 2.



As far as the date and the water temperature is concerned, the COD removal rate shows a declining tendency along with the water temperature declined from July to November (5~13.5℃). But the COD removal rate showed an ascending tendency along with the water temperature decline further from November to February for next year. The COD removal rate is at its maximum when the water temperature is at its minimum in February (5.1℃), but the rate is at its minimum when the water temperature is at its maximum in November (13.5℃). The COD removal rate shows an ascending tendency again along with the water temperature ascending from April to July (13.5~29.7℃).

Discussion

The Shanghu lake ecological wetland has improved the water quality of Shanghu lake effectively. The removal rates of TN, TP and AmmN are significance. The outlet water quality is continuously better than the National Level 2 or Level 3[2]. And the TN, TP and AmmN values in outlet water quality are lower than the treatment effect of wastewater plant in the same period. The aquatic woody plants in Shanghu lake ecological wetland had good purification effects on nitrogen and phosphorus in water body. And the Shanghu lake ecological wetland is a kind of economical and effective method. First report to removal effects on nitrogen and phosphorus of Shanghu lake wetland and woody plants wetland in China.

The principle of wetland purifying is the synergetic and interaction of plants, soil and microorganisms in wetland [3]. Artificial wetland acts through the optional regrouping of physical, chemical and biological action in nature ecosystem, to treat the sewage. Many studies showed[4-6] that it has many merits of using the aquatic plants treatment system to control the water pollution, such as low investment, maintenance and operating costs, simple management, good treatment effects, improving and restoring eco-environment, recycling resource and energy, and harvesting economic plants, etc..

As a new type of technology, the ecological wetland has the results of beautifying environment and relieving greenhouse effect. It has a good performance in treating sewage and purifying eutrophicated water [7]. It has a bright future to use aquatic plants to purify sewage, especially for developing countries including China, with their awkward conditions of the environmental pollution and ecological deterioration, at the same time, without adequate funds to control pollution. The wetland purification gives an alternative treatment technique, and becomes a focus point for study on sewage treatment. The aquatic higher plants growing in polluted water body can improve water quality, relieve or eliminate pollution through the plants' life activities to decompose, transpose or enrich the SS and contamination [8].

The aquatic plants in ecological wetland are susceptible to seasons, both of the cold tolerance plants and thermopile plants need to be studied to adapt the varying season for different districts through the optimal community assembly of different plants so as to optimize sewage treatment effects. This problem needs further research.

It also needs further research to resolve the difficult problem of the mosquitoes infesting in wetland if the aquatic plants grow overstocked or the plants residue salvaged untimely.

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