Analysis of Water Environment Status and Pollution Source at Plain River Network Area

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Abstract: The construction of clean small watersheds for the "Diversion from the River to the Nest" project requires an analysis of the current water quality of the plain river network area. This study aimed at the typical plain river network basin—Zhaohe River Basin, analyzed the current water quality in the basin and the sources of pollutants in the basin and used the WQI model to evaluate the water quality pollution status of the whole basin.So as to provides references for water pollution control and clean construction projects in plain river network areas.The results show that the water quality of 2/3 of the tributaries in the basin is at or inferior to Grade V, the main influencing factors are TN and TP. Pollutants mainly come from non-point source pollution in the process of agricultural production in the basin. Livestock and poultry breeding contribute the least to TN pollution, and rural life pollution contributes the least to TP pollution.

1 INTRODUCTION

The typical plain river network area is characterized by abundant rainfall, gentle terrain, dense river network, warm and humid climate, and developed agriculture and livestock and poultry breeding industries (Shen, 2015). A large number of pollutants produced by agriculture and livestock and poultry breeding will be concentrated in the surface layer of the soil (Zhang, 2010), and enter ditches or rivers with rainfall runoff. However, the flat terrain in the plain river network area and the slow flow of the river can easily cause the wild growth of algae and cause the eutrophication of the water body (Zhong et al., 2021).

Chaohu Lake Basin has been in a state of alternating light to moderate pollution in recent years, and the water quality of lakes in the middle and lower reaches of the country (Zhang et al., 2020). Zhaohe River is one of the main inflows of Chaohu Lake and the main trunk line of " bringing the river to Chaohu". The river network is dense and belongs to a typical plain river network area in my country (Wang et al., 2019). Therefore, this article takes the Zhaohe River Basin as the research object, analyzes the water pollution status in the basin, identifies the main sources of pollutants in the basin and key areas where pollutants are generated, and provides references for water pollution control and clean construction projects in plain river network areas.

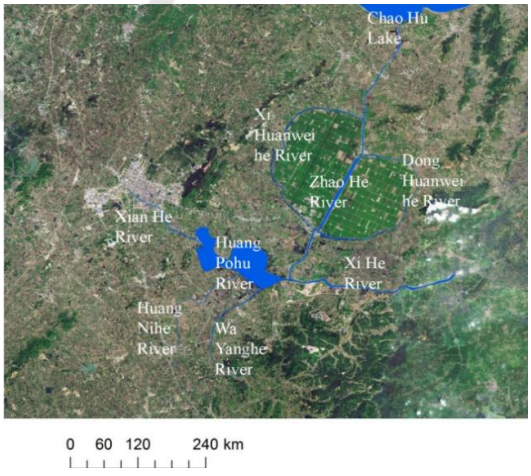

Figure 1: Location and water system map.

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2 OVERVIEW OF THE RESEARCH AREA

Zhaohe River Basin is located in Lujiang County, Anhui Province, China, in the south of Jianghuai hills, near Chaohu Lake in the north, and near the Yangtze River in the south belonging to the Yangtze River system. The main rivers in the basin include 11 rivers including Zhaohe, Xianhe, Xihe, Huangnihe and Wayanghe etc. The specific location of the basin and the distribution of river channels are shown in Figure 1. The study basin belongs to the northern subtropical monsoon region, with a mild and humid climate and four distinct seasons; the average annual rainfall is 1464mm, the precipitation is unevenly distributed during the year, and the phenomenon of plum rain and summer drought is obvious; the south wind is dominant in summer, and the north wind is dominant in winter.

3 DATA COLLECTION AND RESEARCH METHODS

3.1 Data Collection

The main water quality in the basin was collected and analyzed in the main tributaries (11 tributaries) and the main stream in the basin from 2018 to 2019. Based on a preliminary analysis, the most prominent type of pollution exceeding the standard in the basin is total nitrogen, followed by total phosphorus. Therefore, each sample mainly analyzed water quality indicators such as total nitrogen, total phosphorus, ammonia nitrogen and chemical oxygen demand. And in accordance with the " Environmental quality standards for surface water" (GB3838-2002) to evaluate the current water quality in the study area (Ministry of Environmental Protection, 2002).

3.2 Research Methods

The water quality index is a normalized dimensionless number that integrates multiple water quality parameters. The parameters to be considered depend on the use of water. The water quality parameters usually considered include DO, BOD_5, COD, pH, SS, NH_3-N, TN and TP etc. (Zhao et al., 2020). This paper mainly uses the WQI model to evaluate the water quality pollution status of the whole basin, selects 6 water quality parameters of water body DO, BOD5, COD, pH, SS, NH_3-N, and transforms these water quality parameter variables according to the classification index function (SI). As a non-spatial variable, the SI calculation formulas for different parameters are shown in Table 1.

Table 1: The sub-index equations for WQI.

Water quality parameters	Value	Categorical exponential function
DO	X≤8	$SI_{DO}=0$
	8<X<92	$SI_{DO}=-0.395+0.03X^3-0.0002X^3$
	X≥92	$SI_{DO}=100$
BOD_5	X≤5	$SI_{BOD5}=100.4-4.23X$
	X>5	$SI_{BOD5}=(108e^{-0.055X})-0.1X$
COD	X≤20	$SI_{COD}=99.1-1.33X$
	X>20	$SI_{COD}=(103e^{-0.0157X})-0.04X$
NH_3-N	X≤0.3	$SI_{NH3-N}=100.5-105X$
	0.3<X<4	$SINH3-N=(94e^{-0.573X})-51X-21$
	X≥4	$SI_{NH3-N}=0$
SS	X≤100	$SI_{SS}=(97.5e^{-0.00676X})+0.05X$
	100<X≤1000	$SI_{SS}=(71e^{-0.0016X})+0.015$
	X≥1000	$SI_{SS}=0$
pH	X<5.5	$SI_{pH}=17.2-17.2X+5.02X^2$
	5.5≤X<7	$SI_{pH}=242+95.5X-6.67X^2$
	7≤X<8.75	$SI_{pH}=-181+82.4X-6.05X^2$
	X≥8.75	$SI_{pH}=536-77X+2.76X^2$

Note: The variable unit represented by X is mg/L, where pH is dimensionless

WQI model calculation formula:

$WQI=0.22SI_{DO}+0.19SI_{BOD5}+0.16SI_{COD}+0.15SI_{NH3\text{-}N}+0.16SI_{SS}+0.12SI_{pH}$

In the formula: SI stands for classification index. According to the input water quality test data of the model, the water quality of the sampling points is normalized to between 0 and 100, and according to the degree of water pollution, the water quality is divided into 6 categories from 0 to 100, corresponding to severe pollution (<31.0), pollution (31.0-51.9), light pollution (51.9-76.5), better (76.5-92.7) and good (>92.7).

4 RESULTS AND ANALYSIS

4.1 Analysis of the Current Situation of the Water Environment of the Zhaohe River

It can be seen from Table 2 that the pollution situation in the study area is relatively serious. Two-thirds of the rivers have water quality of V or worse. Only the quality of Wayang River, Shungang River and Zhaohe River is in good condition, which can meet the requirements of clean watershed and the goal of construction (quality of III). TN in the study area is the main pollutant exceeding the standard, after it is TP.

Table 2: Evaluation of water environment status of main polluted rivers in the study area.

River monitoring point	Detection Indicator(mg/L)				Water quality category	Substances and multiples that exceed the standard (Class III)
	TN	TP	NH_3-N	COD_{CR}		
Shicaohe river	3.02	0.11	0.65	5.85	worse than V	TN (2.02)
Huangtunhe river	1.85	0.29	1.19	19.62	V	TN (0.85)TP (0.45)
Wayanghe river	0.97	0.06	0.29	10.12	II	——
Huangnihe river	3.18	0.29	1.89	27.38	worse than V	TN (2.18) TP (0.45)
Shunganghe river	0.52	0.07	0.10	12.67	III	——
Peihe river	4.01	0.35	3.05	38.6	worse than V	TN (3.01) TP (1.75)
Dongdawei river	1.79	0.19	1.47	21.83	V	TN (0.79)
Xidawei river	1.12	0.14	0.61	20.4	IV	TN (0.12)
Shengqiaohe river	2.38	0.23	1.61	24.89	worse than V	TN (1.38) TP (0.15)
Mainstream of the West River	1.85	0.18	1.32	27	V	TN (0.85)
Xian he river	4.70	0.57	3.47	24.92	worth than V	TN (3.70) TP (1.85)
Upper Zhaohe river	1.02	0.19	0.34	29	III	——

Analyzing the monthly changes of TN and TP in the main stream waters in the study area (Figures 2 and 3), it can be seen that the main stream has serious total nitrogen pollution, and the water quality is inferior to V. The highest concentration peak appeared in August 2016 which reached 2.6 times of the water quality of V. With the artificial treatment of water bodies, the TP concentration began to decline after mid-2017; the TP content of water bodies is relatively low, and most of them meet the requirements of II water quality standards, but do not exceed the III water standards.

4.2 Analysis of Pollution Sources in the Basin

The TP emission in the study area is about 7,996 tons/year, and the TN and NH_3-N emissions are 7,907 tons/year and 1,299 tons/year, respectively (Table 3), which puts greater pressure on the water environment of the basin.

According to the research of Wang et al. (2019), TN and TP in the Zhaohe River Basin mainly come from agricultural production. According to the composition of pollution sources in the basin (Figure 4), agricultural production pollution

accounts for the largest proportion of TN and TP sources, reaching 66% and 94% respectively. Therefore, the pollution control of the watershed in the study area needs to focus on the prevention and control of agricultural production pollution. In addition, the point source pollution of urban life is the direct source of water pollution, and the amount of its discharge will directly cause the fluctuation of the pollutant content in the river, so it also needs attention.

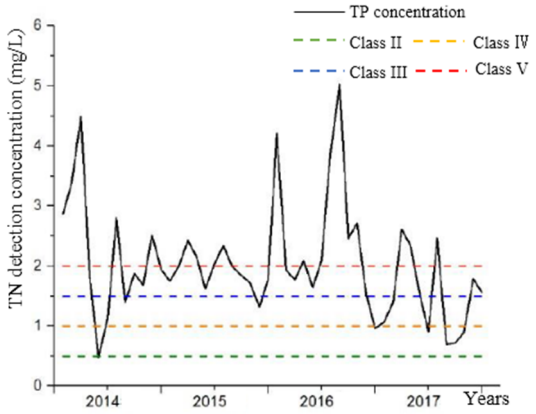

Figure 2: Monthly change of TN content.

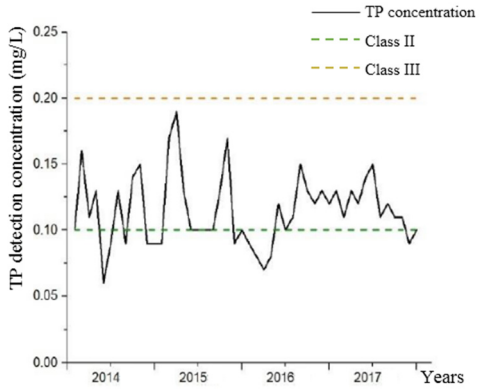

Figure 3: Monthly change of TP content.

Table 3: Current status of nitrogen and phosphorus pollution input in the study area.

Pollution source classification		Input of nitrogen and phosphorus pollution(T/a)			Into the river property
		TN	TP	NH_3-N	
Non-point source	Rural life	1535.47	71.87	653.39	Access to the river
	Livestock and poultry breeding	459.93	345.71	266.74	Access to the river
	Agricultural Production	5203.6	7533.18	-	Access to the river
Point source	Town life Industrial and mining enterprises, etc.	707.99	45.94	378.73	Directly into the river
total		7906.99	7996.70	1298.86	-

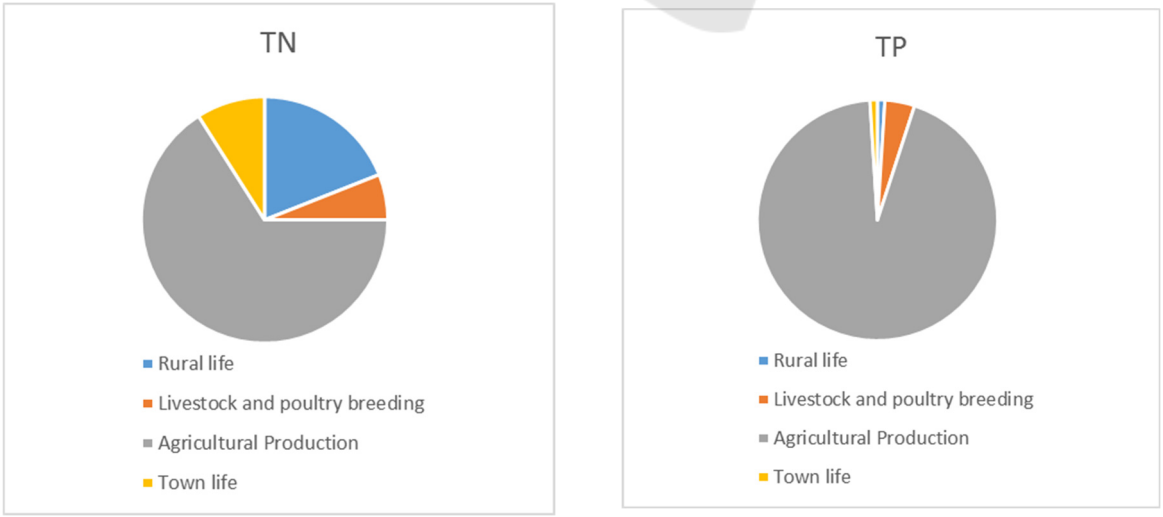

Figure 4: The main sources of pollutants in the study area.

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5 CONCLUSION

By analyzing the current situation and pollution sources of the water environment in the Zhaohe Basin, a typical plain river network basin, the following research results are obtained: The overall water quality of the Zhaohe River Basin is poor. Two thirds of the tributaries have water quality at Class V or Class inferior V. TN and TP are the main pollutants in the basin. In recent years, comprehensive improvement projects have been achieved. With certain results, the water quality of the basin is gradually improving. From the analysis of the sources of pollutants, the TN and TP in the study area mainly come from agricultural production, and it is necessary to focus on monitoring and controlling the TN and TP produced in the agricultural production process.

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