

Analysis of non-point and point source pollution load in DongPieHong Ditch

Yu Shan* · Jun Chen* · Jie Jin* · YongLian Song* · Jun Liu* · DongBiao Wu* · Ke Wu**

Abstract: In this study, the DongPieHong Ditch were taken as the research object, five sampling points were set to measure the COD, NH₃-N, TN and TP indexes. The correlation and principal component analysis were used to judge the main pollution sources and calculate pollution contribution rate. According to the population in the basin, the load of point source pollution into the river was estimated. As a result, the load of COD, NH₃-N and TP into the river was 323.04t/a, 43.8t/a and 3.9t/a, respectively. According to the statistics of the rainfall in the basin, the concentrations of COD, TP and NH₃-N in the initial rainwater were measured and calculated for non-point source pollution, and the results shown that the inflow loads of COD, NH₃-N and TP into the river were 34.59t/a, 0.12t/a and 0.71t/a, respectively. It was found that the main cause of the pollution in the east flash flood gully was point source pollution, and the proportions of COD, NH₃-N and TP into the river were 90.33%, 99.72% and 84.61%, respectively.

Key Words: water pollution; principal component analysis; point source pollution; water quality monitoring;

1. Introduction

Natural water bodies played an important role in the balance of ecological environment, so the treatment of black and odorous water had become one of the key points of environmental governance^[1-2]. In line with the principle of “regulating pollution first”, identifying river pollutants and pollution sources was the premise of river regulation. The commonly used pollution source analysis method was to use the receptor model to carry out principal component analysis on water quality indicators^[3-4], and then combined the field investigation to determine the pollution source type for pollution load calculation, and obtained the main pollution source^[5].

To protect to Chao lake ecology was the hot topic in China[6-9]. This study was the analysis of point source pollution load in the small watershed of DongPieHong Ditch, Chao Lake. The water quality monitoring number used SPSS principal component analysis to identify the main pollution sources^[10], combined with hydrology, topography, drainage network and the runoff coefficient to calculate surface runoff^[11-12], agricultural non-point source^[13], the source of town pollution load, analyzed the structural characteristics of the pollution

source^[14], and provided the basis for the design of the treatment plan.

2. Materials and Methods

2.1 Study Area

DongPieHong Ditch (117° 52' 58.57" E, ~117° 53' 01.11" E, 31° 37' 04.81" N, ~31° 35' 02.80" N) has a total length of 2.7 km and a drainage area of 1.21 km². The bottom elevation is 6.47–8.96 m, and the bottom of the river is 5–8 m wide.

2.2 Sample Collection

2.2.1 River water sample sampling

Five sampling sections (Fig. 1) were set up from upstream to downstream of the river. Water samples were collected by water sampler and returned to the laboratory for COD, NH₃-N and TP concentrations.

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Fig.1 Distribution of sampling points in DongPieHong Ditch

2.2.2 Surface runoff sampling

Moderate rain or heavy rain was selected for monitoring. In the initial flushing stage of rainfall, samples were collected within 30min of the self-generated flow and every 5min. One sample was taken every 10 min between 30 and 60 min. Samples were then sampled at intervals of 30min, with a total sampling time of 3h. Take three equal water samples at each time period, and monitor the concentration of COD, NH₃-N and TP after mixing evenly.

2.3 Pollution Load Calculation Model

2.3.1 Town point source pollution

According to the per capita comprehensive discharge coefficient, the pollutant emissions of residents' living can be calculated. The per capita comprehensive discharge coefficient can be checked by the "Handbook for Pollution Source Production and Pollution Emission Coefficient". The calculation method for the discharge of pollutants from residents' living sources is:

$$G_p = 365 \times N F_p \times 10^{-6} \quad (1)$$

Where: G_p is the pollutant discharge (t/a) of residents' living; N is the resident population (person); F_p is the resident pollutant production coefficient (g/person · d).

2.3.2 Surface runoff pollution

Urban surface runoff pollution calculation method:

$$W_{di,j} = S_{di} \cdot Q \cdot C_{di,j} \cdot \psi \cdot \phi \cdot 10^{-9} \quad (2)$$

$$W_{d,j} = \sum W_{di,j}$$

In the formula, W_{di,j} is the annual discharge (t/a) of pollutants of type i block type j; S_{di} is the land type i area; Q is the annual rainfall (mm); C_{di,j} is the concentration of pollutants in the initial rainwater of the i block (mg/L); ψ is the runoff coefficient; φ is the coefficient of pollutant inflow into river; W_{d,j} is the pollutant discharge (t/a) of pollutant j for one year.

2.3.3 Rural non-point source pollution

Agricultural non-point source calculation method:

$$W_{mi,j} = \theta_{mi,j} \cdot S_{mi} \cdot \phi_{mi} \quad (3)$$

$$W_{m,j} = \sum W_{mi,j}$$

Where W_{mi,j} is the pollution discharge (t/a) of land type i non-point source pollutants for one year; θ_{mi,j} is the land type i discharge coefficient (kg/μ · year); S_{mi} is the land type i area (km²); φ_{mi} is the coefficient of entry into the river for land type i surface source pollutants; W_{m,j} is the non-point source pollutant j one year of pollution discharge (t/a);

3. Results and Analysis

3.1 Spatial Distribution of Pollutants

According to the concentration of various pollutants (Table 1) and spatial distribution characteristics (Fig. 2), the concentration of various pollutants in 5 sampling points did not change much, and the variation coefficient was between 12.86-29.30, indicated that the pollution sources in the river might be distributed in a scattered way. Field investigation shown that there were sewage discharge outlets in the river and they were distributed in a scattered way.

Table 1 Water quality indicators of DongPieHong Ditch

Index	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
COD	19.00	38.00	28.80	8.44	29.30
NH ₃ -N	7.15	14.00	11.63	2.95	25.32
TP	0.78	1.09	1.01	0.13	12.86
TN	11.50	17.00	14.46	2.20	15.24
DO	3.00	5.40	4.44	0.91	20.49

Table 2 Person correlation analysis results

	COD	NH ₃ -N	TP	TN	DO
COD	1				
NH ₃ -N	-0.42	1			
TP	-0.354	0.896*	1		
TN	-0.725	0.908*	0.865	1	
DO	-0.695	0.296	-0.054	0.387	1

* At the 0.05 level (two-tailed), the correlation is significant.

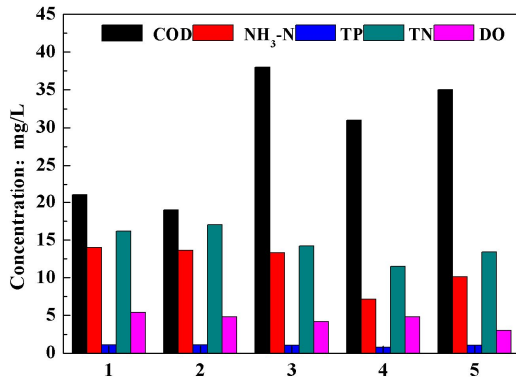


Fig.2 Spatial distribution of pollutants

Table 3 Principal Component Analysis Results

Variable	Main Ingredient	
	PC1	PC2
COD	-0.366	-0.85
NH ₃ -N	0.932	0.221
TP	0.993	-0.04
TN	0.893	0.435
DO	-0.001	0.952
Eigenvalue	2.784	1.87
Total Variance	55.681	37.396
Cumulative Variance	55.681	93.077

3.2 Principal Component Analysis

The SPSS was used to analyze the correlation of the sampled data and the results were analyzed (Table 2). It can be seen from the table that NH₃-N is significantly correlated with TP and TN, indicating that the three pollutants may come from the same source, the main component. The analysis results (as shown in Table 3) shown that the three common factors with eigenvalues greater than 1 are extracted, and the cumulative contribution rate was 93.08%. The main component PC1 was mainly composed of NH₃-N, TP, TN, and the water body nitrogen and phosphorus nutrients. The content of the main component PC2 was mainly composed of COD and DO, which may be related to organic pollution.

3.3 Pollution into the River Load

The investigation of DongPieHong Ditch basin shown that the sewage from industrial enterprises in the river basin was discharged into the sewage treatment plant through the pipe network, and there was no outlet of industrial sewage in the river. Because the river mainly flows through residential areas, and the east coast sewage pipe network construction was not complete, a large number of domestic sewage direct discharge be found. Therefore, the main cause of point source pollution was the domestic sewage discharged into the river through the outlet of the domestic sewage. Due to the low terrain in the west and high in the east, the east bank is the main catchment area of the river. Non-point source pollution is mainly caused by rainwater flowing through different land types(Fig.3) to carry pollutants into the river, which can be divided into agricultural non-point source pollution and surface runoff pollution.

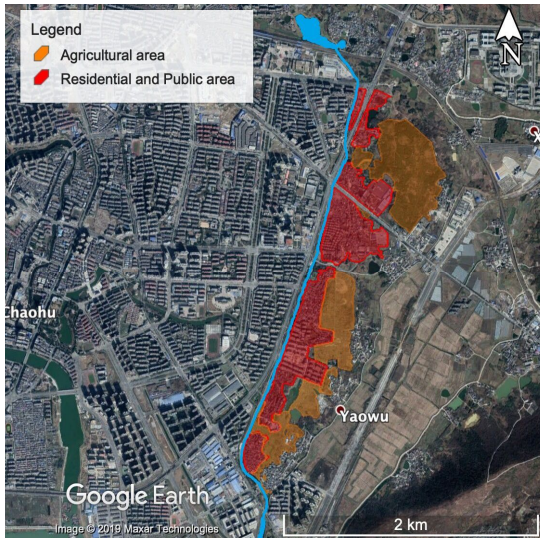


Fig.3 Type of land use of DongPieHong Ditch

3.3.1 Town point source pollution

The point source pollution was mainly the living pollution of urban residents. According to “Technical Guide for the Rural Environmental Contiguous Demonstration Project in Anhui Province”, “The First National Pollution Source Survey of Urban Living Sources and Discharge Coefficients”, the per capita pollutant discharge was determined (Table 4), the annual COD, NH₃-N and TP emissions of about 25,000 people in the basin are calculated, and the pollutant discharge load into the river was calculated with the pollutant inflow coefficient of 0.6 (Table 5).

Table 4 Per capita pollutant discharge

Type of pollution	Types of	COD	NH ₃ -N	TP	unit
Point source	Town drains or ditches	59	8	0.74	g/person·d

Table 5 Load of pollutants into the river

Permanent residents	Pollutant emissions (t/a)			Into the river coefficient	Contaminant into the river (t/a)		
	COD	NH ₃ -N	TP		COD	NH ₃ -N	TP
About 25,000	538.40	73	6.57	0.6	323.04	43.8	3.9

3.3.2 Non-point source pollution

Non-point source pollution was mainly agricultural non-point source pollution and urban surface runoff pollution. According to the area of various land types (Table 6), the average concentration of surface runoff pollutants in initial rainwater (Table 7) and the average annual rainfall of ChaoHu city, the load of non-point source pollution into the river (Table 8) was calculated.

Table 6 Summary of parcel classification area

River name	Residential area (m ²)	Agricultural area (m ²)	Public area (m ²)
DongPieHong Ditch	1494400	2196979	50600

Table 7 Average concentration of surface runoff pollutants in initial rainwater

Pollutant discharge concentration (mg/L)	COD	TP	NH ₃ -N
Residential area	28.95	0.11	0.75
Agricultural area (kg/mu·year)	65.71	0.25	0.76
public area	19.4	0.05	1.27

Table 8 Pollutant Discharge and Inflow Load

Pollution source classification	Annual pollution load (t/a)			Into the river coefficient	Into the river pollution load (t/a)		
	COD	TP	NH ₃ -N		COD	TP	NH ₃ -N
Residential area	21.89	0.08	0.57	0.9	19.70	0.07	0.51
Agricultural area	144.36	0.55	1.67	0.1	14.44	0.05	0.17
public area	0.50	0.001	0.03	0.9	0.45	0.0012	0.03
Subtotal	166.75	0.63	2.27		34.59	0.12	0.71

3.3.3 Structural characteristics of pollution sources

Fig.4 to Fig.6 shown that point source pollution was mainly sources of pollution, among which the main point source pollution was urban living pollution, COD, NH₃-N and TP accounting for the largest proportion of the total river load, respectively 90.33%, 99.72% and 84.61%. Therefore, it can be seen that point source pollution was the largest source of river pollution in DongPieHong Ditch, followed by non-point source surface runoff pollution and

agricultural non-point source pollution.

Table 9 Statistics of pollution source structure

Region	Source type	River load (t/a)		
		COD	NH ₃ -N	TP
DongPieHong Ditch	Point source	323.04	43.80	3.90
	Non-point source	34.59	0.12	0.71
Total		357.63	43.92	4.61

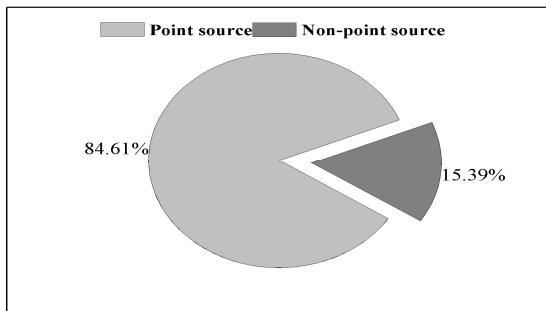


Fig.4 COD pollution source structure

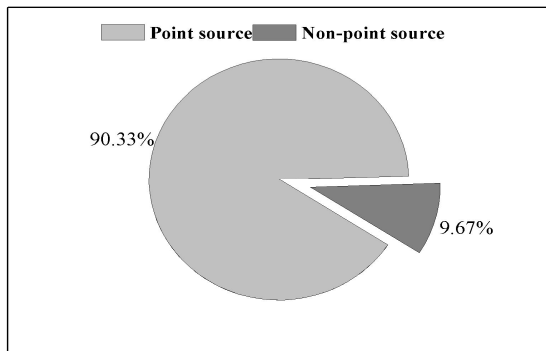


Fig.5 NH₃-N pollution source structure

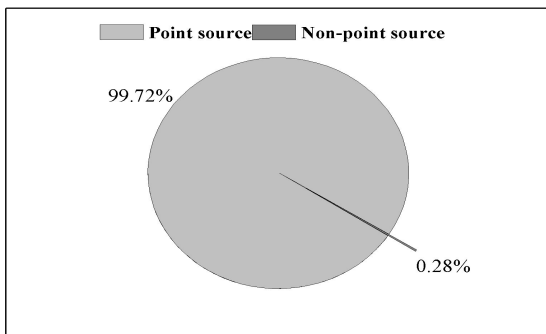


Fig.6 TP pollution source structure

4.Conclusion

According to the results of principal component analysis, it can be concluded that the main reason of water quality deterioration was the surplus of nitrogen and phosphorus, which was closely related to human activities. According to the calculation of the load of pollutants into the river and the analysis of the structure of pollution sources, it can be concluded that the main cause of the water pollution in DongPieHong Ditch was the point source pollution caused by the direct discharge of domestic sewage from residential areas, which COD, TP and TN occupation of discharge was up to 90.33%, 99.72% and 84.61%. In order to control point source pollution, rain and sewage diversion measures should be taken to cut off the sewage outlet and reduce the load of pollution into the river.

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