

Estimation of NH₃-N Pollution Load and Analysis of the Spatial and Temporal Characteristics in Ningxia, China, The Yellow River

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Abstract: In this paper, a new method of load estimation is used to estimate the pollution load of the three sections of Ningxia, China, the Yellow River section. The characteristic load method is used to analyze the NH₃-N pollution load. According to the estimation results of pollutant load, we find the space-time characteristics of NH₃-N pollution. We hope that it can provide theoretical basis and help for the comprehensive management of pollution in the Yellow River in Ningxia province, China.

Keywords: NH₃-N Pollution, Non-point Source Pollution, Characteristic Load Method, Time and Space Characteristics

1. Introduction

Water pollution generally includes point source pollution and non-point source pollution. Point source pollution refers to the pollution sources with fixed point of discharge, which refers to the industrial wastewater and municipal sewage. Non point source pollution is the soil nitrogen, phosphorus, pesticides and other organic or inorganic pollutants, atmospheric dry deposition, urban and road pollutants, in the process of precipitation through surface runoff and underground seepage, into the surface and underground water, pollution of water [1].

Different from point source pollution, non point source pollution has the characteristics of dispersion, concealment, random, latent, cumulative and fuzzy. At present point source pollution has been effectively control and management, but the non point source pollution due to its characteristics is not easy to monitor, it is difficult to quantify, research and control of the difficulty, has become the main source of water pollution [2].

Since 2000, with the introduction of non point source pollution model, especially the mechanism model, China's non point source pollution research has begun to develop rapidly [3]. At present, there are export coefficient method [4], rainfall deduction method [5], runoff division method [6],

correlation method of water quality and quantity [7], etc. These methods can estimate the load of non-point source pollution in the river basin, but it needs many reasons, such as many field materials, high cost and many parameters, which makes it difficult to estimate the non-point source pollution load. In this paper, we use the characteristic load method [8] to estimate the time and space characteristics of NH₃-N pollutant load of Ningxia, China, the Yellow River section, which was proposed by Zhu Lei and Li Huaian.

2. Basic Situation of Research Area

Ningxia Hui Autonomous Region is one of the five Chinese ethnic minority areas, located in Northwest China Eastern, in the upper and middle reaches of the Yellow River Basin. Its southwest and Southeast connected Gansu, east connected Shaanxi, north connected Inner Mongolia. And its geographical coordinates is east longitude 104°17'---109°39', north latitude 35°14'---39°23'. Its territory is long, north-south distance of about 465km and east-west distance of about 45250km. Its total area is 66400 km². Ningxia is located in the upper and middle reaches of the Yellow River, most of its areas belong to the Yellow River Basin.

The Yellow River is the main surface water of Ningxia, China. It flows from the nanchangtan of Zhongwei city, and the outflow from the first ridge North mahuangou in

Shizuishan city. Through the middle of the Wei Ning plain and the Yinchuan plain. Its length is 397 kilometers, accounting for 7.2% of the total length of the Yellow River. The Yellow River is the main water source of Ningxia agricultural, industrial and drinking water, while is the main channel of the Ningxia living and industrial waste water [9]. The Yellow River is the most important crossing river. According to the "environmental quality standard for surface water" (GB3838-2002), the Yellow River's entry section of Ningxia which named xiaheyuan annual water quality as class category II, the water quality is better. But with the enterprise sewage discharge and urbanization process speeding up, in the Yellow River's exit section in Ningxia where named Mahuanggou, the annual water quality category as III class.

3. Estimation Method and Calculation Process

Because it is impossible to carry out the continuous monitoring of non-point source pollution, we need to use the appropriate method to estimate the non point source pollution load based on limited hydrological data.

3.1. Main Idea

This paper mainly uses the characteristic load method, which is a new method to estimate the annual pollution load of pollutants according to the characteristics of point source pollution and non-point source pollution. It is first proposed by Zhu Lei, Li Huaian, et al. The main idea is:

- 1) In a given year, the urban population has not changed significantly, and the emissions of pollutants in urban life are relatively stable, while the emissions of industrial waste water during the year don't change.
- 2) The total pollution load of the river basin can be obtained

by calculation.

- 3) Non point source pollution load estimation can be obtained indirectly through total pollution load minus the point source pollution load.

3.2. Main Formula

The main reason of non-point source pollution is caused by rainfall runoff. In drought period, there is no rainfall in the basin basically. So the resulting pollutant load is mainly point source pollution load. So we can get the following formula:

$$Y_p = \min(c_i \cdot w_i) \quad (1)$$

$$Y_t = c_i \cdot w_i \quad (2)$$

$$Y_{np} = Y_t - Y_p \quad (3)$$

$$N_p = 12 \min(c_i \cdot w_i) \quad (4)$$

$$N_t = \sum_{i=1}^{12} c_i \cdot w_i \quad (5)$$

$$N_{np} = N_t - N_p \quad (6)$$

Y_p ----monthly mean load of point source pollution;

Y_t ----monthly total load;

Y_{np} ----monthly mean load of non-point source pollution;

c_i ----monthly mean concentration in drought period;

w_i ----monthly mean flow in drought period

N_p ----annual mean load of point source pollution;

N_t ----annual total load;

N_{np} ----annual mean load of non-point source pollution;

i ----month, ($i=1, 2, 3, \dots, 12$).

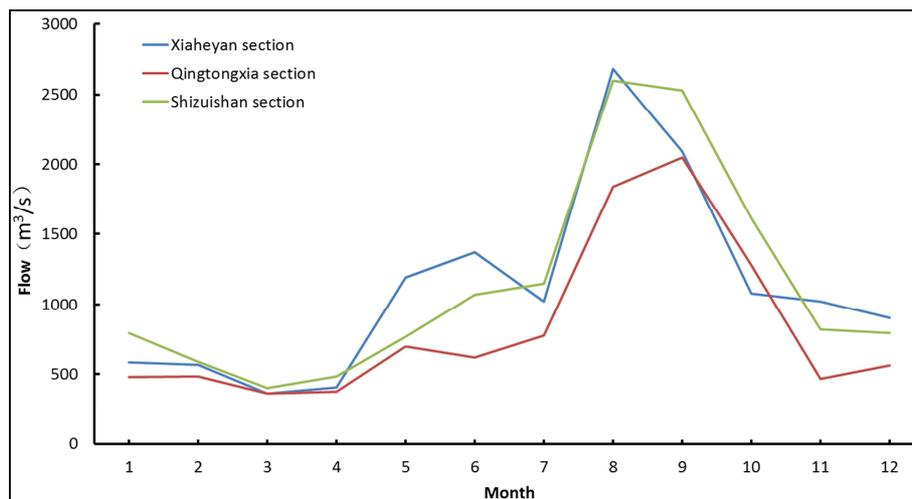


Figure 1. Flow of the three characteristic cross-sections.

4. Estimation Results of Pollutant Load

We select the upstream, middle and lower reaches of the

Yellow River section in Ningxia, China, as research object. At the same time, we choose three sections as our characteristic cross-sections. One of them is xiaheyuan section located in the upstream. One of them is qingtongxia section located in the

middle reach. One of them is shizuishan section located in the lower reach. And the NH₃-N is selected as the water quality parameter. We estimate the point source pollution load and the non-point source pollution load of the three characteristic cross-sections in the selected year (2012). According to the characteristics of rainfall runoff, water period division are as follows: The wet period was June---September; the flat period is April, May, October and November; the drought period is January---March and December.

The Figure1 shows the flow of the three charateristic cross-sections in the selected year.

Just like Figure 1 shows: the tendency of changes in flow over time not too big difference. From January to March, the flow of three characteristic cross-sections decreases. After the minimum appears in March, the flow increases. In June or July, the flow of three charateristic cross-sections has a slight

decline. After that, the flow continue to increase until the peak in August or September. Then the flow of three charateristic cross-sections decreases.

The flow minimum of xiaheyan section is 361m³/s where it appears in March. And its peak is 2680m³/s where it appears in August. The flow minimum of qingtongxia section is 362m³/s where it appears in March. And its peak is 2050m³/s where it appears in September. The flow minimum of shizuishan section is 400m³/s where it appears in March. And its peak is 2600m³/s where it appears in August.

According to the formula of formula 1 to 6, and the known NH₃-N pollutant data of three characteristic cross-sections. We use the characteristic load method to estimate the pollution load of the three sections of Ningxia the Yellow River section. The estimation results are indicated in Figure 2 to 4 and table 1.

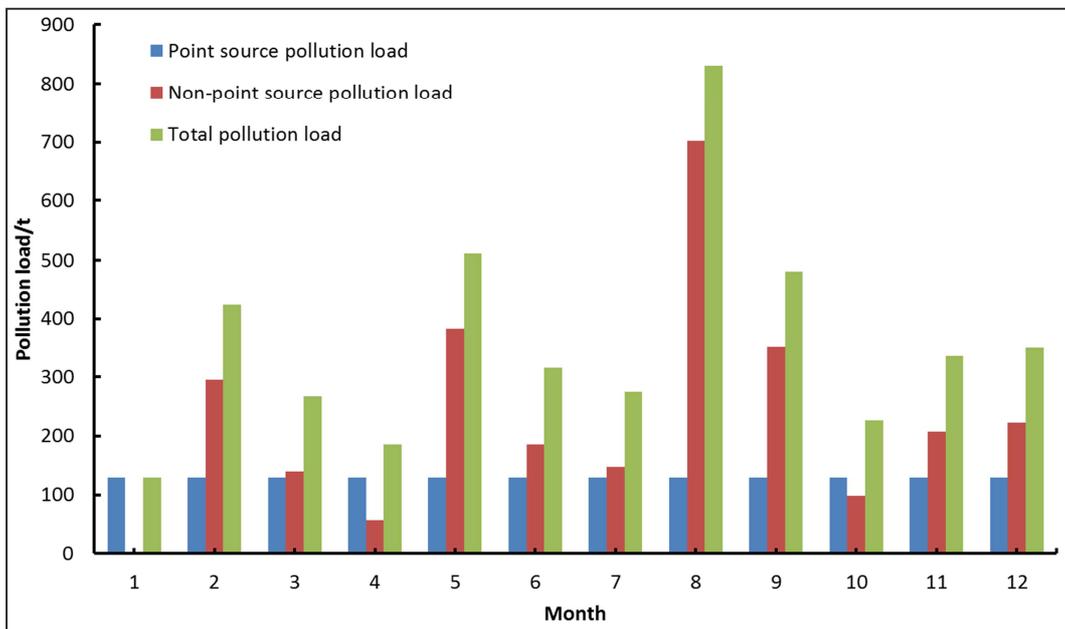


Figure 2. NH₃-N pollutant load of xiaheyan section.

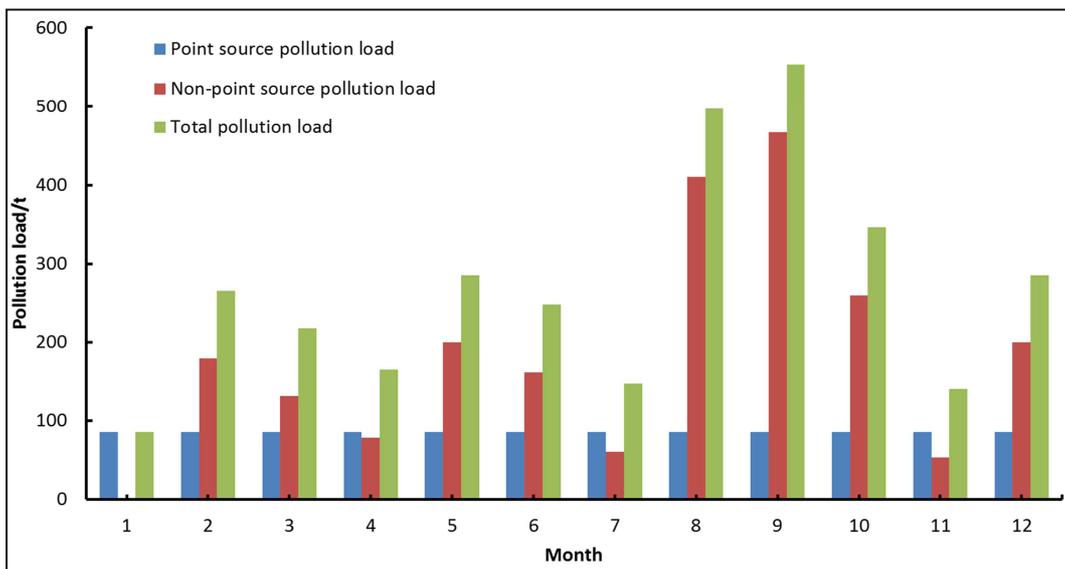


Figure 3. NH₃-N pollutant load of qingtongxia section.

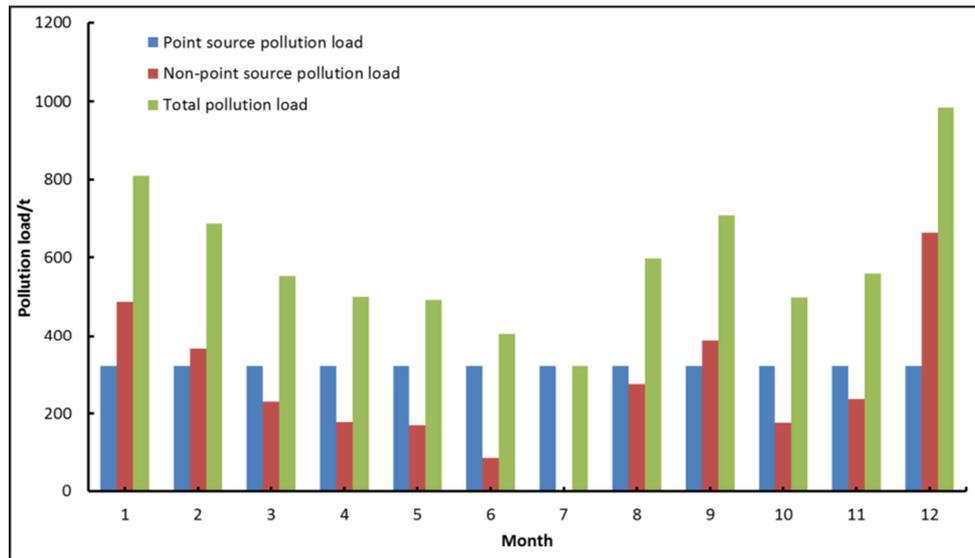


Figure 4. NH₃-N pollutant load of shizuishan section.

Table 1. Annual average pollutant discharge of three section.

Section	Xiaheyuan	Qingtongxia	Shizuishan
Point source pollution load/t (N_p)	1544.4	1034.64	3864
Non-point source pollution load/t (N_{np})	2789.91	2203.93	3254.79
Tatol point source pollution load/t (N_r)	4334.31	3238.57	7118.79
The proportion of point source pollution load	0.35632	0.319474	0.542789
The proportion of non-point source pollution load	0.64368	0.680526	0.457211

5. The Space-Time Characteristics of NH₃-N Pollution

Based on the field survey and relevant information and the estimation results of pollutant load, we try to analyze the temporal and spatial characteristics of NH₃-N pollution, what can provide basic data and suggestions for better governance of the Yellow River.

5.1. The Spatial Characteristics of NH₃-N Pollution

1). According to the estimation results, the NH₃-N pollution load value of the three sections shows the following spatial rule: Shizuishan section > Xiaheyuan section > Qingtongxia section.

According to the figure 5 and figure 6, we find that the most main sewage points and drainage ditches are located in the basin above Shizuishan section. This leads to the NH₃-N pollution load of Shizuishan section to be far greater than the other two sections. The NH₃-N pollution load value of Qingtongxia section is lower than that of Xiaheyuan section. According to the field investigation and lookup data; we find that there is a large reservoir, which named Qingtongxia reservoir, not far away from Qingtongxia section. When the Yellow River into the Qingtongxia reservoir,

considering adsorption and dilution of pollutants, resulting in reduction of NH₃-N concentration of pollutants. That leads to the NH₃-N pollution load value of Qingtongxia section is lower than that of Xiaheyuan section.



Figure 5. Conceptual sketch map of Xia-Qing section.

2). As is shown in figure 7, the basin above Xiaheyuan section and Qingtongxia section mainly is non-point source pollution. But the basin above Shizuishan section mainly is point source pollution. This is because before the Qingtongxia section on both sides of the Yellow River, the quantity of factories and enterprises and drainage ditch is few. After rainfall, the NH₃-N pollution is into the Yellow River through surface runoff, farm drainage and underground leakage, what is non-point source pollution. But before the Shizuishan

section on both sides of the Yellow River, there is a large number of factories and enterprises, living area, drainage ditch, what leads to the basin above Shizuishan section is mainly the point source pollution.

5.2. The Temporal Characteristics of NH₃-N Pollution

1). As is shown in figure 8, the NH₃-N pollution load value of Xiaheyan section and Qingtongxia section shows the following temporal rule: wet period>flat period>drought period.

Because rainfall increases in wet season, so the amount of water in the Yellow River increase and the pollutants are diluted. However, with the increase of rainfall, it will lead to a large number of nitrogen pesticides enter the Yellow River through surface runoff, drainage and underground drainage and other ways. These pesticides are from the both sides land of the Yellow River. And through the actual investigation, we find that the drainage ditches before the two sections have more sewage. At the same time, the concentration of sewage is far greater than falt period and drought period. So it leads to the rule of above.

2). The NH₃-N pollution load value of Shizuishan section shows the following temporal rule:drought period>flat period>wet period.

Based on the known data, the monthly emissions of NH₃-N pollution load of factory enterprise and drainage ditch is basically the same. Because rainfall increases in wet season, so the amount of water in the Yellow River increase and the pollutants are diluted. So the NH₃-N pollution load in wet period is the lowest in the three periods. And the NH₃-N pollution load in drought period is the highest in the three periods.

3). Even though the NH₃-N pollution load value of Shizuishan section in wet period is the lowest in the three periods, it is still higher than the NH₃-N pollution load of Xiaheyan section and Qingtongxia section in wet period.



Figure 6. Conceptual sketch map of Qing-Shi section.

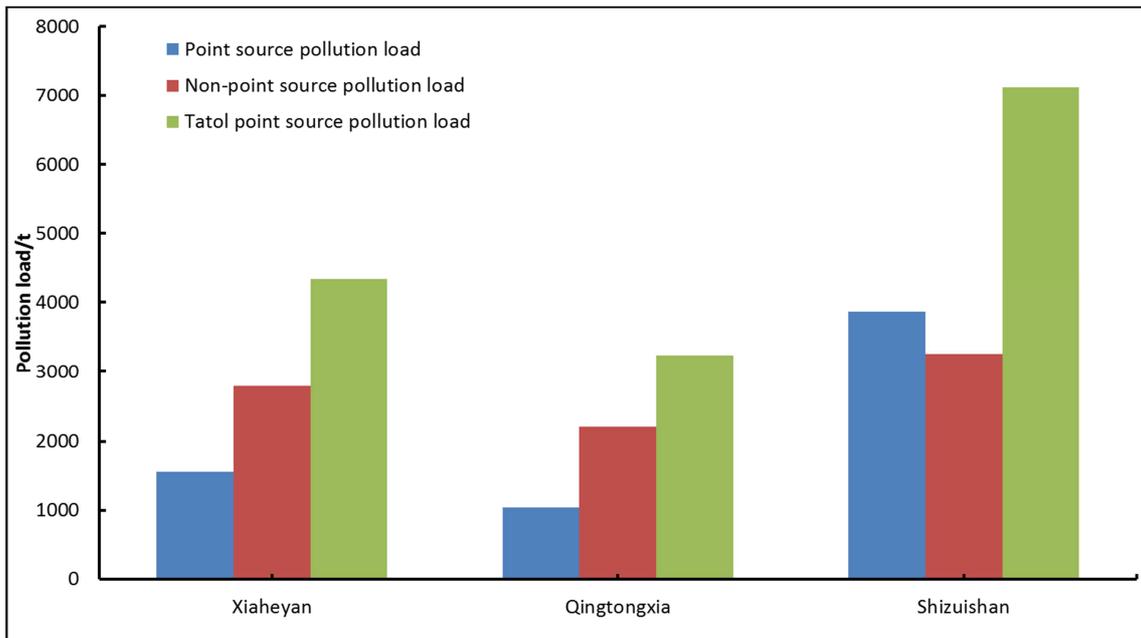


Figure 7. Sketch map of NH₃-N pollution load.

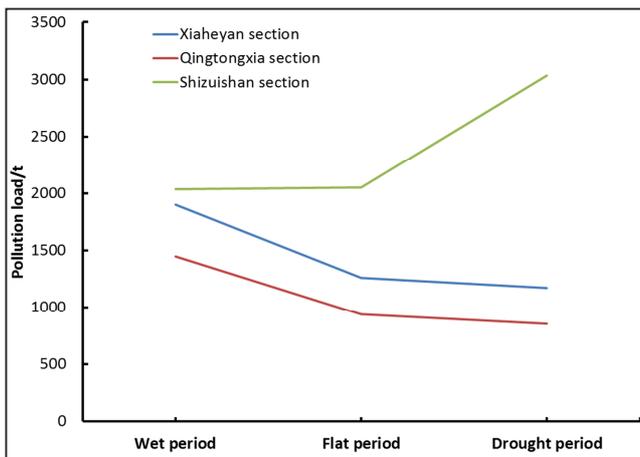


Figure 7. Sketch map of NH₃-N pollution load.

6. Conclusion and Suggestion

1). The basin before Xiaheyan section and Qingtongxia section is mainly non-point source pollution. And non-point source pollution load accounts respectively for 64.37% and 68.05% of the total pollution load. The main reason is the NH₃-N pollution in the farmland enters the Yellow River through the surface runoff, farmland drainage and underground leakage, etc. So we can improve the pollution of the Yellow River from the perspective of agriculture. For example, we can reduce fertilizer loss by improving fertilization methods; strengthen planting trees and grass, forest, etc [10].

2). The basin before Shizuishan section is mainly point source pollution. And point source pollution load accounts for 54.28% of the total pollution load. The main reason is that there is a large number of factories, enterprises, drainage ditches and residential areas in the both sides land of the Yellow River. We propose to develop the relevant laws and supervision system to reduce the discharge of pollutants of the factories and enterprises.

3). Promoting the construction of talents. Strengthening the training of professional staff. Improving the quality of professional technology. Making regular organization to carry out learning exchanges, improving the level of professional team.

4). Promoting public participation in water environment protection. Adhering to the people-oriented, improving the level of public participation, and thus improving the region's water environment protection and water level.

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