Comprehensive assessment of water quality of ten rivers in Zhengzhou main urban area

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Abstract. In order to clarify the water quality characteristics and provide reference for the overall control and prevention of the rivers in Zhengzhou, the comprehensive pollution index method and the Nemerow pollution index method were used to evaluate the water quality of ten rivers in Zhengzhou main urban area. The results show that the water quality of ten rivers in Zhengzhou is worse than that of Class III before February 2018. After that, the water quality was improved and basically reached Class III water quality. Suggestion: the main prevention and control work in Zhengzhou is to control the discharge of pollutants, especially chemical oxygen demand and ammonia nitrogen pollutants.

1. Introduction

Water is the source of life and the controlling factor of ecological environment. Water quality is directly related to the health of every life. Although China has formulated the "Action Plan for Prevention and Control of Water Pollution", the phenomenon of water pollution is still serious, and there is still a long way for water pollution treatment. Scientific water quality analysis is helpful to find out the water environment problem in the region, provide reliable basis for decision makers, and make scientific assessment on the quality of China's water resources. In response to the above problems, many scholars conducted a series of investigations and studies. Zhang et al., Zhang et al. and Xu et al. evaluated the water quality of canal irrigation area with Water Quality Index (WQI)[1-3]. Zhang et al. also did a lot of work on the ground water quality of the Guanzhong basin[4, 5]. Xu et al. studied the characteristics of geothermal water in Xi 'an[6, 7]. Peng et al. used 5 methods to evaluate the water quality of Liuyang river, and the results showed that the comprehensive water quality index method and Nemerow index method had a good evaluation effect[8].

Zhengzhou is the capital of Henan Province, the largest city in Central Plains, and a national central city. Due to the lack of ecological and environmental resources in Zhengzhou, the amount of per capita water resources is about 1/28 of that of the whole country and 1/2 of that of the whole province, which leads to the serious shortage of water capacity and restricts the fundamental improvement of environmental quality in Zhengzhou. With the rapid development of urbanization in Zhengzhou in recent years, the number of population also increases sharply. Population growth has a very serious impact on urban water quality. The more the population grows, the more serious the water pollution becomes. So the assessment of water quality is necessary in Zhengzhou.

In this study, depending on the Environmental Quality Standards for Surface Water (GB3838-2002), 6 indexes including Tem, pH, DO, COD, NH3-N, TP, collected by Zhengzhou Government , were selected to evaluate the river quality using the comprehensive water quality index method and the Nemerow index assessment method, which provides a scientific basis for the targeted improvement of the water quality of ten rivers in Zhengzhou main urban area.

2. Materials and Method

2.1. Study area and samples

Zhengzhou（E112°42'~E114°14' and N34°16'~N34°58'）, located in the hinterland of Central Plains and by the Yellow River, is the political, economic and cultural center of Henan province. Zhengzhou has a continental monsoon climate. The annual average temperature is 15.6℃ and the annual average rainfall is 542.15 mm.

The samples at 15 sites of 10 rivers were collected once a month from September 2017 to May 2020. There are 484 groups of valid water quality data because the river is cut off during the dry season.

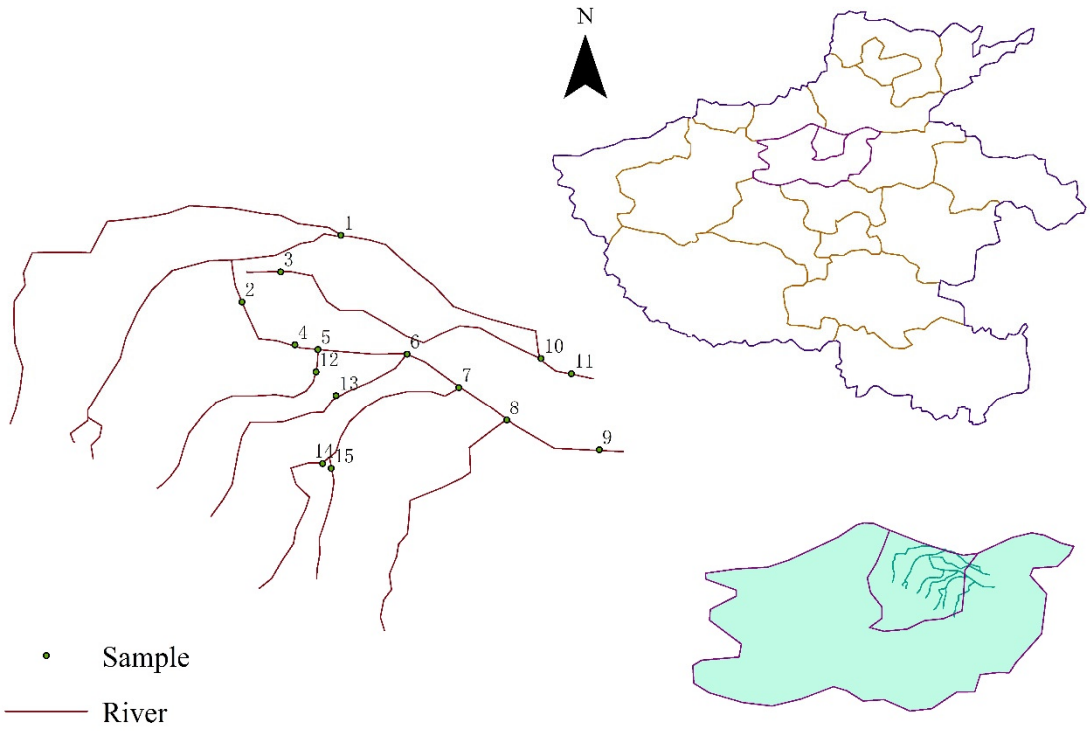

Figure 1. The position diagram of water samples and rivers

2.2. the comprehensive water quality index method

According to the environmental functions and protection objectives of surface water and the surface water environmental quality standard (GB3838-2002), the comprehensive water quality index evaluation method was used.

The comprehensive water index method can reflect the water quality level and find out the pollution factor. The formulas for calculating the comprehensive water quality index PI_C and pollution sharing rate K_i are as follows

$$P_i = \frac{C_i}{S_i} \tag{1}$$

$$PI_C = \frac{\sum_{i=1}^{n} P_i}{n} \tag{2}$$

$$K_i = \frac{P_i}{nPI_C} \times 100\% \tag{3}$$

In the formula, C_i is the measured mass concentration value of class I evaluation factor; S_i is the mass concentration value of class i water standard, P_i represents the pollution index of single water quality index i, PI_C is the comprehensive pollution index of a monitoring section, K_i is the pollution sharing rate of a single water quality index i in the section, and n is the number of water quality indexes participating in the evaluation. The comprehensive pollution index is divided into corresponding water quality levels, as table 1 showed.

Table 1. Water quality level determination based on comprehensive water quality index and the Nemerow water quality index.

Water quality level	Safety	Precaution	Slightly polluted	Moderately polluted	Seriously polluted
PI_C	[0, 0.2]	(0.2, 0.4]	(0.4, 0.7]	(0.7, 1]	(1, +∞)
PI_N	[0, 0.7]	(0.7, 1]	(1, 2]	(2, 3]	(3, +∞)

2.3. the Nemerow index assessment method

The Nemerow index evaluation method, proposed by Professor Nemerow in the United States, takes into account the average value and the maximum value, and has the function of highlighting the detection index with heavy pollution. The evaluation grade is calculated as follows:

$$PI_N = \sqrt{\frac{P_{imax}^2 + P^2}{2}} \tag{4}$$

In the formula, PI_N is the Nemerow pollution index at a monitoring point; P_{imax} is the maximum sub-index of each pollutant, P is the comprehensive water quality index of a monitoring section. The criteria for determining the water quality level of the Nemerow water quality index method was shown in Table 1.

3. Results and discussion

3.1. Discussion on the results of comprehensive water quality index

According to the comprehensive water quality index method, the quality of ten rivers in Zhengzhou main urban area was quantitatively determined, and the results were shown in Figure 2. It can be seen that the comprehensive water quality before February 2018 was category V water standard, and the other months were category III or IV water standard. The water quality from the autumn of 2018 to summer of 2019 can reach III class summer but the autumn water quality of 2019 varied to V water standard. In the spring of 2020 water quality reach III water standard.

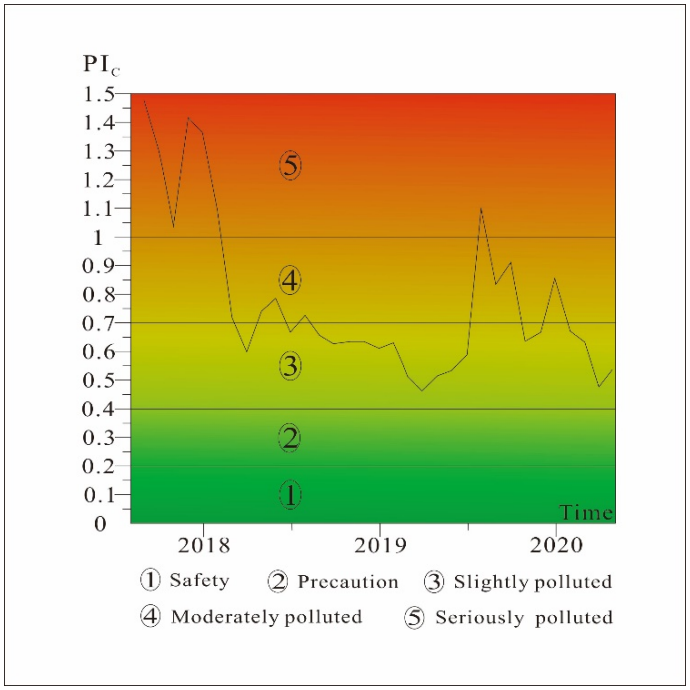

Figure 2. Comprehensive water quality index and water quality judgment of ten rivers in Zhengzhou main urban area from 2017 to 2020

3.2. Discussion on the results of the Nemerow water quality index

According to the Nemerow water quality index method, the water quality of ten rivers in Zhengzhou main urban area was quantitatively determined, and the results were shown in figure. 3. It can be seen that the comprehensive water quality before January 2018 was category V water standard, and the other months were category III water standard or better. From the autumn of 2018 to the spring of 2019, the water quality can reach class II water quality, but in the autumn of 2019, the water quality becomes worse to water standard. III water quality. In the spring of 2020, the water quality has reached the II water standard.

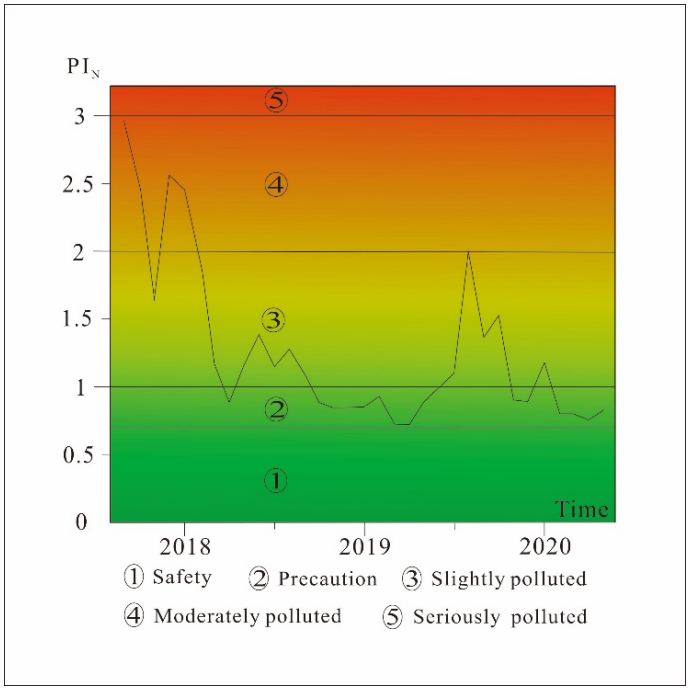

Figure 3. The Nemerow water quality index and water quality judgment of ten rivers in Zhengzhou main urban area from 2017 to 2020

And figure.4 shows the pollution sharing rate for 3 indexes, COD, NH3-N and TP. It can be seen from the figure that the average pollution sharing rate of COD is 0.34, followed by TP and 0.14, and NH3-N has the lowest pollution sharing rate, 0.14. COD pollution sharing rate was the highest in June 2019, 0.49. This indicates that the river pollution in Zhengzhou is mainly due to the high concentration of pollutants in the water body.

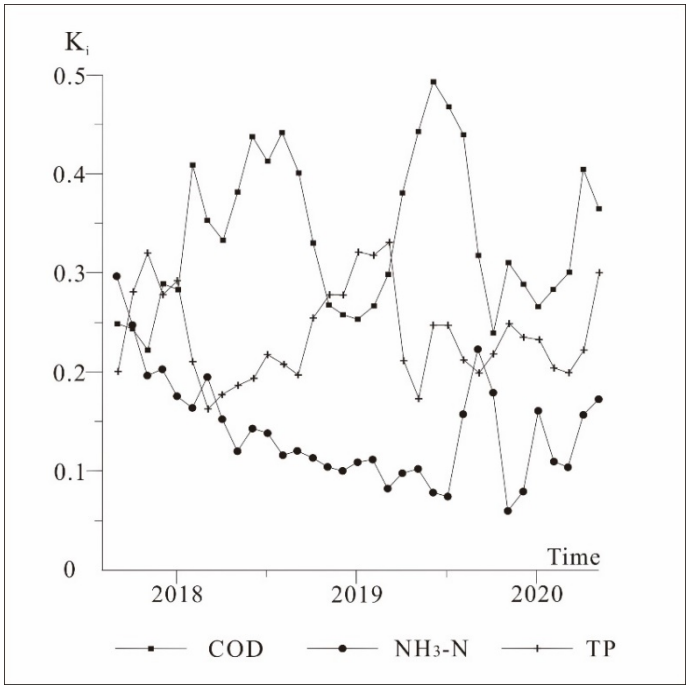

Figure 4.The pollution sharing rate for COD, NH3-N and TP

4. Conclusion

1. The water quality of ten rivers in Zhengzhou urban area is analyzed by using comprehensive pollution index method and Nemerow pollution index method. The results show that from September 2017 to May 2020, the overall water quality of ten rivers in Zhengzhou urban area has basically reached the water quality of class III since 2018.

2. The main pollution factors of ten rivers in Zhengzhou are chemical oxygen demand and ammonia nitrogen.

3. The protection and pollution prevention of ten rivers in Zhengzhou should focus on chemical oxygen demand and ammonia nitrogen pollution control in order to restore healthy water ecosystem.

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