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Analysis of Groundwater Quality Survey and Evaluation Results of Fenghe River in Xi'an

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ABSTRACT. *Based on the 2019 groundwater quality test results of Xi'an Fenghe, evaluate the groundwater quality of Xi'an Fenghe. This article uses single component evaluation method and comprehensive evaluation method to evaluate and analyze groundwater quality of Fenghe River. The results of the single component evaluation method showed that: Xi'an's Fenghe groundwater quality exceeded the standards mainly including $NH4^+$, total hardness, and COD_{Mn}; and the comprehensive evaluation method showed that the groundwater was excellent and good, accounting for 80%, and the poor was 20%. The situation is not optimistic. Based on the evaluation results, the distribution area of the groundwater quality exceeding standards of the Fenghe River and the reasons for exceeding the standards are analyzed, and countermeasures and suggestions for groundwater quality protection are proposed.*

KEYWORDS: *Xi'an, Fenghe groundwater, water quality, evaluation*

1. Introduction

In recent years, with the rapid development of society and economy and the increase in population density, the discharge of various solid wastes and waste water has been increasing, the water environment has been polluted and broken, causing the deterioration of groundwater quality. Water quality is the first gateway for residents drinking water [1, 2], which directly affects the safety of residents' domestic water. In order to understand the current situation of groundwater quality of the Fenghe River [3, 4], Xi'an has launched a special survey of groundwater quality [5].

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2. Physical Geography Overview

The Fenghe River is a tributary of the Weihe River. It originates from the south of Fengyuwozi on the north side of the Qinling Mountains and flows through Chang'an District (about 26 kilometers), Huxian (2.53 kilometers), Fengdong New City (about 10 Kilometers) and Qindu District of Xianyang City (8.87 kilometers), a total of 22 neighborhoods, townships and 86 villages, entered the Weihe River in Yuwang Village of Xianyang City, the total length of the river is 75 kilometers [6, 7]. The Fenghe River Basin covers an area of 1,380 square kilometers, with an average annual runoff of 423 million cubic meters. The groundwater source area of the Fenghe River is basically located in the area to the east of the Fenghe River and west of the Taiping River [8, 9]. Most of the tube wells on the south and north lines are distributed along the Fenghe River [10]. Dominated by diving, and recharged mainly by natural precipitation, lateral seepage of river water and irrigation seepage [11].

Fenghe underground water source protection area. Protected areas are divided into primary protected areas, secondary protected areas and monitoring areas (quasi-protected areas). among them [12, 13]:

First-level protected area: with a mining well as the center, within a radius of 30m.

Second-level protection area: The river side is bounded by the Fenghe River, with a length of 4000m, and the back river side extends from the edge wells by 550m, and is connected by a smooth curve.

Monitoring area (quasi-protection area): There is no monitoring area on the river side, and the back river side extends 100m outward from the outer boundary of the secondary protection area, connected by a smooth curve.

3. Water quality survey indicators and methods

3.1 Water quality survey indicators

Water quality monitoring indicators are pH, total hardness, sulfate, chloride, potassium permanganate index, nitrate, nitrite, ammonia nitrogen and other physical and chemical indicators that reflect domestic pollution as analysis parameters. There are 8 evaluation indicators.

3.2 Water quality survey methods

According to the provisions of the "Water Environment Monitoring Code" (SL219-98) and the actual conditions of groundwater exploitation in Xi'an, the principles of regional control, point-surface integration, and key encryption have been considered. According to the survey, the groundwater source of the Fenghe

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River is currently in use. 21 wells, the distribution of well groups is shown in Figure 1. The average water head burial depth is about 28m, and it has been in a stable mining state in recent years.

3.3 Collection of groundwater samples

According to different hydrogeological conditions and the use of groundwater monitoring wells, combined with the actual situation of local pollution sources and pollutant discharge, we strive to obtain the most representative samples with the lowest sampling frequency and achieve a comprehensive reflection of regional groundwater quality conditions, pollution causes and The purpose of regularity. The water sample was collected in May 2019.

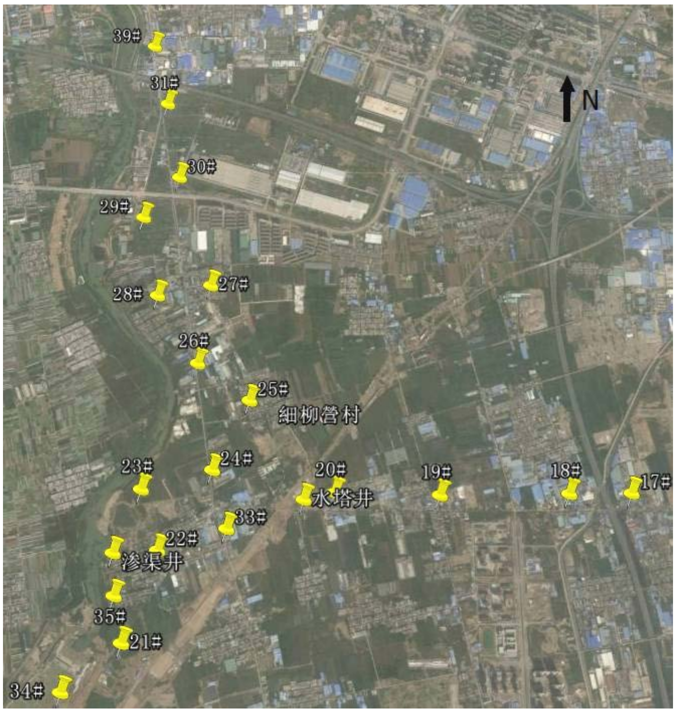

Figure. 1 Distribution of well groups

3.4 Network layout of groundwater monitoring points

Monitoring Point Network Deployment Principle:

(1) It should be able to control different hydrogeological units in general and macroscopically, and it should be able to reflect the environmental quality status of the groundwater system in the area and the spatial change of groundwater quality.

(2) Monitoring of aquifers focusing on water supply purposes.

(3) Monitor key groundwater contaminated areas and areas where pollution may occur, and monitor the pollution level and dynamic changes of groundwater by pollution sources to reflect the characteristics of groundwater pollution in the area.

(4) It can reflect the groundwater recharge source and the hydraulic connection between groundwater and surface water.

(5) The funnel area, ground subsidence, and special hydrogeological issues in this area are monitored.

(6) Consider the impact of industrial construction projects, mine development, water conservancy projects, petroleum development and agricultural activities on groundwater.

(7) The principle of network density of monitoring points is that the main water supply area is dense, and the general area is thin; the urban area is dense, and the rural area is thin; the groundwater pollution area is dense, and the non-polluted area is thin. Obtain sufficient representative environmental information with as few monitoring points as possible.

(8) Considering the representativeness of monitoring results and the feasibility and convenience of actual sampling, as far as possible, select monitoring points from the wells, production wells and springs that are often used.

(9) Do not change the monitoring point network easily, and try to maintain the continuity of single well groundwater monitoring.

Therefore, a total of 10 monitoring wells were deployed this time, which are 17#, 18#, 19#, 23#, 26#, 27#, 28#, 29#, 34# (near the river), and 40#.

4. Water Quality Evaluation

4.1 Evaluation criteria

The national standard "Groundwater Quality Standard" (GB/T14848-2017) is used as the evaluation standard. Since the sampling wells are domestic water or domestic and production water wells, Class III water is used as the standard for evaluating whether the groundwater meets the standards .

4.2 Evaluation method

Based on the water quality monitoring data, the groundwater quality single component evaluation method and groundwater quality comprehensive evaluation method are used to evaluate the groundwater of the Fenghe River.

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4.2.1 Evaluation of individual components of groundwater quality

The individual component evaluation of groundwater quality is classified into 5 categories according to the classification indicators listed in "Groundwater Quality Standards" (GB/T14848-2017). When the standard values of different categories are the same, the preference is not bad.

4.2.2 Comprehensive evaluation of groundwater quality

Comprehensive evaluation of groundwater quality, based on the individual component evaluation of groundwater quality, divides the quality category to which each component belongs. For each category, determine the single component evaluation score Fi according to Table 1. The bacteriological index does not participate in the comprehensive evaluation of groundwater quality. After the F value is determined, the evaluation category of the bacteriological index is noted after the level is determined.

Table 1 Individual component evaluation scores

Category	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ
Fi	0	1	3	6	10

Secondly, calculate the comprehensive evaluation score F according to formula (1) and formula (2).

$$\sqrt{\frac{\bar{F}^2+F_{max}^2}{2}} \quad (1)$$

$$F = \frac{1}{n}\sum_{i=1}^{n} F_i \quad (2)$$

In the formula: $\bar{F}$ is the average value of the score of each individual component Fi; Fmax is the maximum value of the score of the individual component Fi; Fi is the score of a single component;

Finally, according to the F value, the groundwater quality level is divided according to (Table 2).

Table 2 Classification of groundwater quality levels

level	excellent	great	good	poor	Very poor
F	<0.80	0.80~<2.50	2.50~<4.25	4.25~<7.20	>7.20

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4.3 Comprehensive evaluation of groundwater in Fenghe

According to the test data, the comprehensive evaluation results are shown in Table 3.

Table 3 Results of comprehensive evaluation of groundwater in Fenghe

Well number	PH	total hardness	CODMn	SO4-	Cl-	NH4+	NO2-	NO3-	F value	Level
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		
17#	0	0	6	0	0	3	0	/	4.340	Poor
18#	0	1	6	0	0	6	0	/	4.441	Poor
19#	0	1	6	0	0	6	0	/	4.441	Poor
23#	0	6	6	3	0	3	/	/	4.743	Poor
26#	0	3	0	0	0	3	/	/	2.236	Good
27#	0	1	6	1	0	3	1	/	4.412	Good
28#	0	0	6	0	0	6	/	/	4.472	Poor
29#	0	0	0	0	0	3	/	/	2.151	Good
34#	0	0	6	0	0	6	1	1	4.419	Poor
40#	0	3	6	0	0	6	1	/	4.540	Poor

Remark: "/ "Means not checked out.

5. Analysis of evaluation results

5.1 General status of groundwater quality of Fenghe River

According to the "Groundwater Quality Standard" (GB/T14848-2017), the evaluation results of water quality data of 10 observation wells show that the evaluation results are good, there are 2 wells, accounting for 20% of the number of monitoring wells; the evaluation results are good There are 1 well, which accounts for 10% of the number of monitoring wells; the evaluation result is a poor total of 7 wells, accounting for 70% of the number of monitoring wells. Among them, the main pollution factor is COD_{Mn}. Comparing the quality of drinking water, the highest pollution factor exceeds the standard by 3 times, accounting for 80% of the number of monitoring wells. The second is $NH4^{+}$, which exceeds 1.37 times, and 50% of the monitoring wells exceed the standard. The highest total hardness exceeds 1.03 times, and the number of wells exceeding the standard is 10% of the monitoring wells.

5.2 Distribution of groundwater quality exceeding standard indicators and analysis of pollution sources

The water source protection area covers an area of 7.7 km^2, and mainly involves a number of administrative villages, including Huangdui Village, Wuyi Village, Xu Village, Wotou Village, and Jinjia Village. The water source areas are distributed along the east, south, and north lines. The surrounding environment of the protected

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area is different. The east line is dominated by factories and the potential pollution sources are obvious. The surrounding environment of the south line protected area is relatively complicated. There are factories, livestock breeding farms, farmland, etc .; the environmental elements in the northern line protection area are relatively single. The surrounding areas of the deep wells are mainly residential areas, and the opposite side is mainly prefabricated board factories. The main pollution sources of the water source include domestic pollution sources, agricultural pollution sources, industrial pollution, and livestock and poultry breeding pollution.

The well groups with prominent water source problems and hidden risks are summarized below.

(1) Source of domestic pollution

① Domestic sewage

According to the survey, the villages in the area where the protected area is located have no sewage collection and treatment system. The villagers' domestic sewage flows along the street or enters the surface water through the drainage ditch outside the village. The risk of exceeding the ammonia nitrogen and bacterial indicators is extremely high.

According to the survey, the protected area involves a population of about 20,000 people. According to estimates, the amount of sewage generated is about 443,800 m^3/a, the COD is discharged at about 133.15 t/a, and the ammonia nitrogen is about 11.1t/a. Wells near Ling Village, Yuwang Village, Shahetan Village Concentration Area.

② Solid waste

According to the survey, the domestic garbage collection system in the water source protection area is not complete, and most of the rural residents' domestic garbage is dumped near the ditch or in a large pit formed by dredging, posing a potential safety hazard.

According to estimates, the protected area involves a population of about 19,000 people, and the amount of domestic waste discharged is about 2357.9t/a. In addition to the construction waste and domestic waste shipped to this place, currently, there is a large amount of solid waste in the protected area.

(2) Agricultural pollution sources

According to the survey, the crops grown in the protected area are mainly fruit trees and greenhouse vegetables. The use of fertilizers and pesticides during the planting process is likely to affect the quality of groundwater.

According to the survey, the area of agricultural land in the protected area is 2.52km^2. According to estimates, the agricultural pollutant emissions COD 56.7t/a and ammonia nitrogen 34.02t/a are all located in the secondary protection area.

(3) Aquaculture pollution sources

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According to the investigation, there is a pig farm in the water source protection area, with a stock of about 100 heads. The lack of effective collection and treatment measures for feces and urine, random storage and excretion, can easily have a serious impact on groundwater quality.

According to estimates, the total excretion of urinary excrement in the protected area farms is 164.25t/a, and the discharge of nitrogen is 0.71t/a, phosphorus is 0.30t/a, and potassium is 0.82t/a. In addition, a large amount of faecal coliforms can be generated by the accumulation of feces.

(4) Industrial pollution sources

The water source is located in the village in the city. There are many private enterprises in the area, mainly distributed around the eastern and southern parts of the deep wells. The eastern line is more serious, mainly including paper making, quicklime processing, iron making, machinery processing, waste acquisition, etc. It has the characteristics of small production scale, incomplete environmental protection procedures, no pollution prevention measures, and large pollution. Because the Fenghe groundwater source is located in the urban-rural combination area, it is difficult to manage. Therefore, pollutants such as waste water and industrial solid waste are directly discharged into the water source. Long-term accumulation can easily produce toxic and hazardous substances, posing a threat to drinking water safety. According to the survey,

Among them: There is a paper mill between 17# and 18#, iron mills and multiple prefabricated board plants are built around 19# and 20#, an oil refinery is on the west of 23#, and a chemical is about 200m west of the water tower well plant.

(5) Other aspects

The groundwater source of the Fenghe River is basically located in the area to the east of the Fenghe River and west of the Taiping River. Most of the tube wells on the south and north lines are distributed along the Fenghe River. It is only 350m, and wells 17# and 18# on the east line are only about 10m away from the Taiping River. Because the distance to the river is short, and river recharge is the main method of groundwater recharge, groundwater quality is greatly affected by river water quality. According to monitoring and analysis results over the years, single well sulfate, chloride, hardness, etc. Physical and chemical indicators showed a clear upward trend.

6. Countermeasures

6.1 Establishing protective measures for groundwater source wells

By analyzing the external pollutants in the sampling well, it was found that the wellhead is the place where the groundwater is most likely to be polluted, and the wellhead protection measures are not in place. Therefore, it is recommended to conduct a general survey of water source wells in Xi'an, construct protective

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measures for water source wells at risk of pollution, set the protection scope of water source wells, and strengthen daily supervision.

6.2 Construction of water treatment facilities

According to the water sample survey, it can be known that some of the water quality indicators of most water source wells are beyond the standard. After the water quality treatment at the front end of the water supply, it must be supplied to the local residents for daily use, and cannot be directly supplied to the residents for use after extraction.

6.3 Strengthen management

The water administrative department should effectively assume the function of groundwater management. The urban construction department has accumulated a large amount of basic data in the past groundwater management. The two parties must share resources and strengthen communication. Strengthen the long-term monitoring of groundwater dynamics and water quality, and grasp the status and changes of groundwater quality Law to provide a basis for groundwater supply water quality safety.

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