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Study on Karst Development Characteristics of Dawu Groundwater System

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Study on Karst Development Characteristics of Dawu Groundwater System

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Abstract. Karst development has an important impact on regional groundwater movement. Based on the tracer test, this paper analyzes the development of groundwater karst in the Dawu water source. The results show that: 1) The main groundwater flow direction of the Wangzhai experimental area is northeast and southeast, and the velocity of groundwater flow is 110.37~420m/d; the groundwater mainstream direction of the Hougao test area is northward and eastward, and the velocity of groundwater flow is 9.09~289.5m/d. 2) The karst development of the aquifer in the study area is multilayered, and solution opening, solution crack, fracture, pipelines coexist. The Wangzhai study area has a hydraulic connection with the downstream Liuzheng water source, it is not recommended to develop industries with heavy groundwater pollution.

1. Introduction

A series of problems exist in the karst area where the underground karst development is complicated and the groundwater hydraulic connection is not clear. Tracer test have long been widely used to determine groundwater hydraulic connections and determine velocity of groundwater flow[1]. Through the practical research of scholars domestic and foreign, the methods and techniques of tracer experiments have achieved many developments. Fluorescent tracer method, chemical ion tracer method, microbial tracer method etc are commonly used at present[2]. The start of the tracer test abroad is earlier than that of the country. The American used the tracer method to study the flow rate of groundwater flow a hundred years ago. From 1993 to 1997, Martin H et al conducted seven tracer tests to investigate the hydraulic connection between Lake Ritom and groundwater in Switzerland[3]. Dang et al used ^{2}H、^{18}O、^{13}C isotope tracers to determine the recharge source of groundwater[4]. Domestic tracer test began to be applied later. Chen Ming et al used chemical ion tracing to detect groundwater sources in coal mine areas[5]. Xia Bingbing et al used the fluorescent agent tracer method as the dam leakage test technology[6].

By studying the tracer test method, the ammonium molybdate was selected as the tracer for the specificity of the water source downstream of the study area. Groundwater tracer test was carried out in the study area to visually trace the source and destination of karst water. To understand the hydraulic connection between the study area and downstream water sources, regional karst development characteristics, hydrological parameter characteristics and water enrichment.

2. Hydrogeological Conditions

The research area is located in the southwestern Dawu water source area of Linzi District, Zibo City, and it is responsible for municipal water, agricultural water, and production and domestic water consumption of large enterprises and factories in Zibo City. It belongs to the transition zone between

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Luzhong Mountain Area and North China Plain. The south is a low-lying mountain to a low hilly area, and the north is a piedmont plain tilted to the north. According to its genetic type and topography, Fluorescent tracer method, chemical ion tracer method, microbial tracer method, etc. are commonly used at present[7]. The terrain is high in the south and low in the north, with an altitude of 300-780m. The climate is subtropical mansoon climate zone with distinct four seasons, mild climate, abundant rainfall and uneven distribution during the year. The Weihe fault zone in the area is the largest concealed fault zone, and the faults are mainly developed in the northwest and northeast directions[8]. The two major aquifers in the study area are the upper Quaternary aquiferous rock formations with loose rock , and the lower Ordovician aquiferous rock formations with Fracture-karst carbonate rock . The main water-bearing sections are O_2^4、O_2^5、O_2^6limestone.

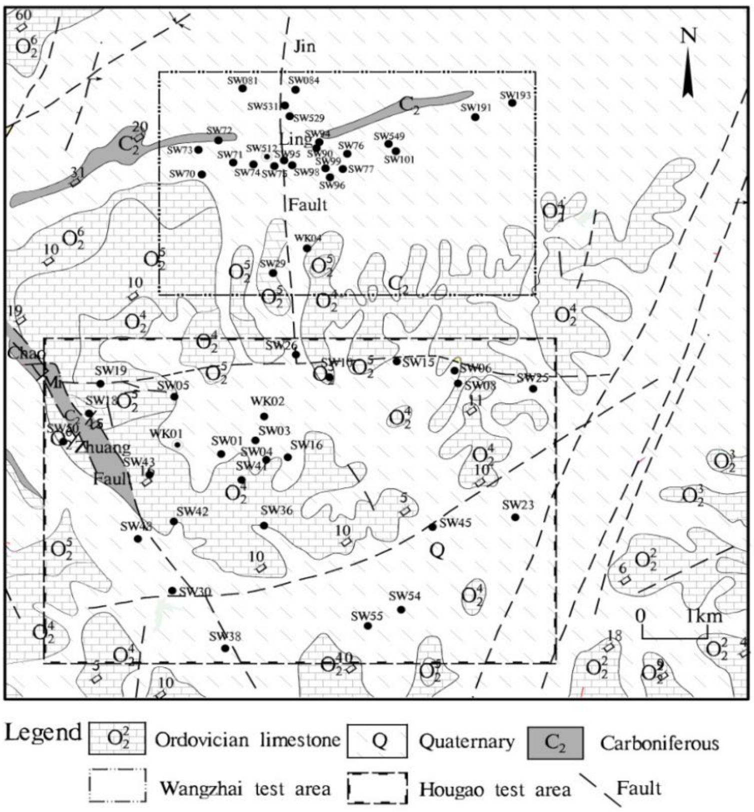


Figure.1 Location of test area and monitoring well

3. Tracer Test Layout

In the early stage of the tracer test, each monitoring well was sampled, and the background value of the molybdenum ion in the study area was calculated to be 0.378 to 5.601 ppb. According to the difference between karst development and groundwater exploitation in Wangzhai and Hougao test area, in the sampling process, considering the distance between the monitoring points and the source wells and the geological structure differences, after the tracer is placed, the samples are taken near and faraway. And according to the test data results, the sampling sequence and frequency adjusted in time.

In the Wangzhai test area, According to the formula, the amount of tracer is 210kg. On March 7, 2017, tracer is injected into the WK1 exploration hole. Samples were collected on March 8, 2017, and the test was officially ended on June 20, 2017, lasting 105 days. In the Hougao test area, on November 16, 2017, 210 kg of ammonium molybdate tracer was injected into the SW512 exploration well. The sampling groups began collecting samples on November 17, 2017, and officially ended on March 9, 2018, lasting 113 days.

4. Analysis and Discussion of Results

4.1. Karst Development Heterogeneity

According to the difference in groundwater flow rate of the tracer test, and taking into account the peak concentration of the monitoring point, groundwater flow direction and geological structure, the tracer diffusion characteristics of the test area are obtained.

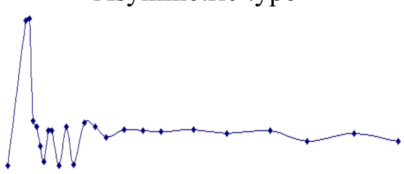
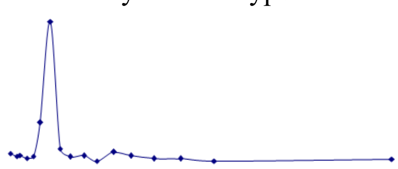
1. After being traced from the source point, the tracer migrates in the Ordovician limestone aquifer. The main direction is northeast and southeast, and the rate of diffusion along the southeast is greater than that to the northeast. The diffusion rate of the tracer in the aquifer is not uniform, and the groundwater flow rate is 110.37-420 m/d, which indicates that the karst development of the aquifer in the Wangzhai test area is uneven. The diffusion rate of the tracer in the aquifer is not uniform, and the groundwater flow rate is 110.37-420 m/d, which indicates that the karst development of the aquifer in the Wangzhai test area is disproportionation.

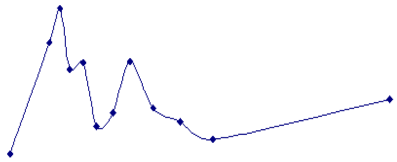
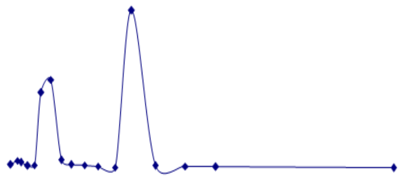
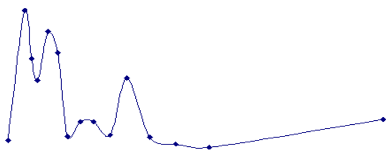
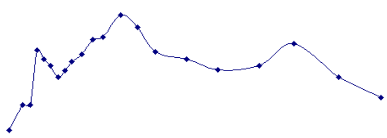
2. After being traced from the source point, the tracer migrates in the Ordovician limestone aquifer. The main direction is northward and eastward. The tracer diffusion rate is greater in the north than in the east, and the groundwater flow velocity in the experimental area is 9.09~289.5m / d, is about 31.8 times, it can be seen that the karst development of the aquifer in the Wangzhai test area is quite different.The Jinling fracture in the experimental area has a conduction-promoting effect on the tracer. The tracer migrated from the source well to the SW529 and SW531 along the fracture. The groundwater flow rate of SW529 and SW531 is larger than the rest of the area, indicating that the fracture near the fracture zone is relatively developed, and the tracer diffuses along the fracture zone at a faster rate.

4.2. Karst Development Characteristics

The groundwater tracer test in the area with good karst development can not only determine the groundwater flow direction and flow velocity in the test area, but also understand the hydrodynamic characteristics of the groundwater. Based on the previous research on the type of tracer concentration curve[9], according to the tracer test results of this tracer test, 5 times of the background value concentration is used as the detection standard, and 18 villages in Wangzhai and Handan will be used. The tracer concentration curve of the detection point is divided into three types: single peak, double peak and three peak curve. In this test, due to the limited number of monitoring points for detecting tracers, the curve type was not fully reflected.

Table 1. Table of karst development characteristics of the test area.

Peak type	Curve type	Curve feature	Checkout point
Single peak curve	Asymmetric type 	The tracer migration speed is reduced, the downstream channel of the sampling point is narrowed, and it is continuously diluted, and concentration tailing occurs.	Wangzhai：SW43、SW36 Hougao：SW77
	Asymmetric type 	The size of the karst channel upstream and downstream of the sampling point is basically the same.	Wangzhai：SW10、SW45 Hougao：SW098、SW096、SW095

Double peak curve	High-low 	The peak of the first channel is high, the peak of the second channel is low and behind the first channel, the downstream channel of the sampling point is narrowed, and concentration tailing occurs.	Wangzhai：SW08 Hougao：SW076、SW090、SW101
	Low-high 	The first channel has a large storage space and a low peak concentration; the second channel is narrowed and the peak concentration is high.	Hougao：SW075 、SW529
Three peak curve	High-low-low 	After the first channel reaches the peak, the second and third channels arrive one after another, and the flow rates are not much different.	Wangzhai：SW16 Hougao：SW531
	Low-high-low 	The first channel has a storage space, the concentration is the smallest, the second channel has the highest concentration, the third channel is narrowed, and is diluted by the first two channels.	Wangzhai：SW04

The type of the detection point of the Wangzhai test area is dominated by a single peak, with single peak curve type accounting for 62.5%, double peak curve type accounting for 12.5%, and three-peak curve type accounting for 25%; The type of curve detected in the test area is dominated by single peaks and double peaks, with single peak curve type accounting for 40%, double peak curve type accounting for 50%, and three-peak curve type accounting for 10%. The tracer concentration has a different curve shape, indicating that the aquifer karst is unevenly developed, solution opening, solution crack, fracture, pipelines coexist, with multiple nature.

5. Conclusion

1.The mainstream of groundwater in the Wangzhai study area is in the southeast direction. The source hole is in contact with the Liuzheng water source in the southeast of the study area. Therefore, the study area should not engage in industries that are polluted by groundwater sources to prevent the cause of Liuzheng water source. The main direction of groundwater in the Hougao study area is eastward and northward, and the Jinling fault has weak water permeability.

2.The diffusion rate of tracer with groundwater flow in the Ordovician Majiagou Formation is different, and the tracer concentration has a different curve shape, indicating that the aquifer karst is unevenly developed, solution opening, solution crack, fracture, pipelines coexist, with multiple nature.

3.There is no correlation between the magnitude of the hydraulic gradient and the transport speed of the tracer. The regional karst medium has the characteristics of heterogeneous anisotropy.

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