Safety Investigation, Monitoring and Evaluation of Groundwater Emergency Reserve Water Source in a City

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Abstract. In order to implement the most stringent water resources management system, strengthen the management and protection of groundwater, it is necessary to carry out the safety investigation, monitoring and evaluation of groundwater emergency standby water sources. Taking a city as an example, a pumping test was carried out in some areas, the results of the pumping test and water resources data were analyzed, and the feasibility of using it as a water source was comprehensively evaluated from the perspective of water quantity guarantee and water quality safety. The results show that due to the lithological differences of aquifers, the water yield property has a large space-time difference; The regional groundwater resources are rich, but the existing emergency water supply capacity needs to be improved; The groundwater quality is generally getting better and the toxic pollutants are reduced, which can meet the quality requirements of emergency water supply after treatment.

Keywords: groundwater, Emergency water source, monitoring and evaluation

1 Introduction

Groundwater is one of the essential resources for human life and economic development. As a renewable water resource, groundwater plays an important role in meeting the water needs of urban residents, agriculture, and industry. However, with the acceleration of urbanization and continuous population growth, groundwater resources are facing increasing pressure and threats [1-3].

When there are significant changes in water sources or severe water shortages, alternative water sources are the most effective way to provide emergency water supply [4, 5]. Groundwater is an important component of water resources and a crucial strategic and emergency resource for sustainable economic and social development, as well as a controlling factor for ecological environments [6]. Therefore, the development, utilization, protection, and management of groundwater play a vital role in ensuring drinking water safety for urban and rural residents, water security for economic and social development, environmental safety, and responding to extreme drought and

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other emergencies. Conducting evaluations of emergency backup groundwater sources is an extremely important and urgent task, as well as a highly challenging technical endeavor [7-9].

In a city like the one mentioned, with a dense population and developed economy, the safety and sustainability of groundwater have become increasingly important. Especially in the face of natural disasters, water source pollution, or failures in water supply systems, the safety of emergency backup groundwater sources becomes crucial [10, 11]. Therefore, conducting safety investigations, monitoring, and assessments of these emergency backup groundwater sources have significant practical significance and urgency.

This article will review and analyze the selection criteria for emergency backup groundwater sources. Taking into account factors such as the sustainability of groundwater extraction and water quality safety, we will use scientific selection criteria to screen and evaluate backup water sources during the investigation. By assessing the safety and stability of backup groundwater sources, we will provide scientific evidence for relevant decision-makers and managers to formulate appropriate management policies and measures, ensuring the reliability and availability of backup water sources and guaranteeing the water supply for urban residents and sustainable economic development. At the same time, it can also provide reference and guidance for groundwater resource management and protection, promoting the sustainable utilization of groundwater resources.

2 overview of the study area

2.1 Regional scope

The study area is located in the west of a city, with a total area of 1092 km^2. The terrain is inclined from northeast to southwest, and the layered structure of the landform is obvious. The north is dominated by mountains and hills, the middle is dominated by platforms and terraces, and the South and West are dominated by plains.

2.2 Water supply

The river system in the city is developed, and there are many large and small rivers, but the local water resources are less, and the transit water resources are relatively rich. The surface water supply is the main water supply, accounting for more than 99% of the total water supply for many years. The water supply infrastructure in the region has been continuously improved, and the number of water supply sources has increased from 6 to 10. In recent years, with the population growth and industrial development, the water demand has increased rapidly, and the increase in the construction of water supply facilities is not enough to meet the demand for water. Moreover, in the process of industrial development, the problem of water pollution has become increasingly serious, and the water supply situation is very tense.

2.3 Hydrogeologic condition

Climate.

The region is located in the subtropical monsoon climate zone and belongs to the typical monsoon marine climate of the subtropical zone. The annual average temperature of the city is 21.4~21.8 °C, and the annual average sunshine hours are 1875.1~1959.9 hours. The annual average rainfall in the core area is 1733mm, and the rainy season is from April to September. The rainfall accounts for about 85% of the whole year. It has the law of decreasing from the East, West, North Hills and the South China Sea to the center of the delta plain.

Stratum and structure.

The study area belongs to the central Guangdong sag of the North Guangdong central Guangdong sag belt of the South China fold system in terms of structural units. The area is dominated by sedimentary strata, with a large area of covered soluble carbonate rocks. The main folds in the area are compound folds such as Huadu syncline and Fengcun anticline, and the arrangement pattern is basically ne. The northeast trending Guangcong fault, the northwest trending Guangsan fault and the East-West trending Shougouling fault all pass through the area, of which the northeast trending Guangcong fault plays a major role in the formation of the basin during the long-term geological history. Controlled by Guangcong fault, the tectonic framework in the basin is dominated by NE trending compound and northward dipping, and the NE trending ridge of residual hill and the plain between hills are arranged in parallel. The central and southern part is sedimentary strata, and the northern basin edge is dominated by granite platform.

The strata in the study area are diverse, with the exception of the Devonian, Carboniferous, Permian, Triassic, tertiary and quaternary systems exposed to the surface, and the strata of other ages are missing. See Table 1 for an overview of the world weary strata in the study area.

Table 1. Overview of Rock Stratigraphy in the Study Area.

community	system	group	code	Sedimentary facies	distribution area	Lithological characteristics	thickness（m）
Cenozoic	Quaternary	Dawan Town	Q*hdw*	Flushing flood Integral phase	Plain and valley on both sides of Liuxi River	Silty clay, pebbles, gravel, sub clay	8.0-20
		Guizhou	Qhg	Flushing flood Integral phase	In the central area of Huadu City	Grey, grayish black silt, silt, fine sand, and gravel containing rich humus and oyster shells	3-24
	paleogene	Xinzhuang	E_1x	Flushing flood Integral phase	Sporadic distribution	Purple red tuffaceous conglomerate, sandy conglomerate, medium to fine sandstone mixed with silty mudstone and tuff, locally mixed with carbonaceous	2-18

						shale	
upper paleozoic	carboniferous	Ceshui	C_1c	Land sea interaction	Around Huashan Town	Sandstone, sandy shale interbedded with sandy conglomerate, iron sandstone, carbon shale, and coal layers, containing plant and brachiopod fossils	145-237
		Shidengzi	C_1s	neritic facies	Hidden beneath the Quaternary strata	Limestone, carbonaceous limestone, dolomite, dolomitic limestone with angular gravel limestone, and thin layered and lenticular mudstone limestone	48-277
		Dasai	$C_{1d}s$	neritic facies	Southwest Basin Area	Siltstone, argillaceous siltstone, intercalated shale	48-277
	Devonian system	Maozifeng	D_3m	Land sea interaction	Around Furong Town	Yellow and grayish green powder, fine sandstone, sandy shale and mudstone interbedded, laminated shale, iron shale and coarse sandstone	156-791
		Yangxi	D_2y	littoral facies	Northwest of Paitan Town	Sandstone, quartz sandstone, volcanic fine-grained clastic rock	120-558

2.4 Groundwater recharge, runoff and discharge conditions

This area is a covered karst basin, which is a typical karst groundwater system. It has the characteristics of multiplicity (solution gap, karst cave and pipeline coexist), open system (four water transform rapidly), high complexity (laminar flow and turbulence coexist, linear flow and nonlinear flow coexist), and dynamics (storm effect). Therefore, the cycle processes of groundwater supply, runoff and discharge in the area are also relatively complex.

The recharge of groundwater in the region includes atmospheric precipitation infiltration, surface water infiltration, irrigation water infiltration and lateral runoff recharge outside the region. The main source of recharge is atmospheric precipitation infiltration. Affected by the seasonal difference of rainfall, the recharge period of groundwater is from April to September every year, and the consumption period is from October to March next year.

The runoff mode of confined water in the concealed Karst Development Zone in the region is mainly overflow, which is discharged in the form of spring or subsurface flow. The terrain of the river network area is flat, the hydraulic gradient of groundwater is gentle, the runoff form is mainly horizontal circulation, and the groundwater has the characteristics of high salinity and complex hydrochemical types. The dynamic change of groundwater is basically controlled by atmospheric rainfall. The infiltration in rainy season increases, the groundwater level rises, and the water level drops due to less recharge in dry season. Due to the shallow groundwater level in the area, the groundwater level rose rapidly after the rainstorm. And in karst area, the conversion of surface and groundwater is rapid.

There are several forms of groundwater discharge in the region: ① springs, which are natural outcrops of groundwater, are distributed in bedrock hilly areas and their edges. There are few plain areas, which are mainly erosional downwelling springs and contact springs, and downwelling springs are dominant. There are rising springs in some sections, and most of the spring points are related to fractures or structural fractures and karst caves; ② Groundwater discharge refers to the discharge of groundwater into rivers, sea water and other surface water bodies. In dry season, groundwater discharge supplies river water, which is the main discharge mode of groundwater; ③ Evaporation and discharge include phreatic soil surface evaporation and plant leaf surface evaporation. Soil surface evaporation is formed only when the phreatic surface is shallow, the capillary zone is close to the surface, and the air relative humidity is low. Therefore, this form of evaporation is relatively weak in the valley plain area, where the vegetation is developed and the plant root system is developed, which is conducive to plant leaf evaporation; ④ Manual water intake refers to the pumping and drainage of artificial shaft sinking, pit pumping and drainage, underground space development and other engineering construction, which is used or drained for production and living. Although the amount of artificial extraction and drainage is small, it is often the main inducing factor of ground collapse disaster.

3 Safety investigation, monitoring and assessment of water sources

3.1 Water quantity guarantee

Evaluate the water security of water security indicators such as the type of groundwater medium, atmospheric precipitation infiltration, single hole water inflow and groundwater reserves in the region.

Type Of groundwater medium.

The lithology, structural characteristics and hydraulic connection of the strata in the region are important constraints for the water supply, water holding, water permeability and water yield of each aquifer. Groundwater types can be divided into pore water, fissure water and karst water according to the types of water bearing media (voids), hydraulic properties and hydraulic characteristics. Among them, bedrock fissure water can be further divided into three subcategories: massive red bed rock pore fissure water, layered rock fissure water and massive rock fissure water according to the differences of water bearing rock formation and hydraulic properties.

(1) Pore water: distributed in the plain clastic rock area in the region. The aquifer is mainly composed of Quaternary sea land mixed accumulation fine sand layer, alluvial proluvial pebble, gravel, medium fine sand, sandy soil and silt, mainly medium sand, with a thickness of 3-30m. The overall characteristics of groundwater in the area are narrow range, thin thickness and instability. The degree of water abundance is affect-

ed by factors such as particle composition and layer thickness, with great differences. It is generally phreatic water and partially confined water. The buried depth of the water level is generally 1.5~9.0m, with an annual variation of 1~2m. The bamboo material Renhe, the southwest of Huadu, the northwest of Shenshan and the south of Huashan are abundant in water,

(2) Karst water: karst water system is widely distributed in the soluble rock area of the basin, including exposed, covered and red bed limestone conglomerate karst water. The characteristics of karst cave water in carbonate rock fractures are large aquifer thickness, karst development, strong and uneven water yield, and shallow groundwater level. The whole area is mainly covered karst, and some shallow fissure karst caves are directly connected with the overlying quaternary system. The exposed carbonate rock fissure cave water, with a small distribution range, occurs in the limestone of Qixia Formation, Hutian formation, shidengzi formation and Tianziling formation, and the water yield of different sections varies greatly.

(3) Bedrock fissure water: mainly distributed in granite, migmatite, clastic rock or red bed in the north and East. According to the lithology and structural characteristics of water bearing medium, bedrock fissure water can be divided into three subtypes: red bed fissure water, layered rock fissure water and massive rock fissure water. The bedrock fissure water bearing rock formation includes various granites of Caledonian and Yanshanian periods and Sinian metamorphic migmatites. The weathered fissures of these rock formations are developed, and the buried depth of the water level in the gentle zone is 0.1-4.14m. The seasonal variation of water content in slope rock mass is obvious, which directly affects the stability of slope. The red clastic rock fissure water is mainly distributed in the west of Guangzhou urban area and Longgui, with a small distribution area. The aquifers are Baikui Paleogene conglomerate, glutenite, calcareous sandstone and mudstone; The water yield is moderate deviation, the spring flow is 0.5-L/s, and the single hole water inflow is mostly 100-1000m^3/d. The buried depth of water level is generally 0.82-4.55m. The fracture water of layered rocks is mainly distributed in Taihe Xinshi Shijing, red mud and the east of huadongbei. The water bearing medium is Devonian, Carboniferous and Triassic clastic rocks (shale, sandstone, etc.), and the buried depth of the water level is 0.52-4.55m. The fissure water of massive rocks is widely distributed in the north and east of the basin, and the water bearing medium is mainly granitoids intruded in different periods, Presinian Yunkai group migmatites and Proterozoic gneisses, of which the lower section of the strongly weathered zone and the moderately weathered zone are the main water bearing rock zones.

Infiltration of atmospheric precipitation.

According to the work outline for the preparation of a provincial groundwater bulletin, the groundwater in the Pearl River Delta and Chaoshan Plain is shallow groundwater with a buried depth of less than 10m. Groundwater dynamics under natural conditions are closely related to meteorological factors such as atmospheric precipitation, and have obvious seasonality. Collect the long-term observation data of groundwater level in the study area, analyze the dynamic change of groundwater, and grasp the response of groundwater level to climate change.

See Fig. 1 for the water level process curve of automatic monitoring well a1-7 from January 22, 2014 to December 31, 2014 and the rainfall curve of corresponding period. It can be seen from the figure that the groundwater level showed obvious response to three strong rainfall in the study area. The variation of groundwater level has the characteristics of periodicity, which is closely related to precipitation in this region. Through data analysis, it can be seen that the change trend of groundwater level is also basically consistent with the magnitude change trend of precipitation. The results show that the variation of groundwater level has a great relationship with rainfall magnitude and rainfall pattern.

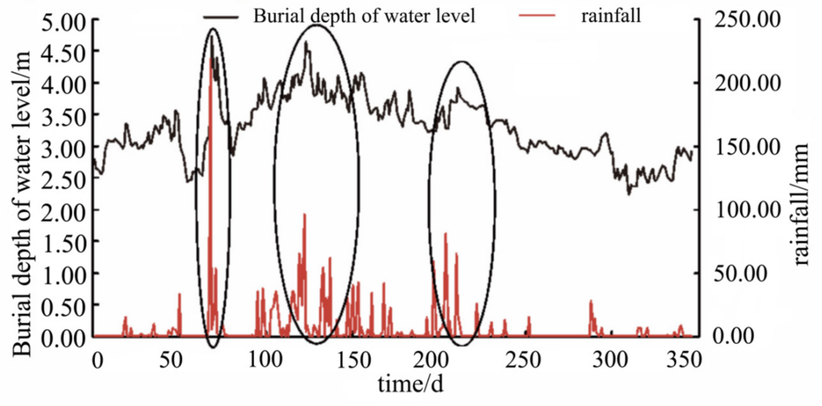

Fig. 1. Water Level Process Curve and Corresponding Period Rainfall Curve

In addition, the soil and rock properties in the process of rainfall infiltration determine the infiltration coefficient of groundwater, which also affects the response process of rainfall groundwater level. In view of the limited monitoring data, it is impossible to analyze the relationship between each monitoring well and precipitation. However, the existing research results show that the karst groundwater system responds very quickly to atmospheric precipitation, and precipitation enters the groundwater system through karst pipeline cracks. The area is a covered karst groundwater system, and the change of precipitation groundwater level is affected by the types of overlying vegetation, land use forms and karst pipeline cracks in the lower part. Compared with the non karst system, there are more influencing factors, so the monitoring and research need to be further strengthened.

The distribution map of precipitation infiltration recharge coefficient in the region obtained by Kriging interpolation method is shown in Figure 2 (a). It can be seen that the infiltration recharge coefficient of atmospheric precipitation in the southeast of the region is larger, while the infiltration recharge of atmospheric precipitation in the middle and central regions of the west is smaller. The western and northern parts of the region are mostly mountainous areas or farmland and woodland covered by vegetation, which is conducive to the recharge of groundwater by atmospheric precipitation; In the southeast of the region, the infiltration recharge coefficient of atmospheric precipitation is the largest. See Fig. 2 (b) for the infiltration of atmospheric precipitation.

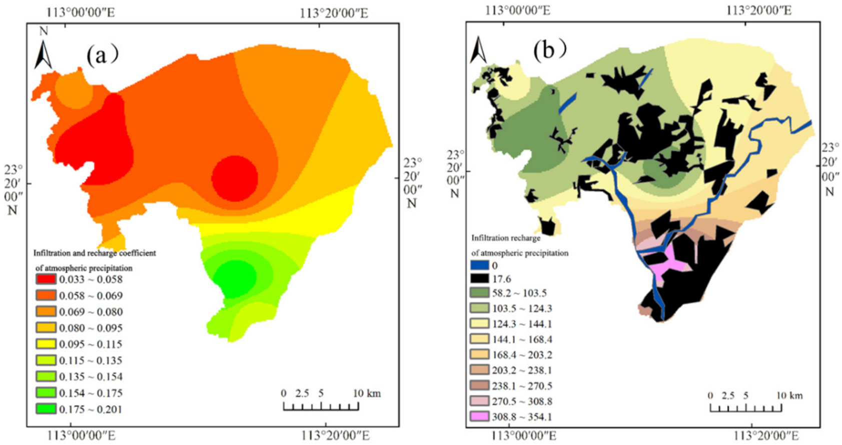

Fig. 2. Coefficient of Atmospheric Precipitation Infiltration Supplement and Amount of Atmospheric Precipitation Infiltration Supplement

Single hole water inflow and groundwater reserves.

Pumping tests were carried out in some areas of the study area, and the pumping test results were analyzed. See Table 2 for the distribution of pumping wells.

Table 2. Statistics of Unit Water Inflow in the Study Area

Drill hole number	groundwater type	Unit water inflow $m^3/d\cdot m$	watery	Drill hole number	groundwater type	Unit water inflow $m^3/d\cdot m$	watery
A1-1	Karst fissure water	87.07~95.74	good	A1-30	Karst fissure water	107.15~128.18	good
A1-2	Karst fissure water	43.92~46.23	good	A1-31	Karst fissure water	74.88~81.50	good
A1-3	Karst fissure water	8.85~9.29	good	A1-32	Karst fissure water	37.94~40.69	good
A1-4	Karst fissure water	56.03~58.98	good	A1-33	Karst fissure water	47.74~57.58	good
A1-5	Karst fissure water	105.19~118.19	good	A1-34	Karst fissure water	62.40	better
A1-6	Karst fissure water	12.00~14.09	good	A1-35	Karst fissure water	9.00	medium
A1-7	Karst fissure water	1.22	poor	A1-36	Karst fissure water	sinking pump	worse
A1-8	Karst fissure water	57.71~68.05	good	A1-37	Karst fissure water	33.32~36.30	good
A1-9	Karst fissure water	2.22	medium	A1-38	Karst fissure water	69.19~72.91	good
A1-11	Karst fissure water	16.06~18.52	good	A1-39	Karst fissure water	95.77~102.02	good
A1-12	Karst fissure water	41.78	good	A1-40	Karst fissure water	15.83	good
A1-13	Karst fissure water	1.53	poor	A1-41	Karst fissure water	5.46~5.72	good
A1-14	Karst fissure water	8.85~9.61	good	A1-42	Karst fissure water	15.80	better
A1-16	Karst fissure water	0.09	poor	A1-43	Karst fissure water	18.76~20.78	good
A1-17	Karst fissure water	70.08	good	A1-44	Karst fissure water	3.60~4.13	medium

Drill hole number	groundwater type	Unit water inflow $m^3/d\cdot m$	watery	Drill hole number	groundwater type	Unit water inflow $m^3/d\cdot m$	watery
A1-20	Karst fissure water	1.21	poor	A1-45	Karst fissure water	131.14~152.88	good
A1-21	Karst fissure water	sinking pump	worse	A1-46	Karst fissure water	0.16	worse
A1-22	Karst fissure water	46.49~61.60	good	A1-47	Karst fissure water	79.76~90.64	good
A1-23	Karst fissure water	0.90	poor	A1-48	Karst fissure water	95.00	good
A1-24	Karst fissure water	2.16~2.59	better	A1-49	Karst fissure water	127.83	good
A1-25	Karst fissure water	0.79	poor	A1-50	Karst fissure water	46.12	better
A1-27	Karst fissure water	46.84~52.9	good	A1-51	Karst fissure water	16.87~19.72	good
A1-28	Karst fissure water	sinking pump	worse	A1-52	Karst fissure water	11.56~14.17	good
A1-29	Karst fissure water	5.34	medium	A1-53	Karst fissure water	0.15	poor

(1) Pore water mainly exists in loose sediments. Mastering the sediment deposition law and analyzing the characteristics of sediments are the main basis for identifying the distribution and formation law of pore water. Loose rock pore water is generally good in water yield, and single hole water inflow is mostly more than $1000m^3/d$.

(2) The karst water in the area mainly occurs in the medium thick bedded limestone of shidengzi formation (c1ds) in the lower series of the Carboniferous system, and is concealed under the Quaternary alluvial proluvial layer. Due to strong weathering, fissure joints and karst are well developed, with a karst rate of 21.4%, and the type of groundwater is confined water. Covered carbonate rock fissure karst water is widely distributed in the basin. The overburden is generally 3-18m thick, and the buried depth of the water level is 0.5-9.16m. The water yield is good (single hole water inflow is generally>i000m^3/d) or good (100-1000m^3/d), and the local water yield (Huashan Huadong) is poor. The limestone conglomerate karst water in the red bed is distributed in Shijing Xinshi Jinshazhou Datansha area in the south of the study area. The water bearing medium is the limestone conglomerate developed in the fractured karst cave, with good water yield (the water inflow of a single hole is more than i000m^3/D). However, due to the different lithology, origin, age, distribution area and structural position, the local water yield is very different. Generally, pure limestone is easier to be dissolved than dolomite, marl and siliceous limestone, and the former is better than the latter in water abundance. Limestone is also often intercalated with non soluble sand shale and siliceous rock, and the dissolution is often developed along the contact surface of the two, so it is relatively rich in water along the trend direction. The degree of karst development is related to the structural position, generally in the syncline core and the plunging end of the anticline are favorable areas for karst development and groundwater enrichment.

(3) The water yield of fissure water varies greatly due to lithological differences. The massive rock fissure water aquifer is mainly Yanshan phase III medium grained porphyritic biotite granite. Affected by the NE trending fault, the fissure is developed, which is conducive to the accumulation and occurrence of groundwater. The water volume is medium, and the spring flow is small, with an average of 0.38 L/s.

3.2 Water quality safety assessment

The monitoring work was carried out for 80 groundwater monitoring wells in the region from 2010 to 2017, and samples were taken twice a year in the wet season (April September) and dry season (October to March next year). The main monitoring items of water quality monitoring can be divided into two categories: one is the comprehensive indicators reflecting water quality conditions, such as temperature, chroma, turbidity, pH value, conductivity, suspended solids, dissolved oxygen, chemical oxygen demand and biological oxygen demand; The other is some toxic substances, such as phenol, cyanide, arsenic, lead, chromium, cadmium, mercury and organic pesticides.

chemical composition of groundwater.

The average pH values of shallow and deep groundwater in the region are 7.24 and 7.74, respectively, which are generally alkaline, showing the characteristics of alkaline environment of groundwater formed by dissolution of limestone and dolomite in karst area. Generally speaking, the pH value in groundwater is determined by the temperature in groundwater and h+in water. In karst water, the pH is mainly affected by HCO_3^- (or CO_3^{2-}). Within a certain range, it increases with the increase of HCO_3^- (or CO_3^{2-}) concentration. However, in human activity areas, the water contains a large number of organic acids, and the change of pH will be more complex.

The TDS in the area is 36.36~353mg/L, with low mineralization. The average values of Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, SO_4^{2-}, and Cl^- in groundwater from geological boreholes were 27.55, 7.17, 49.42, 5.88, 156.18, 26.08, and 38.26mg/L, respectively; The average values of Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3-, SO_4^{2-}, and Cl^- in groundwater of Minjing were 31.73, 23.67, 58.06, 4.55, 141.81, 63.05, and 40.19mg/L, respectively.

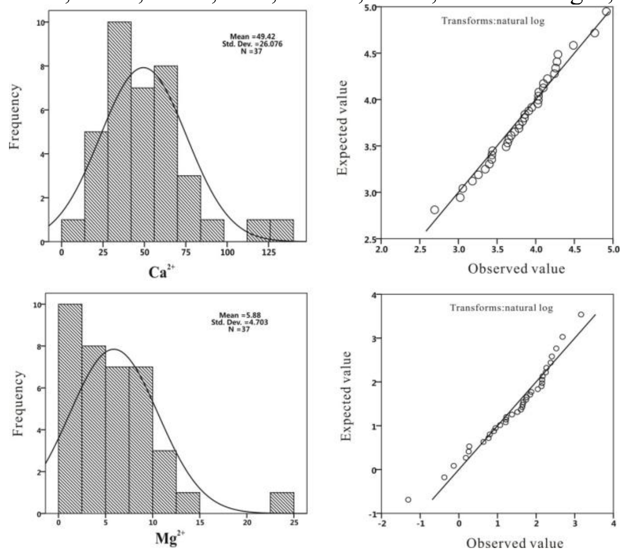

Fig. 3. Ca, Mg Frequency Histogram

In the chemical composition of all groundwater samples in the study area, alkaline earth metal ions (Ca^{2+}+Mg^{2+}) are the main cations, accounting for 40%~90%, while alkali metal ions (K^{+}+Na^{+}) are less than 0~40%. It can be seen from the statistical table that the main chemical type of groundwater in this area is HCO_3 Ca type, followed by HCO_3 • Cl Na • Ca type. In addition, HCO_3 • SO_4 Na • Ca type, HCO_3 • Cl Na, HCO_3 Ca • Mg type are sporadically distributed, which is consistent with the geological background of widespread carbonate rocks and less evaporite rocks in the region. The groundwater in the concealed karst area is recharged by the pore water of the overlying loose rocks. Under the action of karst, the chemical composition of groundwater contains more bicarbonate, chloride, sulfate, calcium ion, sodium ion and magnesium ion, and the pH value is relatively high, mainly neutral weak alkaline. The chemical composition of groundwater in the study area is shown in Figure 4.

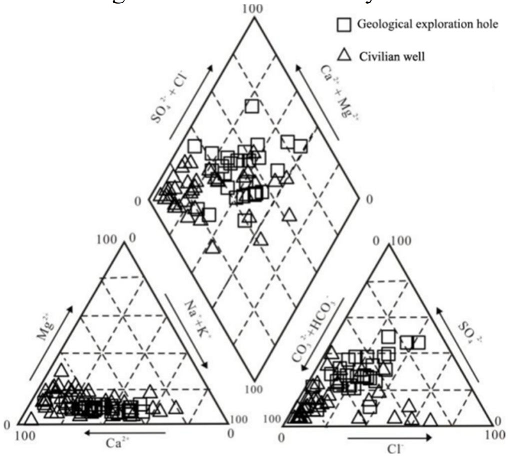

Fig. 4. Chemical composition of groundwater in the study area

Groundwater quality assessment is based on groundwater quality investigation and analysis data or water quality monitoring data, which can be divided into single component assessment and comprehensive assessment. In this paper, the groundwater quality evaluation is carried out by the combination of single item and comprehensive score. The single component evaluation of groundwater quality is divided into five categories according to the classification indexes listed in this standard. When the code is the same as the category code, and the standard values of different categories are the same, it is better than worse.

The comprehensive evaluation of groundwater quality adopts the scoring method with notes. Specific requirements and steps are as follows:

① The items to be scored shall not be less than the monitoring items specified in this standard, but shall not include bacteriological indicators.

② First, evaluate each single component and divide the quality category of the component.

③ Determine the individual component evaluation score F_i for each category according to Table 3.

④Then calculate the comprehensive evaluation score F according to equations (1) and (2)

Table 3. Comparison Table of Individual Group Classification and Evaluation Scores

category	I	II	III	IV	V
F_i	0	1	3	6	10

$$F = \sqrt{\frac{F_1^2 + F_{max}^2}{2}} \tag{1}$$

$$F_1 = \frac{1}{n}\sum_{i=1}^{n} F_i \tag{2}$$

Calculate the comprehensive evaluation score F according to equations (1) and (2).

In the formula, F1 is the average of the scoring values Fi for each individual component;

F_{max} is the maximum value of the evaluation score Fi for a single component;

n is the number of items

⑤ According to the F value, the groundwater quality level is divided according to the following regulations (Table 4), and then the bacteriological index evaluation category is marked after the level designation. For example, "Excellent (Class II)" and "better (Class III)".

Table 4. Comparison Table of Groundwater Quality Levels and Comprehensive Scores

level	Excellent	Good	better	worse	extremely bad
F	<0.80	0.80~<2.50	2.50~<4.25	4.25~<7.20	>7.20

According to the groundwater quality standard, 21 items including turbidity, pH value, chromaticity, chloride, total hardness, nitrate, ammonia nitrogen, cyanide, volatile phenols, total dissolved solids, chromium (hexavalent), sulfate, fluoride, mercury, arsenic, cadmium, lead, manganese, iron, nitrite and oxygen consumption participated in the water quality assessment.

The results show that the water quality indexes of groundwater in the study area in 2016 are mainly class I~III water, and the water quality is generally good, meeting the requirements of centralized drinking water sources and industrial and agricultural water. However, some indicators in some regions are class IV~V water. Ammonia nitrogen, oxygen consumption and volatile phenols are the main indicators of class IV water exceeding the standard, while Fe, Mn and nitrite in some regions exceed the standard; Ammonia nitrogen, oxygen consumption, Mn and Fe are the main pollutants exceeding the standard in class V water, while pH and fluoride in a few places exceed the standard. The water quality in wet season is better than that in dry season.

In 2017, the water quality indexes of groundwater in the region were mainly class I~III water with good quality, which met the normal requirements of centralized drinking water sources and industrial and agricultural water. However, some water bodies also have pollution problems. Oxygen consumption is the main reason for class IV water exceeding the standard, and fluoride and Mn exceed the standard in some areas; Ammonia nitrogen, chloride, oxygen consumption and Fe are the main pollutants exceeding the standard in class V water, while sulfate, fluoride and as are exceeded in a few places. The type III water index in the wet season is similar to that in the dry season; Ammonia nitrogen, chloride, oxygen consumption, Mn and Fe are the main types of water exceeding the standard, while nitrate, volatile phenols and fluoride in some areas exceed the standard; Ammonia nitrogen and oxygen consumption are the main causes of class V water exceeding the standard. Chloride, nitrate and volatile phenols in some areas exceed the standard. Fluoride and Fe in some places exceed the standard.

As the iron, manganese, ammonia nitrogen, oxygen consumption and other items in groundwater generally exceed the standard, the quality level of evaluation is poor, which reduces the quality level of groundwater resources. However, the indicators of iron, manganese, ammonia nitrogen, arsenic and fluoride in groundwater can be improved through water quality treatment, so as to improve the utilization of groundwater. Therefore, iron, manganese, ammonia nitrogen, arsenic, fluoride and other groundwater exceeding the standard can be removed by removing iron, manganese, ammonia nitrogen, arsenic and fluoride; For water with light pollution degree of toxicity index (within 3 times of toxicity index), iron, manganese and arsenic are removed, and mixed water supply is used to adjust the exceeding standard items to within the relevant standard limits, which can be used as water supply source; The water with serious pollution degree of toxicity index (more than 3 times of toxicity index) should not be used as water supply source.

4 Conclusions and recommendations

4.1 Conclusions

(1) The groundwater types in the region are mainly loose rock pore water and karst water. The loose rock pore water is mainly distributed in the river alluvial zone, while the karst water is constrained by lithology and geological structure and enriched in the fold core and karst pipeline. Due to the lithological differences of the aquifers, the water yield property has great temporal and spatial differences.

(2) The area is rich in groundwater resources, but the existing emergency water supply capacity needs to be improved.

(3) The system diagnosed the water quality of the study area. The groundwater quality is generally getting better, and the toxic pollutants are reduced. After treatment, it can meet the water quality requirements of emergency water supply.

4.2 recommendations

(1) Strengthen the construction of supporting facilities for water supply emergency rescue capacity.

The design and construction shall be carried out according to the principles of advanced technology, economic rationality, safety and reliability, and the construction shall be organized according to the requirements of standardization and standardization to ensure the safety and applicability of supporting facilities. Speed up the construction of a number of mobile water intake equipment to achieve flexible water intake and water supply and fully meet emergency needs.

(2) Strengthen the prevention and control of surface/groundwater environmental pollution.

Regularly carry out law enforcement inspection and post supervision on groundwater resources protection and drinking water source environment. Establish risk assessment and prevention mechanism for groundwater and drinking water sources. Strictly manage and control toxic and hazardous substances. Continue to reduce the urban domestic pollution load that affects the quality of groundwater, and control the impact of urban domestic sewage, sludge and domestic waste on groundwater.

(3) Establish and improve the groundwater environment monitoring system and pollution risk early warning system.

Comprehensively check and register the water intake wells in the area, and gradually carry out the remediation work and fine management. Integrate and optimize the layout of groundwater environment monitoring points, improve the groundwater environment monitoring network, and realize the sharing of groundwater environment monitoring information. Establish a standard database of early warning and prediction, and build a groundwater pollution prediction, emergency information release and integrated information socialization service system.

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