Dynamic Analysis and Relationship Research on Precipitation and Groundwater Depth in Zhenlai County

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Abstract. Groundwater is an important source of water resources in Zhenlai County. In recent years, the groundwater level in Zhenlai County has been decreasing. Precipitation as one of the important sources of groundwater supply, the impact on the groundwater level cannot be ignored. In order to derive the relationship between precipitation and groundwater level, this research analysed the relationship between precipitation and groundwater characteristics, typical years and the whole from 2006 to 2012. The results show that the Yinghua and the Yanjiangdongerlong groundwater monitoring points have decreased by 2.03m and 0.42m respectively during 2006-2012, and the increase of precipitation will cause the groundwater level to rise. The research results can provide support for water resources management in Zhenlai County.

1. Introduction
Zhenlai County is located in the north-western part of Jilin Province and belongs to arid and semi-arid areas [1]. The water resources mainly come from precipitation, the Nenjiang River, the Taoer River and groundwater. As the eastern boundary of Zhenlai County, the Nenjiang River can only be used in a small part of the area; the Taoer River has entered a long period of dry season since 1999[2]. Therefore, the main source of water in Zhenlai County comes from groundwater. The Momoge Nature Reserve is located in the eastern part of Zhenlai County. In recent years, the Momoge Wetland has been seriously degraded. In order to improve the current situation of the wetland, groundwater numerical simulation work was carried out in Zhenlai County to grasp the changes of the groundwater level, so as to provide reasonable suggestions for the restoration of the wetland. Precipitation, as an important source of groundwater supply, has an important impact on the water resources of Zhenlai County [3]. Therefore, it is necessary to understand the impact of precipitation on groundwater. In order to find out the response of precipitation in Zhenlai County to groundwater, this paper analyses the data of precipitation and groundwater depth in Zhenlai County from 2006 to 2012, and provides reference for the distribution of water resources in Zhenlai County and the study of local groundwater. The data comes from the Baicheng Weather Station and the China Geological Environment Monitoring Groundwater Yearbook.
2. Data analysis

2.1. Precipitation characteristics analysis
Zhenlai County is situated in the mid-latitude inland area and belongs to the temperate continental monsoon climate with four distinct seasons, with an average annual temperature of 4.9 °C and an altitude of 128-210 meters. In Figure 1, The average annual precipitation in Zhenlai County was 334mm from 2006 to 2012. The largest precipitation was in 2012. The annual precipitation was 429.3mm. The total precipitation in 2007 was the smallest, and the annual precipitation was 285mm. The overall precipitation in 2006-2012 is increasing year by year. The precipitation in Zhenlai County is mainly concentrated in June-August, accounting for 63%-85% of the total annual precipitation; October-March is winter, cold and dry, and the precipitation is scarce, and the precipitation only accounts for 1% -10% of the total annual precipitation.

![Precipitation](image)

Figure 1. Change in precipitation in Zhenlai County from 2006 to 2012.

2.2. Analysis of groundwater depth characteristics
Changes in groundwater depth reflect changes in groundwater recharge and consumption [4]. According to the aquifer structure, the groundwater flow in Zhenlai County basically flows from west to east. This research selects two diving monitoring points, Yinghua and Yanjiangdongerlong. The time period is from 2006 to 2012, and the amount of precipitation data is provided. The Yinghua diving monitoring point is located in the groundwater recharge area, and the Yanjiangdongerlong diving monitoring point is located in the drainage area.

| Monitoring points   | Minimum depth | Maximum depth | Average depth | Maximum increase | Minimum increase | Difference |
|---------------------|---------------|---------------|---------------|------------------|------------------|------------|
| Yinghua             | 2.85          | 6.75          | 5.18          | 2.22             | 1.31             | 2.03       |
| Yanjiangdongerlong  | 5.2           | 8.02          | 6.27          | 0.88             | 1.25             | 0.42       |

The variation of groundwater depth in Yinghua and Yanjiangdongerlong from 2006 to 2012 is described in Table 1. According to groundwater data analysis, the groundwater level of the groundwater depth of the Yinghua monitoring site fluctuated frequently from 2006 to 2012.
average depth of the groundwater level in the past 7 years was 5.18m. In October 2006, the groundwater table had the smallest depth and the depth was 2.85m. In September, the groundwater level had the biggest buried depth of 6.75m, and the maximum difference in groundwater depth was 3.9m. The groundwater level burial depth of the Yanjiangdengerlong monitoring point was also in a fluctuating state. The average depth of groundwater depth in 2006-2012 was 6.26m. In November 2011, the buried depth was the smallest, the depth was 5.2m, and the maximum buried depth appeared in August 2010. The depth was 8.02m and the maximum difference in buried depth was 2.82m.

Figure 2 is based on the monthly variation data of the groundwater depth at the two monitoring points of Yinghua and Yanjiangdengerlong in 2006-2012. The overall groundwater level of the Yinghua monitoring site was higher than that of the Yanjiangdengerlong, and the groundwater depth was decreasing year by year. However, although the depth of the groundwater of the Yanjiangdengerlong was fluctuating, the overall level of groundwater depth has remained stable over the past seven years. By 2012, the groundwater depth of the Yinghua monitoring site was the same as that of the Yanjiangdengerlong Monitoring Point. From the overall trend, it can be concluded that the groundwater in Zhenlai County has different degrees of decline and recovery every year. However, the annual increase of groundwater level in Yinghua Monitoring Point was difficult to reach the state at the beginning of the year, indicating that local groundwater exploitation was more serious. After the groundwater depth of the Yanjiangdengerlong monitoring point declines, the initial state can be restored, and the groundwater depth remains unchanged. This may be due to the fact that the Yanjiangdengerlong monitoring point is close to the Nenjiang River. Under normal conditions, the groundwater level is concentrated in the Nenjiang River. However, when the groundwater depth drops to a certain extent, the Nenjiang River water is backed up to the groundwater, so that the groundwater depth remains relatively stable.

![Figure 2. Groundwater depth variation of the diving monitoring point from 2006 to 2012.](image)

2.3. Influence of precipitation on the change of groundwater depth during the year
For the comparison of the annual precipitation data from 2006 to 2012, the typical years of 2007 and 2012 are selected, and the process map of the year-to-year relationship is plotted, as shown in Figures 3 and 4.
Figure 3. Comparison of precipitation and groundwater depth in 2007.

Figure 4. Relationship between precipitation and groundwater depth in 2012.

According to the data, the total precipitation in 2007 was 240.7mm, and the precipitation in flood season was 188.8mm; the maximum groundwater depth in the Yinghua monitoring site was 6.47m during the year, and the minimum groundwater depth in the year was 3.18m; the Yanjiangdongerlong monitoring point during the year, the maximum groundwater depth was 7.75m, and the minimum
The groundwater depth was 5.7m during the year. It can be seen from Figure 3 that in 2007, the groundwater depth decreased from the beginning of the year, and the decline was the largest in June-August. With the increase of precipitation, the groundwater depth in September increased. And at the end of the year, the groundwater depth of the Yinghua and the Yanjiangdongerlong monitoring point decreased by 0.81m and 0.43m respectively compared with the beginning of the year.

In 2012, the total precipitation was 429.3 mm, and the precipitation during the flood season was 278.1 mm. The maximum groundwater depth of the Yinghua Monitoring Point was 6.57 m during the year. The minimum groundwater depth during the year was 5.85 m. The maximum groundwater depth in the Yanjiangdongerlong monitoring site was 7.33 meters, the minimum groundwater depth was 5.56 meters during the year. In 2012, the groundwater depth of the groundwater changed little in the whole year, and declined slightly from January to June. With the arrival of the flood season, the groundwater depth began to rise, and the depth of groundwater at the end of the year was basically the same as that at the beginning of the year. It can be seen from Figure 3.

Through the analysis of precipitation and groundwater depth data in 2007 and 2012, it can be obtained that the trend of groundwater depth in the year was first reduced and then increased. According to the local situation, due to the concentration of spring crops in January-June, the main source of farmland irrigation water is groundwater exploitation, which leads to the gradual increase of groundwater depth [5]. The lowest water level generally occurs in July-September, occasionally change with the actual situation of precipitation. In Figure 3 and Figure 4, it can be seen that the groundwater depth reduction in 2007 was greater than that in 2012, indicating that groundwater exploitation was particularly serious during the year. After entering the flood season from June to August, the precipitation increased gradually, and the groundwater depth began to rise. Due to the infiltration, the groundwater depth rose and the relative precipitation increased with a certain delay, generally lagging 1-3 months [6]. In 2012, the groundwater depth began to rise in July; in 2007, the groundwater depth began to rise from September. The groundwater burial depth recovery date was relatively late in 2007, which was related to the relatively small amount of precipitation and the serious groundwater exploitation. However, regardless of the total annual precipitation, the groundwater level will increase with the increase of precipitation, indicating that the impact of precipitation in Zhenlai County on groundwater depth cannot be ignored.

2.4. Impact of years of precipitation changes on groundwater level
Figure 5 shows that the relationship between the precipitation in 2006-2012 and the groundwater depth of the Yinghua and the Yanjiangdongerlong monitoring sites. It can be concluded from the figure that the overall precipitation shows an upward trend; the groundwater depth of the Yinghua monitoring site was generally declining; the groundwater depth of the Yanjiangdongerlong monitoring site has occasionally decreased, but the overall stability.
Figure 5. Comparison of precipitation and groundwater depth changes from 2006 to 2012.

Precipitation has a great impact on groundwater depth, but as the precipitation increases year by year, the groundwater depth was declining. The correlation between years of precipitation and groundwater depth was poor [7]. It shows that the amount of groundwater exploitation in the Zhenlai County area has exceeded the amount of groundwater recharged by means of precipitation, etc. In the area of Zhenlai County, there is the Momoge Wetland National Nature Reserve. The decline of the groundwater level will not only lead to insufficient water supply in Zhenlai County, but also affect the ecological environment of the Momoge Wetland.

3. Conclusion

According to the analysis of the precipitation data of Zhenlai County in 2006-2012 and the monitoring data of groundwater depths in Yinghua and Yanjiangdongerlong, the following conclusions can be drawn:

- In 2006-2012, the precipitation in Zhenlai County showed an overall increasing trend.
- The groundwater recharge in Zhenlai County was insufficient or the amount of exploitation was too large, so that the groundwater depth cannot be restored to the initial level.
- As the amount of precipitation increases, the groundwater level will rise accordingly, and the rise in groundwater level will be delayed by 1-3 months compared to the flood season. Precipitation not only directly supplies groundwater, but also affects the local residents' demand for groundwater exploitation, which indirectly affects the change of groundwater depth.

Groundwater is an important source of water resources in Zhenlai County and plays an important role in maintaining the local ecological environment and ensuring the use of water for residents. Through the analysis of precipitation and groundwater depth in Zhenlai County, it can be seen that precipitation in Zhenlai County has an important recharge effect on groundwater depth, and local groundwater exploitation is serious. The recharge of groundwater by precipitation is not enough to supplement the consumption of groundwater. Although the local project of Yin Nen Ru Bai has been used as a supplementary water source [8], Zhenlai County still needs to control the amount of groundwater exploitation to prevent the formation of a falling funnel to maintain the local ecological environment.
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