Groundwater dynamic analysis of a typical small watershed in the Loess Plateau

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Abstract. After the implementation of the project of returning farmland to forest and ditching and rebuilding land in Yan'an area, the hydrological process in the basin has changed. In order to clarify the dynamic characteristics of groundwater, a typical Nanniwan basin was selected, and groundwater monitoring equipment was installed in the upstream, middle and downstream respectively. The dynamic changes of groundwater in the basin. The results show that among the annual precipitation in the small watershed of the Loess Plateau, June-August (summer) is the wet season, with the most concentrated precipitation, with a total precipitation of 451.8 mm, of which August has the largest precipitation; the groundwater depth gradually increases before September. After September, the upstream and downstream water levels begin to stabilize or rise; the upstream groundwater level fluctuates slightly; the shallow groundwater areas in the middle reaches have large fluctuations due to the large water users; the groundwater depths in the downstream areas are generally between the upstream and between the middle reaches, the depth of burial showed a slight increase overall.

1. Introduction

The Loess Plateau is one of the most fragile typical areas of the ecological environment in my country with complex topography and geomorphic conditions and crisscross channels. Since the national implementation of the "returning farmland to forest" policy in 1999, the loess hilly area has been effectively controlled by returning farmland to slopes, newly built terraces and forest and grass vegetation construction, and the ecological environment has also been significantly improved [1-3]. Although this project has effectively curbed soil erosion and maintained soil nutrients [4], it also led to regional hydrological changes, such as increased dry soil layers and reduced runoff [5], which gradually threatened local sustainability development. Therefore, analyzing the hydrological effects of returning farmland to forest and grassland has become a current research focus.
In the gullies of the Loess Plateau, groundwater is relatively shallow and relatively abundant, and is an important source of water for production and living. Research on groundwater dynamics is to further ascertain the hydrogeological conditions of the study area, especially the recharge, runoff, and discharge conditions of groundwater, grasp the dynamic laws of groundwater, and provide scientific basis for groundwater resources evaluation, scientific management, and research and prevention of environmental geological problems. Research on the groundwater dynamics in the gully of the Loess Plateau is of great significance to the construction of the gully's ecological environment and agricultural production. This paper takes a typical loess plateau gully as the research object, based on the positioning monitoring of the gully groundwater, analyzes the dynamic change characteristics of groundwater in different positions of the gully, so as to provide a theoretical basis for the management of groundwater resources in the Loess Plateau.

2. Overview of the study area
The study area is located in Jiulongquangou, Nanniwan Town, Baota District, Yan'an City, Shaanxi Province. It belongs to the loess hilly and gully area of northern Shaanxi. The gully in the study area is 9.8km long from north to south. The elevation of the river course decreases from 1170m to 1093m from south to north, with an average drop of 0.78%. The width of the river valley is generally between 250 and 500m. The study area belongs to the temperate monsoon climate zone, with cold and dry winters and little precipitation; summers are hot and rainy with concentrated rainfall. The average water surface evaporation for many years is about 1000mm, and the land evaporation is 550mm. Rainfall is unevenly distributed in time and space, with great seasonal variation and low utilization rate. The annual average precipitation is 573mm. Winter precipitation is the least, accounting for 3% of annual precipitation, summer is the most, accounting for 47% of annual precipitation, of which July and August have the most precipitation, accounting for 40% of annual precipitation, and spring generally accounts for 22% of annual precipitation. The soil in the basin is dominated by loess soil and cinnamon soil. The soil profile has obvious layers. The soil erosion in the area is relatively serious. The channel is mainly composed of arable land, mostly dry land and paddy field.

3. Data and methods
The Jiulongquangou channel is selected for dynamic analysis of groundwater level. Monitoring wells are arranged in the Quaternary pore aquifer sub-system phreatic water, mainly Pleistocene, Holocene alluvial sand, sandy gravel water-bearing rock groups, according to the channel trend, respectively in the upstream, midstream, and downstream locations of the channel. Well, set up a set of HOBO water level recorders, monitoring time from May 2020 to October 2020, the main growth period of cover crops. The precipitation in the study area is collected through the weather stations installed in the area.

4. Results
4.1. Changes in precipitation during the year
The daily precipitation in the study area from May to October is shown in Figure 1. It can be seen from the figure that the precipitation in the study area is similar to that of most parts of the country. June to August (summer) is the wet season, with the most concentrated precipitation. The precipitation in June, July, and August were 99.0 mm, 108.8 mm, and 244.0 mm respectively. The total precipitation in March was 451.8 mm. The precipitation in August was the largest. From the daily precipitation distribution chart, August The days of concentrated heavy precipitation are also the most distributed in each month.
4.2. Dynamic characteristics of groundwater level

It can be seen from Figure 2 that before September, the depth of the water level gradually increased, until the upstream and downstream water levels began to stabilize or rise after September; in general, with the arrival of the rainy season, the groundwater level began to rise, and the depth of the water level. However, the study area still uses agricultural water for irrigation, so the groundwater level did not rise significantly during the rainy season, but mainly after September. On the one hand, it is due to the fact that there is less agricultural water use at this time, and on the other hand, it is due to precipitation. The recharge of groundwater has a certain lag. At the same time, the extent of water level changes varies with the depth of the water level. The shallower the water level, the more obvious the changes will be affected by precipitation. As the depth of the water level increases, the extent of the impact of precipitation will gradually decrease. The year is relatively wet. Therefore, from the histogram of daily precipitation changes during the year, the magnitude of the change is relatively large. However, the direct recharge effect of precipitation on the groundwater in the wet season is not obvious. Instead, the groundwater level is effectively recharged after the rainy season, and the water level begins to rise.

From May to early June, the amount of groundwater extraction and natural discharge decreased, the infiltration and replenishment of irrigation water in winter and spring increased relatively, and the groundwater level generally rose. On the whole, early June was the highest period of the whole year. At the beginning of September, motorized wells in the upper, middle, and downstream areas were put into use. The amount of evaporative discharge increased and the groundwater level generally dropped.

The upstream groundwater is the most stable from May to October, and the buried depth remains fluctuating between 1.5-2.1 m, with small fluctuations. This is mainly due to the fact that the upstream groundwater changes are less subject to human disturbance, and there is a relatively stable source of groundwater supply and excretion. Affected by the lag of precipitation replenishment, after September, the buried depth has decreased and the water level has risen slightly.

In the shallow groundwater area in the middle reaches, groundwater is sensitive to irrigation, extraction and evaporation. The water level changes with the amount of irrigation and groundwater extraction. The depth of groundwater fluctuates between 0.8-4.8 m, with great fluctuations. In addition, the villagers in this area are relatively dense and domestic water is concentrated. The groundwater depth increased significantly from May to mid-July, and the water level began to show a sharp downward trend. However, from mid-July to mid-August, due to the increase in precipitation. In addition, the area has a relatively shallow buried depth, so the water level has been recharged quickly, the water level has recovered, the buried depth has gradually decreased, and the water level has risen; subsequently, with the replenishment of the concentrated precipitation in August, the water level has rapidly increased in late August. Rise, and finally, under mining conditions, the depth of groundwater increases and the water level drops.
The buried depth of groundwater in the downstream area is generally between the upstream and the middle reaches, and the variation range of the buried depth is between 1.8-2.9 m. The overall buried depth showed a gradually increasing trend from May to October, but the buried depth increased after September. The big trend has decreased, and the water level has basically been stable.

![Figure 2. Dynamic changes of groundwater in different locations.](image)

5. Conclusion
The distribution of annual precipitation in the small watersheds of the Loess Plateau is similar to that of most northern regions of the country. June-August (summer) is the wet season, with the most concentrated precipitation. The total precipitation in June, July, August and March is 451.8 mm. Among them, August has the largest rainfall, and the number of days of concentrated heavy rainfall is also the most distributed in each month.

The recharge of groundwater in the channel mainly comes from precipitation. The buried depth of groundwater gradually increased before September. After September, the upstream and downstream water levels began to stabilize or rise. On the one hand, there is less agricultural water use at this time, and on the other hand, the recharge of groundwater by precipitation has a certain lag.

The groundwater level in the channel fluctuates differently in different regions. The upstream is less subject to human disturbance and has a relatively stable source of groundwater replenishment and excretion. The groundwater is most stable from May to October, with relatively small fluctuations. In the shallow groundwater area in the middle reaches, groundwater is sensitive to irrigation, extraction and evaporation. The water level changes with the amount of irrigation and groundwater extraction. Due to the large water users, the fluctuation range is extremely large. The buried depth of groundwater in the downstream area is generally between the upstream and middle reaches, and the overall buried depth is slightly increasing.

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