

The Regulation Mechanism and Model of Water Resources in the Loess Plateau

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Abstract

From the perspective of water resource utilization cycle, a water utilization system basically includes five links, water source system, water delivery system, water distribution system, user system and drainage system. Water resource regulation is to minimize the ineffective loss of water resources from all aspects of water resource utilization. The water resource regulation process should include the regulation of five links: water source system, water delivery system, water distribution system, user system and drainage system. The five systems are simplified into three parts, namely the source (water source system), the intermediate link (water delivery system, water distribution system, user system), and the end (drainage system). This study starts from the link of the water resource utilization system, and studies the regulation mechanism and mode of water resources, in order to provide a reference for the regulation of regional water resources.

Keywords

Water Resources; Regulation Mechanism; Regulation Model; Surface Regulation and Storage; Underground Storage.

1. Introduction

In the traditional water resource regulation of the channels in the Loess Plateau, the water source system mostly directly intercepts the channel water flow and precipitation in the form of check dams and reservoirs, or obtains concentrated water sources by pumping groundwater through machine wells. The water measures realize the process of water distribution and supply directly to the user [1]. Because the water flow in the channel on the Loess Plateau is relatively small, the water source system is mostly check dams. Soil interflow is a kind of water movement in porous media, an important part of slope runoff, and its flow rate is usually slower than that of surface runoff. In the process of rainfall forming runoff in the small watershed of the Loess Plateau, the flow collection process in the soil is slow and can last for several days, weeks or even longer, which has a direct impact on the quality parameters such as farmland water and fertilizer. Therefore, taking advantage of this feature of soil interflow and adjusting it reasonably can not only reduce the waste of water resources, but also effectively prevent the

adverse effects caused by soil interflow. The non-dynamic regulation based on soil interflow is to adjust the redistribution of water potential, soil moisture and water around the farmland by adopting storage and drainage measures for soil interflow, and making reasonable terrace grading inside the channel to form a certain slope. Under the premise of no power, the channel farmland can be irrigated when it is dry and can be drained when it is flooded. The water resource regulation modes mainly include surface regulation and storage, underground regulation and storage, and unsaturated zone regulation and storage.

2. Traditional Regulation Mechanism of Channel Water Resources

Check dams have played an important role in the regulation and utilization of water resources and the prevention and control of soil erosion in the Loess Plateau. The fundamental difference between check dams and small reservoirs lies in the attitude towards sediment. Small reservoirs are used for long-term water storage and profit, and sediment deposition is harmful to the reservoir's performance. On the contrary, the check dam is for the benefit of retaining mud. With the accumulation of sediment, the area of the dam gradually expands, and its economic benefits also increase gradually. The function of the dam body is to store flood and silt, and it is the main body of the check dam project. Compared with general reservoir dams, it has similarities and differences. The main difference is that the main task of the dam body of the check dam project is to hold mud, rather than to store water for a long time. When the high-sand-laden water flow reaches the front of the dam, the sediment is deposited, the flow rate slows down, and the clear water higher than the elevation of a certain discharge culvert is discharged. After the dam is formed, it is put into production and no longer plays the role of water storage. Especially for the channel with irregular water flow, the check dam only plays the role of flood retention and cannot form an infiltration line. If an earth dam is used, the dam slope can be steeper than the dam slope of a reservoir dam, and the requirements for basic geological conditions are lower. The requirements for drainage facilities at the foot of the slope are relatively simple, and generally do not consider the stability of the dam slope caused by the sudden drop of water, while the reservoir is the opposite. The intermediate link, namely water supply, water distribution system and user system, is the link with the greatest potential for water saving, and doing a good job in saving water in this link not only reduces the waste and loss of water, but also reduces the discharge of wastewater. , can effectively alleviate the contradiction of water shortage, so this link is often the focus of regulation [2].

In the Loess Plateau, the channel anti-seepage project and the pipeline water delivery project are the main measures to save water in the current canal water transmission and distribution system. Compared with earth canals, the anti-seepage of mortar block stone can reduce the leakage loss, the concrete lining can reduce the loss one, and the anti-seepage of plastic film can reduce the leakage loss and above, and at the same time, it can save investment and operation management and maintenance costs. After the channel anti-seepage measures are adopted, the water saved can be used to expand the irrigation area. According to statistics, there are 10,000 anti-seepage linings in the country, accounting for the total length of the channel, and the anti-seepage rate of the channel is relatively low. Pipeline water delivery projects are mostly used in sloping farmland or plateau land on the Loess Plateau, and are less used in trenches. In addition, the sprinkler irrigation system and the micro-irrigation system are also more advanced water-saving irrigation technologies in the regulation of intermediate water distribution, but their popularity is relatively low due to the high cost [3].

3. The Undynamic Regulation Mechanism based on Soil Flow

The water stored in the trench reservoir is the main water source for farmland irrigation. The traditional check dam or reservoir is used for water storage. The upstream water level is raised

through water storage, and it is used as one of the main water sources for irrigation and is connected to the water transmission and distribution system. . On the other hand, different levels of horizontal terraces are set up in the trenches, the elevations between the terraced fields are gradually reduced, and intercepting ditches are excavated between the farmland fields at certain intervals. When irrigating, using the upstream water storage, combined with the water transmission and distribution facilities and the adjustment of the gate valve between the farmland, under the action of the gravitational potential, the farmland with the slope can realize the step-by-step irrigation from the upstream to the downstream. At the same time, when the precipitation is heavy and drainage is required, the intercepting ditch in the field intercepts the soil flow generated in the previous field, so as to remove excess water from the farmland, reduce flood disasters, and prevent the formation of underground wetlands and secondary soil salinization. In the dry season, in addition to the irrigation of the upstream storage water sources, the water accumulated in the intercepting ditch can be re-irrigated into the fields to effectively alleviate the drought [4]. The mechanism of this kind of soil interflow regulating farmland irrigation is to establish a permeable intercepting ditch at the lower sill of the terraced field under the conditions of the traditional water storage mode and irrigation and drainage system, so as to change the groundwater level of the farmland to realize the control of the farmland.

4. Channel Water Resource Regulation Mode

4.1. Surface Regulation and Storage

The surface water in the channel of the Loess Plateau is mainly the surface runoff generated by the outflow of precipitation and groundwater system. Due to the concentrated precipitation and heavy rain in the small watershed of the Loess Plateau, waterlogging disasters often occur in the channel. In addition, the annual runoff of surface water is concentrated in the three months of July, August, and September. During this period, the precipitation is abundant and the surface runoff is large, which cannot be used for some time, and a large amount of surface water is lost, resulting in a waste of water resources. According to the above analysis, the regulation of surface water in the area is divided into two parts: systematic regulation and engineering regulation. Engineering regulation refers to the use of engineering measures to adjust the surface water in the channel. At present, engineering regulation focuses on regulating the amount of rainwater that falls on the surface from the surface self-produced water in the area. Previously, the rainwater was mainly self-falling, artesian flow, and self-seepage, and the storage form was mainly It is the conversion of rainwater into soil water, and the use of soil pores as the storage space of rainwater. Therefore, the establishment of rainwater storage projects in the trenches is one of the important measures to comprehensively control water resources and actively develop new water sources [5].

Taking the Jiulongquan Gully watershed in Nanniwan Town, Yan'an City as an example, the ground of this watershed is severely cut, and the water movement is affected by topographic fluctuations. The negative landform of the channel has the characteristics of natural water collection after rainfall. Check dams, reservoirs, ponds and weirs built in the trenches can effectively store precipitation resources after rainfall. There are two small reservoirs in Jiulongquan Gully, with a total water storage area of 80,000 m², and there are many ponds and weirs, which play a certain role in the retention of rainfall. The total amount of water storage in various pits and ponds in the rainy season can reach 150,000 m³. The storage capacity of the pond and dam can be based on the design rainfall with a guarantee rate of 10% as the reference standard, and the runoff coefficient is selected as 0.67, and the precipitation below 6mm in this area basically cannot produce runoff and needs to be deducted. The accumulated rainwater resources are mainly used as supplementary irrigation water.

In the total regional runoff, the runoff in the spring dry season from April to June only accounts for 15% of the total annual runoff, which is not conducive to channel farmland irrigation, while in the rainy season from July to October, the runoff accounts for 65% of the total annual runoff. For example, in July 2013, continuous heavy rainfall occurred in the Nanniwan area. The rainfall in the basin reached 350mm in July, which was three times the rainfall in the same period of the year. Waterlogging occurred in the Jiulongquan basin, and the maximum runoff of the channel was the usual number. ten times. The annual average precipitation in the region is 550 mm, and the runoff modulus of produced water in this region is about 38,500 m³/km². In the Jiulongquanguou watershed, the rivers have perennial water flow, with an average flow rate of 0.05 m³/s; the Aougou has flood currents during the rainstorm period; the submerged currents formed by the Liangmao fissures can also supplement the surface water of the channels. The annual runoff of the river can reach 1.58 million m³.

4.2. Underground Storage

Groundwater, as one of the main water sources in the channels of the Loess Plateau, has great potential for regulation, storage and utilization due to its relatively stable water volume. Underground reservoirs are an important means to optimize the allocation of water resources. It can increase the interception of precipitation resources and shallow groundwater resources, and improve the utilization rate of regional water resources; it can also store abundant and dry harvests, and adjust the uneven distribution of water resources in time and space. The functional characteristics of underground reservoirs are mainly reflected in their regulation and storage capacity. The water storage function of the underground reservoir is based on the storage capacity space generally constructed in the pores of the water-bearing medium. Following the principle of "filling the deficit with abundance" and utilizing the huge water storage space, the underground reservoir can store a large amount of water during the wet season for use in the dry season. Select appropriate locations and approaches, and artificially intervene in the replenishment and extraction of groundwater in the reservoir area through corresponding engineering means. On the one hand, the water resources that can be economically and reasonably used in the underground reservoir are transferred to the reservoir to the maximum extent, and on the other hand, the water in the reservoir is transferred out to the water demand unit most efficiently at the right time. This completes the effect of optimizing the allocation of water resources. In addition, the underground reservoir can also prevent land subsidence, moisten the ecological environment, increase the interception of precipitation resources, adjust the microclimate, and store cold and heat. These are all extension functions, based on water storage and water transfer functions [6-7].

Underwater interception is a horizontal water harvesting project that intercepts underground underflow through the construction of underground seepage interception corridors in valleys or in front of mountains in arid or semi-arid areas where the phreatic level is relatively high [8]. Among the total runoff in the hilly area of the Loess Plateau, the runoff in the spring dry season from April to June only accounts for 15% of the total annual runoff. In the rainy season (July to October), runoff accounts for 66%. At this time, although sufficient water resources were provided for irrigation, because there were no backbone storage projects and water conservancy irrigation facilities on the river course, the loss of runoff was serious and the utilization rate was very low. According to the characteristics of runoff in the channel and the amount of local investment, small underground water storage facilities can be built in the channel to intercept the subsurface flow and carry out water-saving irrigation. When this kind of structure is flooded, the flood flows away from the top of the structure, and the underground buildings are not at risk of being washed out and silted up; in the dry season in winter and spring, the water in the channel is less or cut off, and the underground water storage structure can trap the sand eggs after layer of undercurrent. Therefore, it was decided that the water

source project should adopt the construction of a horizontal catchment project to intercept the subsurface flow. Underwater interception is a horizontal catchment project that intercepts underground underflow through the construction of underground seepage interception corridors in valleys or in front of mountains in arid or semi-arid areas where the phreatic level is high. In the loess hilly area, water resources are very precious, so the limited water resources of intercepted undercurrent should be properly utilized to obtain greater benefits. Generally speaking, micro-irrigation technology is used to irrigate cash crops, because the benefits of increasing the yield of cash crops are significant, the investment recovery period is short, and the effect is very obvious. In Yan'ergou, Liulin Township, Baota District, Yan'an City, two interception and water-saving projects have been completed. In addition to satisfying its own irrigation tasks, the water-saving irrigation system also delivers water to the surrounding 2.0 hm² orchards.

4.3. Non-saturated Belt Regulation and Storage

The main source of soil water in the Loess Plateau is precipitation, which is the determinant of the dynamic change of soil water quantity. In general, the vertical variation of soil water in the Loess Plateau can be divided into three basic levels [9].

Soil moisture active layer (0-20 cm): Due to the influence of meteorological factors such as strong precipitation and evaporation, the soil moisture has a large range and a high frequency of change. Generally, the soil moisture content is 16%-17%, and the moisture content drops to about 12% during drought, and can be restored to 20% during precipitation. Above, reaching the level of field capacity, soil moisture is extremely unstable, and the coefficient of variation of water content is generally around 20%.

Soil moisture secondary active layer (20-50 cm): This layer is still affected by meteorological factors, but relatively to a lesser extent. It is neither like the active layer where the moisture fluctuates and changes frequently, nor is it like the soil layer below 50 cm, where the moisture content is high and stable. The coefficient of variation is 13%, which is lower than that of the upper layer and is at the lower limit of the main distribution layer of plant roots.

A relatively stable layer of soil moisture (50-200 cm): In the same year, the soil water content was high and relatively stable, and the coefficient of variation was small, which was lower than that of the active layer and the sub-active layer. Therefore, it can be regarded as a stable reservoir for the soil of the Loess Plateau, and it is the main water source for deep-rooted crops such as wheat to use deep water storage, which is the reason for the strong drought resistance of the soil in the Loess Plateau.

5. Conclusion

The significance of agricultural irrigation is to replenish the amount of soil water in a timely manner, so that it can meet the requirements of crop water consumption and water consumption. The water deficit of the crops itself is caused by the transpiration of the crops being greater than the water absorption of the roots, and the poor soil water content is one of the main reasons that affect the water absorption of the roots of the crops. Not only did the biomass accumulation of crops in different growth stages respond differently to water deficit, but also the effects of water shortage at a certain stage on the subsequent growth and development of crops and the accumulation of dry matter were also different. Therefore, it is a theoretical basis for agricultural water saving to adjust the soil moisture content according to the requirements of different stages of crop growth, and irrigate in the critical period (the critical period of crop water demand). Clarifying the dynamic changes of soil moisture content is essential for guiding water-saving irrigation. The shortage of farmland water is caused by soil evaporation and crop transpiration being greater than the natural effective recharge of soil

water. Different crops and different crop growth stages have different water requirements or water consumption, and the natural effective replenishment of soil in different periods is also different. To study the relationship between the two, when crops require more water, the natural effective replenishment of soil water is less. Irrigation during the period of time can improve the efficiency of water use, and it is also the basis for the rational allocation of water resources in the unsaturated zone.

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