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Evolution Characteristics And Mechanism Analysis Of Sea (Salt) Water Intrusion On The South Coast Of Laizhou Bay

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Abstract
The south coast of Laizhou Bay is a typical sea-saline intrusion area in my country. This paper summarizes the evolution characteristics of sea-saline intrusion in the south coast of Laizhou Bay since the late 1970s. It has been in a stable development stage for years. The buried paleochannel zone has become the main channel for the intrusion of sea (salt) water to land in the study area. The continuous high-intensity development of brine resources and the protection of underground freshwater resources have greatly slowed down the rate of seawater intrusion.

Key Word: *Sea (salt) water intrusion; Evolution characteristics; Laizhou Bay*

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I. Introduction

The south coast of Laizhou Bay is a typical silt and muddy plain coast in my country, with low terrain and wide tidal flats, which is a typical transition zone between land and sea [1]. Since the 1970s, the excessive exploitation of groundwater in the coastal plain has led to serious sea (salt) water intrusion, infecting groundwater, aggravating soil salinization, and forming geological problems of sea (salt) water intrusion; at the same time, the south coast of Laizhou Bay is rich Containing brine is the largest brine mining and salt chemical base in my country. With the continuous development of brine resources, a new situation has emerged for the intrusion of salt water on the south coast of Laizhou Bay [2,3]. This paper analyzes the evolution characteristics of saline water intrusion since the late 1970s, and summarizes the new mechanism of saline water intrusion.

II. Analysis of evolution characteristics of saline water intrusion

Although the distribution of underground salty and fresh water is affected by the background conditions of strata deposition, under the action of hydrodynamic conditions, the salty and fresh water interface will also change. Since the 1970s, affected by natural factors and human activities, the brackish-fresh water interface in Laizhou Bay has advanced inland (that is, the beginning of saline-salt water intrusion), which can be divided into four stages:

The first stage is the occurrence and development stage (1976-1985). Due to less precipitation, increased evaporation, and sharp increase in industrial and agricultural water demand, the groundwater level dropped, and sea-salt water intrusion began. In the initial stage of saline water intrusion, the intrusion is slow, the intrusion area

is small, and the intrusion is mainly local. By 1985, the invasion area expanded, the invasion range developed from local to regional, and the invasion distance to the south increased. The maximum invasion distance was about 6km north of Longchi Town, Changyi City.

The second stage is the stage of rapid development (1986-1990). Due to the large-scale exploitation of groundwater in Changyi City, the groundwater level dropped sharply, and the groundwater sinking funnel continued to expand. It is about 12km south of Qingxiang, Changyi City.

The third stage is the stage of slow development (1990-2000). In this stage, people gradually realized the harm of saline water intrusion, and the exploitation of groundwater was properly restricted. The speed of invasion slowed down, and partial retreat occurred, and the salt water in the Liutuan-Qingxiang area of Changyi City retreated 8km to the north.

The fourth stage is the stable development stage (2000~present). In this stage, people have better controlled the interface between salty and fresh water by adjusting the exploitation of groundwater and brine. Make the salty and fresh water interface controlled within a certain range. The saline water intrusion front defined by the standard of salinity 2.5g/L, at this stage, the dynamic change of the saline water intrusion front is basically in a state of hesitation.

III. Analysis of influencing factors on migration of brackish-fresh water interface

Geological conditions

The Quaternary deposits in the study area are relatively thick, and the sediment genesis types are mainly marine facies, limnic facies, and fluvial alluvial deposits, and many buried paleochannels have been formed by the development of rivers entering the sea. The buried paleo-channels are generally thicker and the sediment particles are coarser, becoming the main aquifer in this area. The paleochannel belts are palm-shaped and radially distributed to the north, and can be divided into five main channel belts in general. On the alluvial-diluvial fan of the Weihe River, the buried depths of the top and bottom of the paleochannel sand layer are generally about 5-8 meters and 30-35 meters at the top of the alluvial fan body; In the coastal plain area outside the alluvial fan, the buried depths of the roof and floor of paleochannels are generally about 12-24 meters and 40-50 meters respectively. The burial depth of sand layers in the buried paleo-channel belt in the study area has the following distribution pattern: the burial depth of the sand layer in the channel belt changes from shallow to deep from south to north on the roof, and the burial depth of the floor on the alluvial fan also changes from shallow to deep from south to north, while The burial depth of the coastal plain outside the alluvial fan becomes shallower; the cumulative thickness of sand layers in the buried paleochannel belt of the Weihe River can reach about 20-50 meters in the northern part of Changyi.

The confined brine formations in the lower part of the study area correspond to the palaeochannel belts in the south and middle of the area, and have good connectivity. The aquifer spreads with the southward movement of the brine and becomes a channel for the southward intrusion of salt water. The burial of brine is multi-layered, the concentration of pressurized brine is high, the storage body is large in size, and it has a good hydraulic connection with non-brine layers, which makes it possible for brine to invade southward under the pressure of salt water head, and in the paleochannel strong Under the action of the permeable sand layer, it invaded the freshwater area in the south in a large scale and rapidly, and its invasion level is closely related to the burial characteristics of the paleo-channel.

Climatic factors

Sea level rise caused by climate warming is the global climate background of saline water intrusion in the study area. Sea level change is also the main factor causing seawater intrusion in the study area. According to

the monitoring and analysis results of the State Oceanic Administration, the sea level along the coast of China shows a fluctuating upward trend, and the sea level rise rate in the Bohai Sea is 2.3 mm/year. The study area also exhibits a discernible sea level rise trend. The ocean is the northern boundary of the groundwater system in the study area. The rising sea level directly affects the change of the groundwater dynamic field, which has a certain impact on the balance of the salty-salty interface of the regional groundwater, and also aggravates the occurrence of seawater intrusion disasters.

The strong and continuous northeasterly wind in the study area makes this area a frequent occurrence of storm surge disasters. According to the Marine Bulletin of the State Oceanic Administration, from 2000 to 2009, there were 21 storm surges in the study area and 5 disasters ; In 2004, the strongest extratropical storm surge disaster occurred along the coast in recent years. After the tide receded, some seawater remained in the coastal plain depression, causing seawater intrusion disasters.

Exploitation of groundwater resources

In the natural state, groundwater recharge mainly comes from precipitation infiltration and river water seepage; the direction of groundwater runoff is basically the same as that of rivers, from south to north; groundwater discharge is mainly through evaporation and seaward runoff in coastal areas.

Since the 1970s, with the development of the social economy, the demand for water resources has been increasing. In order to meet the demand for water resources in social and economic development, Changyi City has established groundwater sources near the urban area and on both sides of the Weihe River. land. From 1985 to 2005, the groundwater table has been declining with the continuous increase of groundwater extraction (Figure 2). By 2012, the water level in the center of the funnel during the dry season was -22.33m, and the area of the funnel closed by the -4m line was 174.76km2.

Exploitation of brine resources

The coastal zone of the study area is rich in brine resources, and the salt and salinization industry is the top priority of the coastal development of the study area. At present, 80km2 of salt fields have been developed, with an annual output of 4 million tons of raw salt. If one ton of salt is produced from 16m3 brine, the annual brine mining volume will be 64 million m3. With the continuous development of brine resources, the mining depth is also increasing, making the groundwater level in the brine area continue to decline, forming a brine mining funnel in the coastal area, which reduces the head pressure of the salt water to a certain extent, and changes locally The direction of groundwater flow makes the salt water flow to the funnel area. This is also one of the reasons why the rate of saltwater intrusion has slowed down or even retreated in recent years. On the other hand, the groundwater table in the brine area is lower than sea level, which also provides a driving force for the intrusion of seawater into the brine area. Due to the intrusion of seawater, the concentration of brine resources is reduced.

IV. Conclusions

This paper systematically summarizes the evolution characteristics of saline water intrusion on the south coast of Laizhou Bay since the late 1970s. It has gone through stages of occurrence, rapid development, and slow development. Has not changed much. At the same time, the main factors affecting seawater intrusion were analyzed. The extensive Quaternary marine strata and paleochannels in the study area provide a geological basis for sea-salt water intrusion. The continuous high-intensity development of brine resources and the protection of underground freshwater resources have greatly slowed down the rate of sea-salt water intrusion.

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