# Sea water intrusion in the Yellow River Delta of Shandong Province based on hydrogeochemical characteristics Analysis

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**Abstract.** To study the source of sea water intrusion in the Yellow River Delta, groundwater sampling was conducted in typical sections of the Yellow River Delta. Through the analysis of major ions and isotopes of water samples, the study showed that the groundwater in the Yellow River Delta originated from ancient seawater and atmospheric precipitation deposited by sea intrusion during the geological-historical period, and there was basically no mixing of groundwater and modern seawater.

Keywords: Yellow River Delta, sea water intrusion, hydrogeochemistry, isotopes.

Sea water intrusion refers to the process and phenomenon that the hydrodynamic conditions of the coastal underground aquifer are changed under the influence of natural or human factors, disrupting the equilibrium state between freshwater and seawater or ancient brackish water, resulting in the intrusion of seawater or highly mineralized brackish water along the aquifer in the inland direction, referred to as seawater intrusion[1-3]. Sheng, Yongfang et al. and Mao, Hao et al.[4] suggest that there is a serious seawater intrusion in the Yellow River Delta. In this paper, the groundwater near the main rivers in the Yellow River Delta is used as the research object, and the main ions and stable isotopes in the groundwater are analyzed to explore the evolution pattern of the groundwater in the Yellow River Delta and the correlation relationship between the river water, groundwater and modern seawater, therefore to verify whether there is seawater intrusion.

The Yellow River Delta area is based on the Taikoo, Paleozoic and Mesozoic boundaries, on which huge thick Cenozoic strata are deposited, the maximum thickness of the Cenozoic boundary is about 7000 meters, and the sedimentary layers are mainly Paleoproterozoic and Neoproterozoic. By the regional geological background and depositional environment, the characteristics of the groundwater aquifer group in the area are determined. According to the burial conditions and hydraulic properties of groundwater, the aquifer group in the area can be divided into three aquifer groups: shallow submerged - micro-compressed water, medium compressed water and deep compressed water.

## 1. Sampling points and sample assays

A total of 38 water samples were taken,9 groundwater samples were taken along the Tushi River, 8 groundwater samples were taken along the Maqi River, 15 groundwater samples were taken along the south bank of the Yellow River, and 6 groundwater sampleswere taken along the Xiaoqing River. Field site tests were conducted for water temperature, air temperature, pH, conductivity and salinity. Water chemistry conventional ions, halogenated elements, trace elements and stable isotopes were tested in the sample chamber.

### 2. Analysis of results

#### 2.1 δD-δ18 O relationship

The distribution of sample points on the  $\delta D-\delta 18$  O relationship (Figure 1) can be divided into two parts: one part is distributed next to the atmospheric precipitation line and is between the local precipitation infiltration multi-year average and the mountain precipitation multi-year average, with light evaporation, probably related to the flow through the surface before infiltration, which is the infiltration recharge of atmospheric precipitation; the other part of the sample point distribution reflects the strong evaporation and then infiltration into the subsurface.

When the water sample points are located on the line of local precipitation and standard seawater, there are two possibilities of evaporation and seawater mixing. From the isotope distribution position, except for three sample points F8, H2 and H15, most of the points are currently deviated from the line, which is equivalent to the evaporation effect of the multi-year average of local rainfall infiltration, and the possibility of seawater mixing can be excluded. For the three sample points F8, H2 and H15, H2 is far from the Marina, and the two points F8 and H15 can be considered as having a greater possibility of receiving seawater mixing, but reaching their respective points under the stronger evaporation effect.



Figure 1  $\delta D$ - $\delta^{18}$  O relationship

#### 2.2 Cl-ô18 O relationship

The data of the four groups of water are labeled on the Cl- $\delta$ 18 O relationship graph (Figure 2), and the samples can be divided into two parts for discussion: the  $\delta$  O values of the first part of the samples18 are roughly distributed between -9.0 to -7.0‰, representing the interval value of local atmospheric water infiltration, and -7.7‰ is the multi-year average of local precipitation infiltration, which is basically located on the atmospheric precipitation line on Figure 3. the Cl content is expanded from 92.56 mg/L expanded to 4977 mg/L, indicating the lack of correlation between  $\delta$ 18 O values and Cl content, and the relationship between Cl and  $\delta$ 18 O is consistent with the process of dissolved evaporative salts from atmospheric water sources, and there is no mixing relationship between groundwater and seawater (or brine).

The  $\delta 18$  O values of the second part of the samples are roughly distributed between -6.5 and -3.5‰, representing the range values of local atmospheric precipitation after the evaporation effect. When the  $\delta 18$  O values were biased toward -6‰, the sample sites gradually deviated from the atmospheric water line, showing the evaporation effect. the Cl content expanded from 141.1 mg/L to 22,339 mg/L, again expressing the missing correlation between  $\delta 18$  O values and Cl content. the

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Cl and  $\delta 18$  O relationships were consistent with the process of dissolved evaporated salts from atmospheric water sources, and there was no binary mixing relationship.

## 2.3 Br/Cl-Cl relationship

By the analysis of the Cl- $\delta$ 18 O relationship, the samples near the fronts are all dissolved with evaporated salts and the water samples are affected by the Br/Cl ratio of evaporated salts. In the coastal zone because the Br/Cl ratio of precipitation is similar to that of seawater, the seawater ratio is also the starting value for the change of Br/Cl ratio of groundwater. As the Cl concentration increases, the evaporative salt effect also increases. It is also influenced by the input of artificial pollutants.

According to Fig. 4, the Br/Cl ratio in local groundwater ranged from  $1.3 \times 10-3 \sim 4.8 \times 10-3$ , and most of them belonged to the normal range with no obvious abnormal values.



Figure 2 Cl-818 O relationship diagram



Figure 3 Diagram of Br/Cl-Cl relationship

## 3. Conclusion

This area is mainly a brackish water area, derived from ancient seawater deposited by sea erosion during the geological history. The water samples taken along the river, with water molecular composition derived from atmospheric precipitation, are basically free from the mixing of groundwater and brackish water, reflecting the dilution of salinized water by river infiltration. The similarity between the samples of major chemical components indicates that the freshwater dissolves evaporated salts and the evaporated salt composition mainly originates from atmospheric precipitation.

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