A study on the characteristics of groundwater by stable isotope in Luohui irrigation scheme, China

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1. Introduction

In recent years, the arid regions in Northwest China have faced increasingly serious eco-environmental challenges with the population growth and economy development. To utilize water resources effectively and achieve sustainable development, it is necessary to understand the interaction between surface water and groundwater, groundwater fluctuation in different aquifers. The difference of isotopic content in different water can provide some important information to investigate the exchange of surface water with groundwater and the leakage between aquifers. In fact, the application of these relatively new techniques has proved to be an attractive tool for the quantitative evaluation of groundwater system, assessment of the availability of water resource, as well as to protect the fragile eco-environmental system.

2. Materials and methods

The study area (32,000 ha), the Eastern Block of Luohui Irrigation Scheme (**Fig.1**), has been suffering from salinization problems since the introduction of irrigation in 1950s. In this area apple, peach and pear (salt sensitive fruit trees), wheat and jujube (moderately tolerant crop) and cotton (tolerant crop) have been cultivated. The main objective of this research was to apply indicators and assess salinization threats as part of the efforts of combating further land degradation.

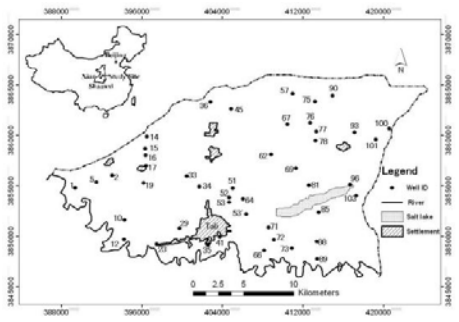

Fig.1 Map of the study area

Field measurements have been conducted, which consisted of measurement of electrical conductivity of groundwater, groundwater temperature and groundwater depth as well as other related parameters. In September and December 2009, water samples in the schemes were sampled, all the samples were taken 2m under the groundwater surface, and the sealed in the special bottles for isotope use. All the samples were analyzed by MAT-253 Mass Spectrograph and auto-sampler was used for precision control.

Stable isotope analysis: Oxygen (18O) and Deuterium (D) abundances are expressed as ratios in delta notation (δ) as per mil differences relative to the standard known as the Vienna Standard Mean Ocean Water (VSMOW). They are defined as follows: Where $\delta^{18}O(\delta D) = (R_{sp}/R_{st} - 1) \times 1000$. R_{sp} .and R_{st} are the ratios for D/H or $^{18}O/^{16}O$ in the sample or standard respectively. $\delta^{18}O$ and δD were analyzed by a Delta S mass spectrometer with analytical precision of ±0.15 and ±1□ , respectively.

3. Results and discussion

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3.1 **Isotope feature of meteoric water**

Due to most of the world□s precipitation is derived from evaporation of seawater, the $\delta^{18}O$ and δD composition of precipitation throughout the world is linearly correlated. This relation is known as the global meteoric water line and expressed as follows: $\delta D = 8\delta^{18}O + 10$. However, the meteoric water line is different, so the isotopes mean value $\delta^{18}O$ is -4.52□ , δD is -31.15□ were collected (**Table 1**), then we can get the local meteoric water line and expressed as follows: $\delta D = 7.71\delta^{18}O + 3.71$.

Table 1 The stable isotope data of the meteoric water

Code	Date	$\delta^{18}O$(□)	δD(‰)
P1	2008/3/29	-2.520	-10.805
P2	2008/4/2	-6.496	-55.392
P3	2008/4/8	-3.584	-11.710
P4	2008/4/11	-6.440	-40.158
P5	2009/9/9	-2.651	-20.113
P6	2009/9/9	-3.513	-30.612
P7	2009/9/10	-4.102	-35.918
P8	2009/9/10	-6.864	-44.512

3.2 **Isotope feature of Luohe river water**

Stable isotope technology analyzer was used to measure the content of $\delta^{18}O$ and δD of the river water samples collected in Sep and Dec., 2009 (**Table 2**), then we can get the Luohe river water line expressed as follows: $\delta D = 3.73\delta^{18}O$ -47.00

Table 2 The stable isotope data of the Luohe river water

Place	2009.9		2009.12	
	$\delta^{18}O$	δD	$\delta^{18}O$	δD
R1	-7.304	-66.330	-7.894	-77.496
R2	-7.509	-65.681	-7.539	-71.838
R3	-7.786	-73.855	-8.233	-61.896
R4	-7.023	-64.727	-8.101	-74.294

3.3 **Isotope technology for tracing groundwater movement**

Based on the local precipitation isotope value and Luohe river isotope value, we set up the relationships of groundwater isotope between $\delta^{18}O$ and δD in Luohui irrigation scheme. The isotope values of groundwater are below the local meteoric water line, indicating that the groundwater are supplied (direct or indirect) by the local precipitation. **Fig.2** shows the result: (1) Depth<3m, some wells near the Luohe river water line, it means that the well recharge speed, supply source for evaporation fractionation is small; (2) 3m<depth<10m, the isotope concentration more than the depth of 3m, so almost all of the wells were affected by the evaporation fractionation; (3) Depth>10m, the value of stable isotope is very dilution, it means that the groundwater supply with precipitation in irrigation area is possible.

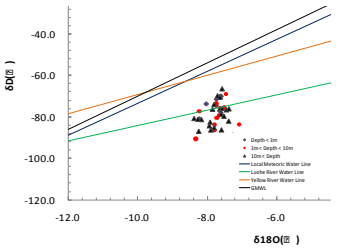

Fig.2 Relation of δD-δ18O for groundwater in depth

According to the mass conservation of stable isotope and the principle of water balance, we can calculate the supplementary amount after the source of supplementary has been fixed. The isotopes mean value of river water $\delta^{18}O$ is -7.68□ , δD is 75.59□ ; the isotopes mean value of rainfall $\delta^{18}O$ is -4.52□ , δD is -31.15□ ; and the isotopes mean value of groundwater $\delta^{18}O$ is -7.62□ , δD is -74.65□ ; the method of δD was calculated that the ratio of river water is 98.4%, the rainfall is 1.6%; the method of $\delta^{18}O$ was calculated that the river water is 97.9%, the rainfall is 2.1%.

4. Conclusions

The study of water transport was completed through field investigation, on-site observation, stable isotope technology, and so on. The main study conclusions are as follows: 1) analysis of supply character to groundwater in irrigation scheme through isotope tracing technology; 2) the main resources of groundwater recharge in summer are rainfall and river water, but while it is only river water in winter. 3) Calculated the ratio of the mix water from the river water and precipitation in Luohui irrigation scheme.

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