Research on the hydrologic cycle characteristics using stable isotopes of oxygen and hydrogen in the Jinxiuchuan Basin

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Abstract

Wang, T., Xu, Z., Zhang, S., Zhang, L., & Zhao, Z. (March-April, 2017). Research on the hydrologic cycle characteristics using stable isotopes of oxygen and hydrogen in the Jinxiuchuan Basin. *Water Technology and Sciences* (in Spanish), 8(2), 105-115

Stable isotopes of oxygen ($\delta^{18}O$) and hydrogen (δD) in water were used as important indicators to research the hydrologic cycle or processes. To study the hydrologic cycle characteristics of the Jinxiuchuan basin, the isotope labelling and the industrial salt tracing method were used in this research. Sixty-seven samples of different water bodies were collected at different sampling sites from July 2011 to July 2012. The stable hydrogen and oxygen isotopes in water samples were measured by using Liquid Water Isotope Analyzer (LWIA-24d) to study the conversion relationship among precipitation, river water, soil water, and groundwater of the Jinxiuchuan basin in Jinan. The results show that δD and $\delta^{18}O$ varied from 35.6 ‰ to 128.3 ‰ and from 5.3 ‰ to 17.5‰, respectively. A meteoric water line of $\delta D = 7.16\delta^{18}O + 4.35‰$, which was in accordance with the global meteoric water line and the meteoric water line of China, was established in the Jinxiuchuan basin. The deuterium excess values vary with time and space, ranging from 5.1 to 22.3‰, and increase gradually from the southeast to the northwest. In addition, the exchange of different water bodies was determined preliminarily, the rates of precipitation transforming into river water, soil water, and groundwater are 43.76%, 21.91% and 6.84%, and the remaining is 27.49% returned to the atmosphere. The results indicated the hydrologic cycle characteristics in the Jinxiuchuan basin. It may provide the references for precipitation isotopes research in semi-humid regions.

Keywords: Stable isotopes of hydrogen and oxygen; precipitation; deuterium excess; Jinxiuchuan basin.

Resumen

Wang, T., Xu, Z., Zhang, S., Zhang, L., & Zhao, Z. (marzo-abril, 2017). Estudio de las características del ciclo hidrológico empleando isótopos estables de oxígeno e hidrógeno en la cuenca de Jinxiuchuan. Tecnología y Ciencias del Agua, *8(2), 105-115.*

Se emplearon isótopos estables de oxígeno ($\delta^{18}O$) e hidrógeno (δD) en agua como indicadores importantes para comprender el ciclo hidrológico o sus procesos. Para comprender las características del ciclo hidrológico en la cuenca de Jinxiuchuan, en este estudio se empleó el método de marcaje isotópico y la técnica de trazabilidad de sal industrial. Se tomaron 67 muestras de distintos cuerpos de agua en diferentes sitios de muestreo de julio de 2011 a julio de 2012. Se midieron los isótopos estables de hidrógeno y oxígeno en las muestras de agua mediante el uso del Analizador de Isótopos en Agua Líquida (LWIA-24-d) para examinar el vínculo entre la precipitación, el agua de río, el agua de suelo y el agua subterránea de la cuenca de Jinxiuchuan, en Jinan. Los resultados muestran que δD y $\delta^{18}O$ variaron de 35.6 ‰ a 128.3 ‰ y de 5.3 ‰ a 17.5 ‰, respectivamente. La línea de agua meteórica se estableció en la cuenca de Jinxiuchuan, por ejemplo $\delta D=7.16\delta^{18}O+4.35$ ‰, lo cual concordó con la línea de agua meteórica global y la línea de agua meteórica de China. Los valores de exceso de deuterio varían en el tiempo y el espacio, entre 5.1 y 22 ‰, e incrementan gradualmente del sudeste al noroeste. Asimismo, se determinó preliminarmente el intercambio de distintos cuerpos de agua; los índices de precipitación que se transformó en agua de río, agua de suelo y agua subterránea son de 43.76%, 21.91% y 6.84%, y el restante 27.49% regresó a la atmósfera. Los resultados indicaron las características del ciclo hidrológico en la cuenca de Jinxiuchuan, las cuales tienen valor de referencia para la investigación de isótopos en la precipitación en regiones semihúmedas.

Palabras clave: *isótopos estables de hidrógeno y oxígeno, precipitación, exceso de deuterio, cuenca de Jinxiuchuan.*

Received: 27/03/2016
Approved: 26/10/2016

Introduction

The hydrogen and oxygen stable isotopes in water are widely used as tracers in meteorology, hydrology, and hydrogeology (Bosilovich & Schubert, 2002; Wang & Xu, 2011). The stable isotopes fractionation run through the entire hydrologic cycle in large scale, and the environment change as well as the mixing of different water make the content of δD and $\delta^{18}O$ different from other water bodies (Zhang, Wu, & Wen, 2006; He *et al.*, 2006). The isotopic ratios of hydrogen and oxygen in precipitation are closely related with meteorological processes and moisture sources. The δD and $\delta^{18}O$, particularly in the small-sized basin, are not only controlled by the climate change (Wu, Wan, & Lin, 2011; Wu, Yang, & Ding, 2011; Pan, Ping, & Gleixner, 2011), but also affected by the local meteorological and geographical conditions that make them change regularly with time and space (Price & Swart, 2008). In view of the composition of stable isotopes in precipitation, the main issues in this research field have focused on the temporal and spatial variation, the meteoric water line, deuterium excess, isotope effect and theoretical relations, and so on (Li, Zhang, & Ma, 2012). The research on hydrogen and oxygen studied in China had started in 1966, and observation stations of stable isotope were built up collect rainfall samples in large and medium-sized cities of China (Song, Liu, & Sun, 2007). Zhang and Wu (2007) analyzed the change of $\delta^{18}O$ in precipitation based on the rainfall samples and meteorological data, the results showed that $\delta^{18}O$ was affected by season, altitude, rainfall and temperature effects. Liu, Tian and Yao (2009) analyzed the relationships of $\delta^{18}O$ in precipitation with latitude and altitude, and established a quantitative relationship.

The data of stable isotopes in precipitation presented a seasonal distribution in the semi-arid and semi-humid region in China (Tian & Yao, 2004). However, the research on the stable isotopes of atmospheric precipitation in monsoon climate mountain area was relatively less than others so far. In view of the current status of the research in this field, this paper aimed to the following parts: (1) the variation of stable isotopes in atmospheric precipitation; (2) the establishment of local meteoric water line equation, and (3) the conversion rates of precipitation into surface water, groundwater, and soil water. Meanwhile, some insights to the water cycle mechanism in the semi-humid region will be added in this research. This paper may provide technical support for the establishment of the eco-hydrologic model and the sustainable management of water resources.

Material and methods

Site description

The study area is located in the southern mountainous area of Jinan, Shandong Province. The area of the drainage basin is 528.2 km^2 with a total river length of 41.63 km (figure1). There are two reservoirs, Jinxiuchuan Reservoir and Wohushan Reservoir, in the study area. The Jinxiuchuan Reservoir is located in the midstream, and the other one in the downstream. The total storage capacity is 0.6 billion m^3. They are not only the main drinking water sources of the resident population but also the recharge area of rivers, lakes, and springs of Jinan.

The climate is of the semi-humid warm temperate continental monsoon type with annual average precipitation of 703.1 mm. According to the survey, there are few historical precipitation of spring (April) and autumn (October) in Jinxiuchuan Basin, and maximum precipitation is 0.8 mm occasionally. Summer is generally from late May to early September. The average temperature is about 25.1 °C and the extreme maximum temperature is more than 40 °C. The average rainfall is about 380 mm that over 83% of the annual rainfall due to the warm moist air flow from the sea. Winter is generally from late November to early March of the following year. Due to the continental polar air masses, the average temperature of the region in winter is about 2 °C, and rainfall is about 6 to 15 mm, which occupies only 6-11% of the annual

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• ISSN 0187-8336

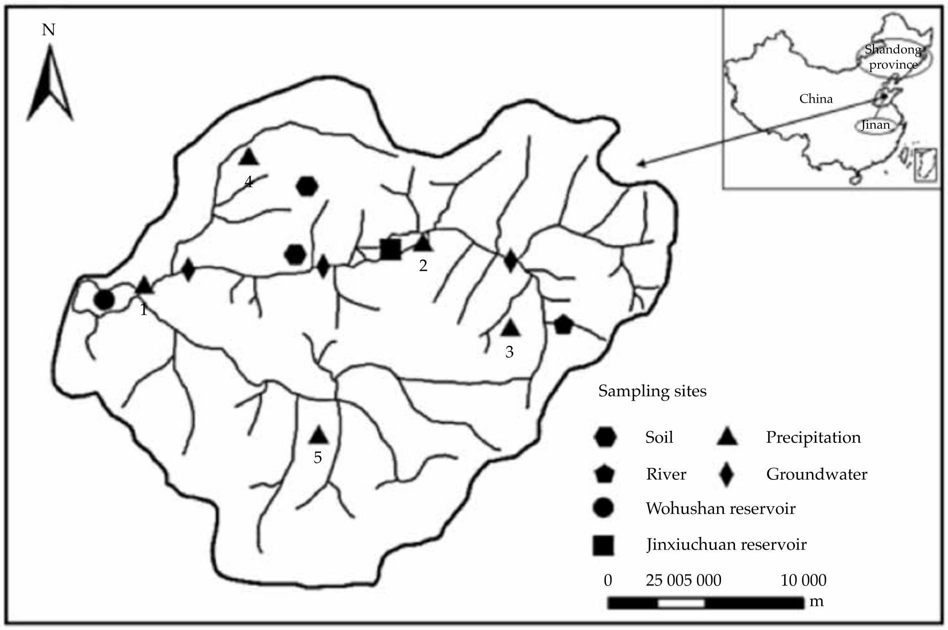

Figure 1. The map of the study area and sampling sites (1 Zhonggong; 2 Jinxiuchuan watershed; 3 Ouchi; 4 Zhengjia; 5 Liubu).

rainfall. The transitional seasons of spring and autumn are both less than two months. The Jinxiuchuan Basin's climate is characterized by spring the dry multi-winds, the winter snow.

The Jinxiuchuan basin basement is Archean Taishan Group metamorphic rock, which terrain slopes downward from the south to the north. The rock stratum is monoclinic occurrence without obvious folds. The basin mainly includes Cambrian and Ordovician, which are limestone. The surface dissolution is well developed with karren, slot, dissolving fissure, and so on. It has good connectivity, which can be propitious to recharge groundwater in the Jinxiuchuan basin.

Sample collection and analysis method

Sampling methods

Water samples of precipitation, river water, soil and groundwater, as show in figure 1, were collected from July 2011 to July 2012. After each precipitation event, rainfall samples in all sites were collected, which were obtained by rainwater tanks. In order to avoid isotope fractionation, each rainfall sample was stocked in a 150 ml sealed brown vial and placed in the dark at a lower temperature.

To ensure the accuracy of water samples of river and groundwater, the implementation of sampling must strictly enforce according to Assurance Manual of Environmental Water Monitoring Quantity (China National Environmental Monitoring Centre Assurance, 2010). Water specimens were collected by using polyethylene bottle of acid-washed. During sampling procedure, firstly, the bottles were washed three times by using raw water, then samples were collected at the sampling sites. To avoid the isotopic fractionation of the sample, firstly, samples were collected below the surface, then the air in the bottle was vented, and the samples were stored in an airtight; finally, the samples were sent to a laboratory to analyze under refrigerated conditions.

According to characteristics of topsoil in the Jinxiuchuan Basin, the soil samples were collected from five different depths (0-10 cm,

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10-20 cm, 20-25 cm, 25-30 cm, 30-35 cm). The collect private collector of soil was employed to store it, to avoid isotope fractionation, the samples were sealed in a cool place. In the end, 67 samples of different water bodies were collected for analyzing the composition of hydrogen and oxygen stable isotopes.

Analysis method

Water samples were analyzed by using Liquid Water Isotope Analyzer (LWIA-24d, Los Gatos Research, USA) at the Key Laboratory for Yellow River Delta Ecological Environment of Shandong Province. Based on the international V-SMOW standard, isotope value was marked by δ (‰). δ refers to thousand points of difference between the ratios of the two measured stable isotopes and the standard (Craig, 1961), as the following Eq. (1):

$$\delta‰ = \frac{R_{\text{sample}} - R_{\text{standard}}}{R_{\text{standard}}} \times 10^3 \quad (1)$$

Where R is the isotope ratio (D/H or $^{18}O/^{16}O$), the positive and negative value of δ indicated that the sample is richer in the heavy isotope and light isotope than the standard, respectively. The precision of the D/H is within ± 0.6‰, and $^{18}O/^{16}O$ within ± 0.2‰.

The calculation of weighted average is showed in the following. As a starting point, suppose that there are X samples, and they are $X_1, X_2, \ldots, X_i$ (I = 1, 2, 3… n). Every sample (X_i) contains a certain amount of Y_i. The weighted average of Y is called Y', and the formula as follow:

$$Y' = \frac{\sum_{i=1}^{n}(X_i * Y_i)}{\sum_{i=1}^{n}(X_i)} \quad (i = 1, 2, 3\ldots n) \quad (2)$$

Water retention and renewal time is an important link in the transformation process of water in the phreatic water aquifer. The two end-member isotope mixing model is used to part water sources. Given that mixed water (sample) comprises well mixed M and N water samples, the proportions of M and N in the sample can be derived from a conventional two end-member mass-balance equation in terms of δ values:

$$Q_{\text{sample}}\delta_{\text{sample}} = Q_M\delta_M + Q_N\delta_N \quad (3)$$

$$Q_{\text{sample}} = Q_M + Q_N \quad (4)$$

$$X_M = \frac{Q_M}{Q_{\text{sample}}} \quad (5)$$

Where X_M and X_N are the fractions of M and N in the sample, respectively.

The solution for X_M is:

$$X_M = \frac{\delta_{\text{sample}} - \delta_N}{\delta_M - \delta_N} \quad (6)$$

Results and discussion

Variations of δD and δ18O of the Jinxiuchuan Basin

From July 2011 to July 2012, the basic information of precipitation, temperature and relative humidity was measured and showed in figure 2. The results showed that: precipitation and temperature have obvious seasonal variations. The average monthly relative humidity gradually decreases from February. The lowest value is about 36% in April or May, the maximum value of 89% in August. However, the value of relative humidity in September decreases again, and the difference between maximum and minimum value is 53% in figure 2.

The data of stable isotopes in precipitation was employed to research its change in the local region. The characteristic values of isotopiciso-topic included the weighted average value of δD, δ^{18}O and deuterium excess in each sampling

Tecnología y Ciencias del Agua, vol. VIII, núm. 2, marzo-abril de 2017, pp. 105-115
• ISSN 0187-8336

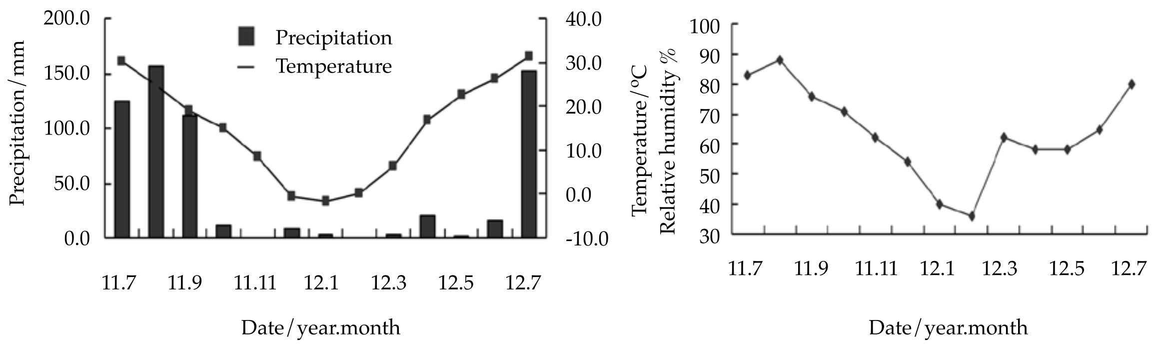

Figure 2. The monthly rainfall, temperature and relative humidity from 2011.7 to 2012.7.

Table 1. Atmospheric precipitation details in the Jinxiuchuan Basin.

Sampling points	Location	Height (m)	Time	Average monthly Temperature (°C)	Relative humidity (%)	Average monthly rainfall (m)	Weighted average value (‰)		*d*-excess (*d*) (‰)
							δD	$\delta^{18}O$	
1	117.01°E	127	Summer	26	78	76	-61.5	-8.9	9.7
	36.49°N		Winter	1	54	8	-109.3	-15.6	15.5
2	117.17°E	240	Summer	27	82	124.2	-54.4	-7.9	8.8
	36.51°N		Winter	2	50	19	-87.8	-12.8	14.6
3	117.22°E	360	Summer	27	86	156.1	-44.9	-6.4	6.3
	36.47°N		Winter	2.5	55	26	-92.9	-13.6	15.9
4	117.07°E	285	Summer	26	66	69	-63.1	-9.1	9.7
	36.55°N		Winter	0	43	21	-113.8	-16.3	16.6
5	117.11°E	261	Summer	27	74	51	-62.7	-9	9.3
	36.42°N		Winter	1	41	2	-116.6	-15.8	9.8

site (Wu *et al*., 2011a y b; Zhai, Wang, & Teng, 2011), as shown in Table 1. Summer precipitation is from June to September, and the winter precipitation is from November through the following March. April, May, and October are the major time of transmission for water vapor. The local evaporation is relatively slow with low surface temperature, and cannot form effective precipitation. In order to avoid replication of the season samples, the precipitation data of these three months are not used for comparison.

According to the isotope data, δD in atmospheric precipitation is within the limits of -128.3 to -35.6‰, averaging -79.8‰, while $\delta^{18}O$ range from -17.5‰ to -5.3‰, with the average of -11.3‰. Comparing the two isotope values, the change of $\delta^{18}O$ is smaller than δD. The reason is mainly that the fractionation effect of hydrogen isotope is much better than oxygen isotope. Zheng, Hou and Ni (1983) reported that δD range from -210‰ to 20‰, and $\delta^{18}O$ from -24‰ to 2.0‰ in precipitation of China. In the study area, the stable isotopes content belong to the ranges of China and the global atmospheric precipitation, and the average values are smaller than both of them.

The weighted average values of δD and $\delta^{18}O$ in precipitation were obtained by the precipitation-weighted method, to get the seasonal variation law of the isotope values, as shown in

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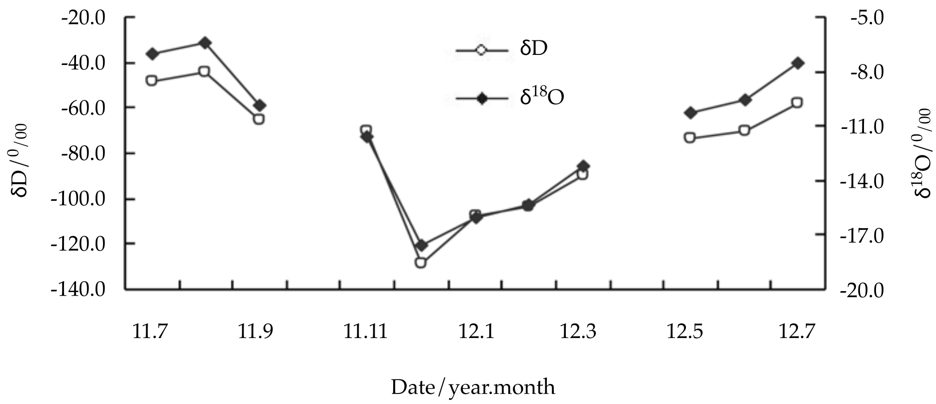

Figure 3. Changes of δD and δ18O in precipitation with time from 2011.7 to 2012.7.

figure 3. The results indicated that δD and δ^{18}O have an obvious change with the season, and the maximum values of δD and δ^{18}O occurred in July and August (wet season) were -35.6% and 5.3%, respectively; and their average values were -43.8‰ and -7.6‰, respectively. The minimum δD and δ^{18}O occurred in November and December (the dry season) were -128.3‰ and -17.5‰, respectively, and the average were -122.6‰ and -15.3‰, respectively.

The isotope values shown in figure 3 has great difference between summer and winter, and it indicated the precipitation was controlled by different water sources. The basin has a typical monsoon climate and is affected by the warm moist air flows from the sea, and the rainy days and precipitation amount are mainly concentrated in summer. It results in the enrichment of heavier isotopes, therefore, the values of δD and δ^{18}O become larger. However, the polar continental air mass is prevailing in winter, and the weather is dry and wintry. As the vapor pressure of isotope is inversely proportional to the mass number, heavy isotopes were condensed preferentially with transported of water vapor, and it led to δD and δ^{18}O dilution in precipitation. The reason eventually made δD and δ^{18}O decrescent in winter precipitation. Precipitation was invalid in April and October for analyzing isotopes. In history, the rainfall amount of April and October is little in the Jinxiuchuan Basin. Results from figure 3 indicated that sampling sites are the most representative.

Meteoric water line of the Jinxiuchuan Basin

The relationship between δD and δ^{18}O of precipitation is generally referred to the meteoric water line (MWL), which is of great significance to study the isotope changes in the water cycle (Li, Li, & Shen, 2010). Craig (1961) initially put forward for the global meteoric water line (GMWL) equation: $\delta D = 8\delta^{18}O + 10‰$, the average value of GMWL is 10‰. When the values are less than 10‰, the imbalanced degree of the gas and liquid isotopic fractionation has a big impact on the formation of clouds. If it is less than 10‰, the evaporation plays a significant role during the precipitation process. According to the 107 rainfall samples of isotopes, Zheng Shuhui et al. (1983) obtained the meteoric water line in China(CMWL): $\delta(D) = 7.9\delta^{18}O + 8.2‰$. The local meteoric water line (LMWL) equation is as follows: $\delta D = 7.16\delta^{18}O + 4.35‰$, $R^2 = 0.92$.

The LMWL of the Jinxiuchuan Basin is close to GMWL and CMWL, as shown in figure 4. But the slope and intercept of the former line are lower than those of the latter, due to the impact of evaporation. The δD and δ^{18}O values of

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• ISSN 0187-8336

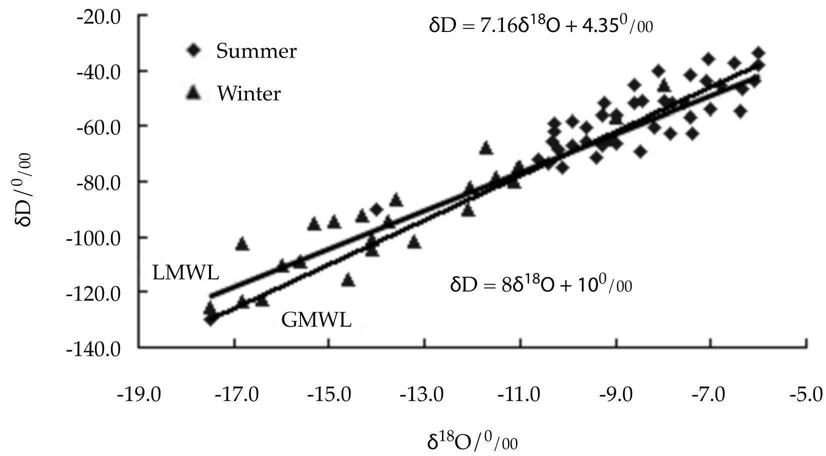

Figure 4. The relationship between δD and δ18O in precipitation.

precipitation are mainly distributed in -90‰ ~ -30‰ and -11‰ ~ -5‰ in summer, respectively. The variation ranges of δD and δ^{18}O of precipitation are -130‰ ~ -70‰ and -17.5‰ ~ -12.8‰ in winter respectively, influenced by evaporation. Most of the isotope values are higher in summer than those in winter from the figure 4.

*Deuterium excess analysis (***d***-excess)*

Deuterium excess (*d*-excess), referred to as *d* value, is put forward by Dansgaard (1964), the formula for $d = \delta D - 8\delta^{18}O$. Different values reflect the disparate unbalanced degree of evaporation and condensation process in the region intuitively. It also shows the relationship between d and evaporation rate in the region of the moisture source. In other words, the higher evaporation, the greater the value of *d*. It is actually an important comprehensive environmental index of atmospheric precipitation (Wang, Chen, & Wang, 2009). According to the linear relationship between *d* values and isotopes, the former is considerably affected by temperature, humidity, rainfall and secondary evaporation within the region. Generally, global average *d* value is 10‰. The process of the water cycle is mainly affected by evaporation in one region, and *d* value is greater than 10‰ in general.

In the study area, vapor sources of precipitation have different sources in summer and winter due to the monsoon, which led to higher *d* value in winter than summer. In addition, the *d* values of different sampling sites along the direction of the clouds movement are different. There is little precipitation at Zhonggong and Liubu sampling sites, therefore it is not discussed. The changes of *d* value at Zhengjia, Jinxiuchuan Reservoir, and Ouchi sampling sites from July 2011 to July 2012 are shown in figure 5. The *d* values vary from 5.1 to 22.3‰ throughout the year. It ranges from 5.1 to 10‰ in summer (from June to September), the average is 7.9‰, and the maximum is less than 10‰. The results indicated that the area is mainly controlled by marine air masses in summer. However, *d* values are higher in winter (from December to March), with the range 12.8 to 22.3‰, and an average of 14.0‰, which is higher than summer. It showed that the *d* value is mainly affected by polar air masses in winter.

Due to the monsoon climate, the ocean warm air masses firstly move to the Jinxiuchuan Basin in summer, and then pass the Ouchi sampling site located in the southeast. The isotope data of Ouchi represent the initial summer precipitation data, the *d* value of 5.1‰; *d* values tends to increase from southeastern (Ouchi) to north-

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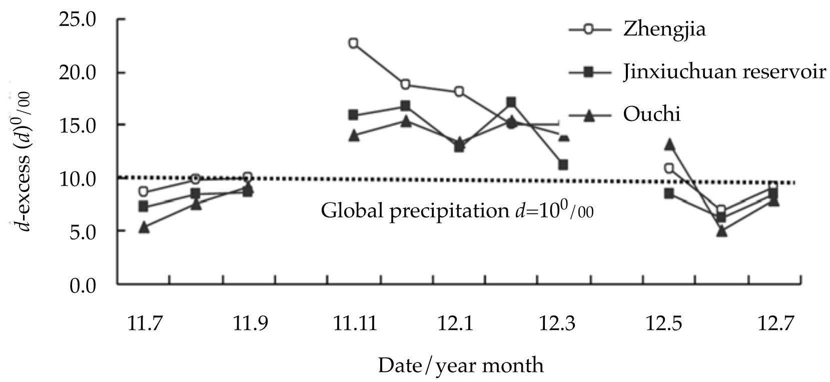

Figure 5. Change curve of deuterium excess from 2011.7 to 2012.7.

western (Zhengjia), range from 5.1 to 7.0‰. In winter, the polar continental air masses first reach to Zhengjia rainfall station located in the northwest and the isotope data can represent the initial winter precipitation data, *d* value is 22.3‰; *d* values tends to decrease from Zhengjia to Ouchi, range from 22.3 to 12.8‰.

Analysis of conversion relationship among different water

Hydrogen and oxygen isotopes are used to mark atmospheric precipitation, river water, Spring water (groundwater) and soil water. According to the representative sample data of 37 groups, the isotope compositions in different water were compared, and the transforming relationships were determined.

As showed in figure 6, $\delta^{18}O$ values of river water are near the atmospheric precipitation line with a small deviation, and these points scatter between the values of precipitation and groundwater of the Jinxiuchuan Basin. It indicated that supply components for the river are consistent with the river components. The study area belongs to mountain and hilly area, whose area is small so that atmospheric precipitation mainly transforms into surface water and groundwater. Those are the main supply source of the river.

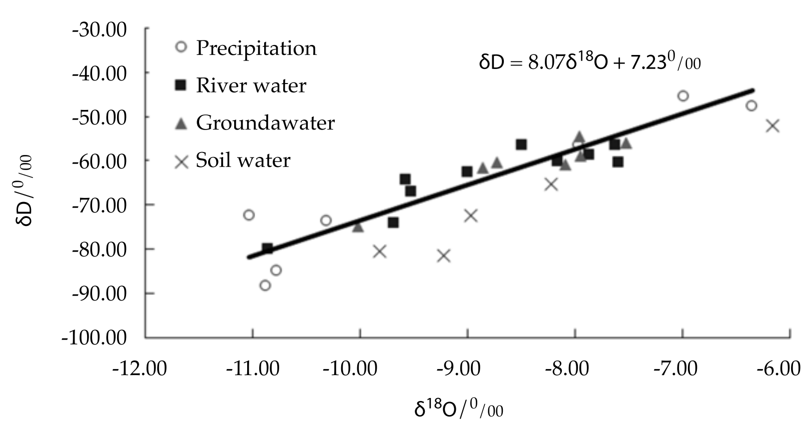

Figure 6. Analysis of isotope composition in different water.

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• ISSN 0187-8336

The $\delta^{18}O$ values of groundwater and river water have a high degree of fitting, and the $\delta^{18}O$ values of groundwater are mainly distributed among the $\delta^{18}O$ values of precipitation, as shown in figure 6. The results showed that there are close relationships in different water bodies. The soil thickness is small and the average of about 20 cm, and a rigid top slab of the impermeable floor. However, karren, slot, dissolving fissure develop extraordinary in the Jinxiuchuan Basin, so as to the more frequent hydraulic contact between groundwater and precipitation.

In the Jinxiuchuan Basin, the river is supplied by precipitation in the form of overland flow, and soil water and groundwater from infiltration of precipitation. Groundwater exposes on the surface and supplies river by spring. River evaporates in the process of flow and then returns into the atmosphere. The water cycle is completed between different water bodies finally. According to equation (6) and take $\delta^{18}O$ for example, δ_M is the value of precipitation, $\delta^{18}O$ = -7.9713‰; δ_N is the value of groundwater, $\delta^{18}O$ = -8.8895‰; δ_{sample} is the value of river water, $\delta^{18}O$ = -8.4877‰. After calculation, precipitation accounts for 43.76% in river water. In the same way, precipitation accounts for 21.91% in soil water and 6.84% in groundwater, as shown in table 2. The δD and $\delta^{18}O$ of river water increase from valley to outlet because of the weak evaporation, and the river is supplied by groundwater. It is confirmed by field investigation that three springs expose to supply surface water, which makes groundwater convert into surface water. So the proportion of river water transformed by soil water and groundwater is 28.75%. The total supply ratio is 72.51%, and the remaining is 27.49%. The remaining water consumed by surface evaporation and plants intercept, which can be understand as the soil water and river water reverse supplemental atmospheric water.

Based on the relevant data of the Jinan's hydrological bureau, the above conclusions are verified by the water balance method. Taking precipitation and river as an example, the conversion relationship between rainfall and river water are analyzed based on the precipitation of August 25, 2011. There are five precipitation monitoring sites, and the average precipitation is 55.2 mm. The watershed total rainfall is calculated by the Thiessen polygon method, and the value is $2976.66\times10^4 m^3$. River runoff is calculated based on the data of river level before and after this precipitation, and it is $1254.36\times10^4 m^3$. The river section is downstream in the Jinxiuchuan Basin. The ratio of between rainfall and river water is 42.14%. The results showed that the precipitation accounts for 42.14% in river water, and the results obtained from two methods are close to each other. Meanwhile, it indicated that the previous conclusion which obtained from the stable isotopes method is scientific and rational.

Atmospheric precipitation is absorbed or becomes surface runoff, which gradually flows into rivers. Surface water partly evaporates and infiltrates into the soil to recharge groundwater. The atmospheric precipitation converts into surface runoff and underground runoff eventually through a series of processes, and groundwater changes into surface water. From table 2, the conversion rate of groundwater is high in the slope runoff area of the Jinxiuchuan Basin. The study area has strong ability to intercept and store water, because it has higher vegetation coverage. Karren, slot and dissolving fissure well developed, which leads to increase the number of infiltration recharge to groundwater in the slope zone.

Table 2. Supply ratio of atmospheric precipitation.

Water type	δ value		Supply ratio
	δD/‰	**δ¹⁸O/‰**	**of atmospheric precipitation /%**
Soil water	-72.3637	-8.9569	21.91
Groundwater	-74.9468	-8.8895	6.84
River	-56.5361	-8.4877	43.76

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ISSN 0187-8336 •

Conclusions

Rainfall samples were collected examined from July 2011 to July 2012 in the Jinxiuchuan Basin. The results showed that composition of hydrogen and oxygen stable isotopes within the range of δD and δ^{18}O in China and global atmospheric precipitation; δD in precipitation is within the limit of -128.3 to -35.6‰, and the average is -79.8‰; δ^{18}O ranges from -17.5 to -5.3‰, and the average is -11.3‰. The local meteoric water line is $\delta D = 7.16\delta^{18}O + 4.35‰$ ($R^2 = 0.92$), which slope and intercept are both less than the global meteoric water line due to the impact of evaporation in the Jinxiuchuan Basin. Values of d-excess vary with time and space. On the one hand, *d* values are higher in winter than summer due to the impact of different air masses. From here, the following are divided into the second paragraph. The conversion relationships and rates of different water bodies are determined preliminarily in water cycle process of the Jinxiuchuan Basin. Results as follows: the rates of precipitation transforming into river water, soil water and groundwater are 43.76, 21.91 and 6.84%, respectively. The rates of groundwater transforming into river water is 28.75%, and 27.49% of the surface water supplies the atmosphere by evaporation. Based on the the analytic result, the conversion relationships and rates of different water body of the hydrologic cycle in the Jinxiuchuan Basin are initially determined.

Acknowledgments

Research funding was provided by the National Sci-Tech Support Plan (grant no. 2012BAD08B05 and 2015BAD20B02), the Shandong Province Water Conservancy Research and Technology Promotion Projects (grant no. SDSLKY201410), the Graduate Innovation Foundation of University of Jinan (grant no. GIFUJN). Many thanks to Teacher YongSen Wang at the University of Jinan for assistance with statistical analysis, and the editors and anonymous reviewers who provided essential guidance on previous versions of this manuscript.

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ISSN 0187-8336 •