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# Hydrological and pollution processes in mining area of Fenhe River Basin in China

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The hydrological and pollution processes are an important science problem for aquatic ecosystem. In this study, the samples of river water, reservoir water, shallow groundwater, deep groundwater, and precipitation in mining area are collected and analyzed. $\delta D$ and $\delta^{18}O$ are used to identify hydrological process. $\delta^{15}N$-$NO_3^-$ and $\delta^{18}O$-$NO_3^-$ are used to identify the sources and pollution process of $NO_3^-$. The results show that the various water bodies in Fenhe River Basin are slightly alkaline water. The ions in the water mainly come from rock weathering. The concentration of $SO_4^{2-}$ is high due to the impact of coal mining activity. Deep groundwater is significantly less affected by evaporation and human activity, which is recharged by archaic groundwater. There are recharge and discharge between reservoir water, river water, soil water, and shallow groundwater. $NO_3^-$ is the main N species in the study area, and forty-six percent of $NO_3^-$-N concentrations exceed the drinking water standard of China ($NO_3^-$-N $\leq$ 10 mg/L content). Nitrification is the main forming process of $NO_3^-$. Denitrification is also found in river water of some river branches. The sources of $NO_3^-$ are mainly controlled by land use type along the riverbank. $NO_3^-$ of river water in the upper reaches are come from nitrogen in precipitation and soil organic N. River water in the lower reaches is polluted by a mixture of soil organic N and fertilizers.



## 1. Introduction

Nitrate pollution of water has become a worldwide water quality issue (Nestler et al., 2011; Xue et al., 2013). In recent years, nitrate concentrations in water bodies increase with the increase of human activity, industrial production, domestic sewage discharge, fertilizer application, landfill pollutants and fossil fuel leakages, which have attracted by the researchers in at home and abroad (Sebilo et al., 2006; Tobari et al., 2010). Nitrates in drinking water and foodstuff are excessive, and can transform into nitrosamines, which is a carcinogenic substance in the intestines and stomach (Fewtrell, 2004; Xue et al., 2009). The World Health Organization (WHO) has stipulated that $NO_3^-$-N concentrations in drinking water should be limited to 10 mg/L (WHO , 1993).

Nitrate pollution should be controlled only when nitrate pollution sources is accurately identified. Traditional methods of identify sources of nitrate pollution are mainly by investigate land use type and characteristics of local hydrochemical in the polluted areas. However, the results from these methods have not been satisfactory. In recent years, some researchers have found that different nitrate sources contain different nitrogen (N) and oxygen (O) isotope ratios. Therefore, nitrate sources in water body can be identified according to isotopes N and O, which can compensate for the deficiency in traditional methods, and provide a new method to identify pollution sources (Kellman and Hillaire-Marcel, 2003; Kendall and Coplen, 2001; Wassenaar et al., 2011; Widory et al., 2013). The $\delta D$-$H_2O$ and $\delta^{18}O$-$H_2O$ has been used to reveal the relationship between surface water and groundwater (Peng et al., 2015).

The problem of overlapping nitrate sources must be resolved firstly, which is caused by isotopic fractionation due to the physical and biological processes. Isotopic $\delta^{15}N$-$NO_3^-$ and $\delta^{18}O$-$NO_3^-$ are used to identify nitrate pollution sources in this study. At parents, the research and data on the pollution sources and $NO_3^-$ transformation based on isotopic $\delta^{15}N$-$NO_3^-$ and $\delta^{18}O$-$NO_3^-$ is limit in the mining area of Fenhe River Basin. However, there is less research on hydrological process based on $\delta D$-$H_2O$ and $\delta^{18}O$-$H_2O$. Hydrochemical and isotopic composition of river water, reservoir water, shallow

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groundwater (water level between 0 and 30 m), deep groundwater (water level≥50 m) and precipitation in mining area of Fenhe River Basin are analyzed in this study. The objectives of this study are (1) to identify sources of dissolved chemical ions and their impact factors; (2) to reveal hydrological processes by $\delta$D-$H_2O$ and $\delta^{18}$O-$H_2O$; and (3) to determine sources and transformations of nitrates combination with $\delta^{15}$N-$NO_3^-$and $\delta^{18}$O-$NO_3^-$.

## 2. Material and methods

### 2.1. The experimental site

The experimental site is located in the mining area of Fenhe River Basin in China, with latitude 35°20′13″N - 38°56′17″N, longitude 110°29′48″E-113°32′27″E (Fig. 1). Fenhe River Basin, with a catchment area of 3.9 × 10$^4$km$^2$. The altitude ranges from 368 m to 1670 m (AMSL). The study area is the major coal producing area, and it's also the main industrial area, agricultural area and urban residential area of Shanxi Province. The water quantity of industrial production and residents living in the Fenhe River basin is about 2.32 × 10$^9$ m$^3$/a, which accounts for about forty-six percent of the total water consumption in the Shanxi Province.

The average annual precipitation is 504.8 mm. The precipitation is decreasing with a rate of 21.49 mm/10a in the past 50 years. Precipitation is concentrated in June to September in the form of heavy rain (about 70% of precipitation). The spatial distribution shows that the regional precipitation is unevenly distributed. Evaporation of surface water is between 1000 mm and 1200 mm, and the value is high in Yuncheng Basin.

The terrain of Fenhe River Basin is a graben rift valley, the alluvial fan of border mount is hypsographic feature and complicated ditches, with a small area and a huge slope. There are different shapes of loess hills and tableland between the mountain and basin in the east due to the slowly changing terrain. Fenhe River can be divided into the upper, middle and lower reaches by Lancun Station and Shitan Station according to the characteristics of Fenhe River.

### 2.2. Sample collection and field experiment

The water samples of river water, reservoir water, shallow groundwater, deep groundwater and precipitation are collected from April 2012 to May 2015 in the mining areas of Fenhe River Basin (Fig. 1). Precipitation are collected by a special rainwater collector and stored in the sample bottle after each rainfall event.

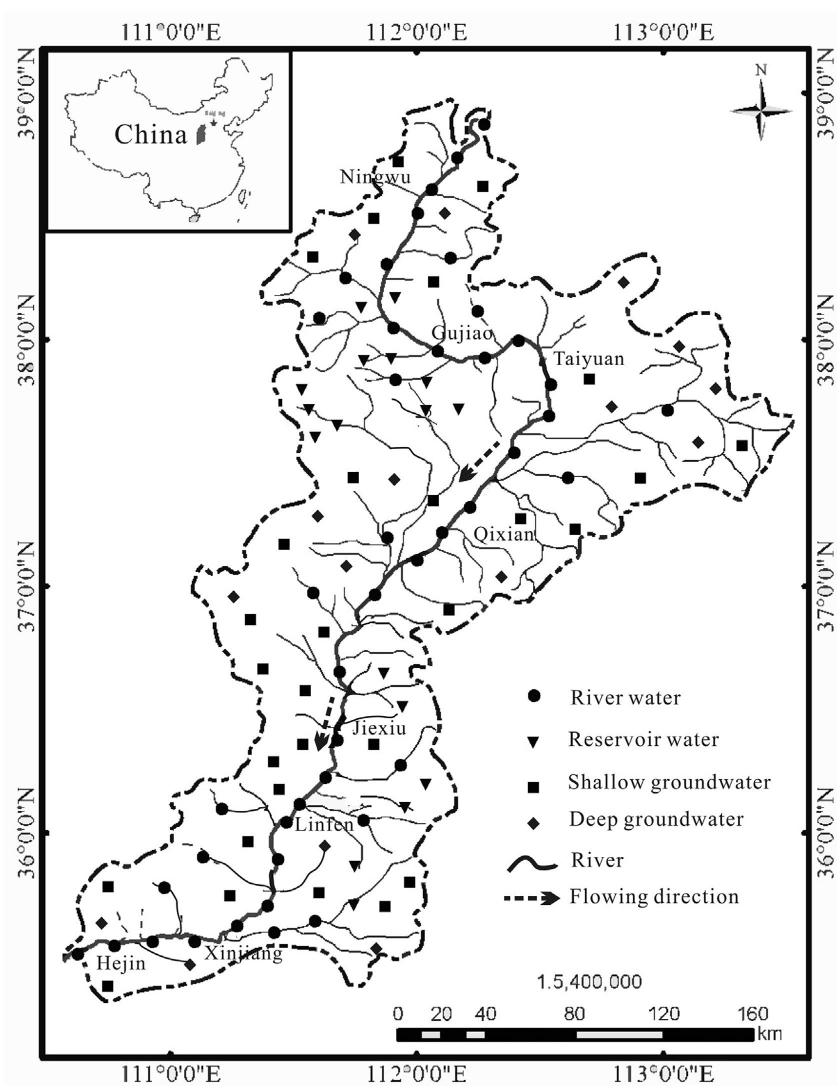


**Fig. 1.** Location of the sampling sites in the Fenhe River Basin.