Distribution and Genesis of Groundwater TDS in the Plain Area of the Kashgar River Basin, Xinjiang (Postprint)

Authors: Wang Hongtai, Zhou Jinlong, Zeng Yanyan, Zhang Jie, Wei Xing, Chen Jinsong

Date: 2020-06-27T00:00:00+00:00

Abstract

Based on 74 sets of groundwater quality test results from the plain area of the Kashgar River Basin in Xinjiang in 2014, Kriging interpolation, Gibbs diagrams, ion ratio methods, and mineral saturation index methods were used to reveal the distribution characteristics and genesis of TDS in groundwater. The results show that: TDS in the phreatic water of the study area ranges from 354.80~6505.00 mg · L^{-1}, with an average value of 1,994.36 mg · L^{-1}, no brine distribution, and generally shows a pattern of high in the west and low in the east, with hydrochemical types mainly being SO4 · Cl-Na · Ca · Mg, HCO3 · SO4-Na · Ca · Mg, and HCO3 · SO4-Ca · Mg; TDS in the confined water is generally higher, ranging from 214.00~14,548.00 mg · L^{-1}, with an average value of 2,480.30 mg · L^{-1}, and its distribution characteristics generally show a pattern of high in the south and low in the north, with hydrochemical types dominated by SO4 · Cl-Na · Ca · Mg, HCO3 · SO4-Na · Ca · Mg, and SO4-Na · Ca · Mg. The main mechanisms controlling TDS in groundwater in this area are natural geographical factors, rock weathering, evaporation concentration, mineral dissolution, and human activities.

Full Text

Distribution and Cause Analysis of Groundwater TDS in the Plain of Kashgar River Basin, Xinjiang

WANG Hong-tai[1], ZHOU Jin-long[1,2], ZENG Yan-yan[1,2], ZHANG Jie[1,2], WEI Xing[1,2], CHEN Jin-song[1]

[1]College of Hydraulic and Civil Engineering, Xinjiang Agricultural University, Urumqi 830052, Xinjiang, China

[2]Xinjiang Hydrology and Water Resources Engineering Research Center, Urumqi 830052, Xinjiang, China

Abstract

Based on 74 sets of groundwater quality measurements from 2014 in the plain area of the Kashgar River Basin in Xinjiang, this study employs Kriging interpolation, Gibbs diagrams, ion ratio analysis, and mineral saturation index methods to reveal the distribution characteristics and genesis of Total Dissolved Solids (TDS) in groundwater. The results indicate that TDS in phreatic water ranges from 354.80 to 6505.00 $mg \cdot L^{-1}$, with an average of 1994.36 $mg \cdot L^{-1}$. No saline water was detected, and the overall distribution pattern shows higher values in the west and lower values in the east. The primary hydrochemical types are $SO_4 \cdot Cl$-$Na \cdot Ca \cdot Mg$, $HCO_3 \cdot SO_4$-$Na \cdot Ca \cdot Mg$, and $HCO_3 \cdot SO_4$-$Ca \cdot Mg$. In confined water, TDS is generally higher, ranging from 214.00 to 14548.00 $mg \cdot L^{-1}$, with an average of 2480.30 $mg \cdot L^{-1}$. The distribution pattern is characterized by higher values in the south and lower values in the north, with dominant hydrochemical types of $SO_4 \cdot Cl$-$Na \cdot Ca \cdot Mg$, $HCO_3 \cdot SO_4$-$Na \cdot Ca \cdot Mg$, and SO_4-$Na \cdot Ca \cdot Mg$. The main mechanisms controlling groundwater TDS in this region include natural geographic factors, rock weathering, evaporation concentration, mineral dissolution, and human activities.

Keywords: groundwater; TDS; evaporation concentration; mineral dissolution; Kashgar River Basin; Xinjiang

Groundwater serves as the primary source for agricultural irrigation in arid regions. Excessive salt accumulation in groundwater leads to soil secondary salinization, which severely damages soil productivity, affects agricultural production, and degrades the ecological environment, thereby impacting economic development [1]. TDS reflects the salt content in groundwater [2], and the mechanisms influencing groundwater TDS include dissolution of soluble minerals, evaporation concentration processes, ion exchange adsorption, and human activities such as excessive groundwater exploitation, agricultural irrigation, and fertilizer application [3-7]. Investigating the distribution and genesis of groundwater TDS is crucial for preventing groundwater pollution and rationally planning and utilizing groundwater resources.

The plain area of the Kashgar River Basin is located in southwestern Xinjiang, deep in the interior of the Eurasian continent and far from coastlines, with an arid climate. Although the region has relatively abundant water resources, their temporal and spatial distribution is uneven, making it one of China' s water-quality-deficient areas. Previous studies by Wei et al. [8] have shown that medium and high salinity shallow groundwater exists in the Kashgar region, while Zeng et al. [9] reported that the TDS exceedance rate in the Kashgar River Basin reaches 69.2%. Zhou et al. [10] found that medium-salinity groundwater accounts for 30.6% of the total plain area in the Tarim Basin. However, these studies have paid limited attention to the overall TDS distribution and

genesis in the plain area of the Kashgar River Basin. This paper analyzes the overall distribution of groundwater TDS in the study area and focuses on revealing its genesis from the perspectives of natural geographic factors, evaporation concentration, rock weathering, cation exchange adsorption, mineral dissolution, and human activity impacts.

1.1 Regional and Hydrogeological Overview

The Kashgar River Basin covers a total area of 8.18$×10^{4}$ km^2 and features a warm temperate continental arid climate with scarce precipitation and slow hydrological cycling [11]. The basin' s topography is generally higher in the west and lower in the east, bordered by the southern slopes of the western Tianshan Mountains to the north, the Pamir Plateau to the west, the northern foothills of the Kunlun Mountains to the south, and opening eastward toward the Taklamakan Desert. Elevations range from 500 to 7559 m, with primary landforms including tectonic denudation mid-high mountains, tectonic denudation low hills, piedmont slope accumulation alluvial-pluvial plains, and river accumulation alluvial plains [12].

The main aquifer system in the Kashgar River Basin plain area consists of Quaternary unconsolidated rock pore water-bearing formations, comprising two types of water-bearing rock groups [Figure 1: see original paper]: (1) Upper Pleistocene alluvial-pluvial layer water-bearing rock group, where the lithology in the piedmont alluvial-pluvial plain zone is dominated by gravel and sandy gravel, and the contact zone between the piedmont alluvial-pluvial plain and alluvial plain consists mainly of sandy gravel and gravelly sand, with groundwater types being single-structure phreatic water; and (2) Upper Pleistocene-Holocene alluvial layer water-bearing rock group, composed of gravelly sand, medium-coarse sand, medium-fine sand, fine silt, and sub-clay,

Note: Figure translations are in progress. See original paper for figures.