Hydrochemical Composition of Natural Water Bodies and Their Controlling Factors in Eastern Hunshandake Sandy Land (Postprint)

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Abstract

The eastern region of the Hunshandake Sandy Land is located on the Inner Mongolian Plateau, where natural waters are freshwater. Hydrochemical classification using the original Durov three-line diagram reveals that surface water belongs to the bicarbonate group, whereas groundwater exhibits multiple types, including bicarbonate, mixed, and sulfate groups. The distribution of natural water samples in the Gibbs diagram demonstrates that lithological control represents the primary control on the hydrochemical composition of natural waters in this region, distinguishing it from natural waters in the western and central deserts of China, which are dominated by evaporation-crystallization due to intense evaporation. Ionic ratio relationships of natural waters indicate that groundwater exhibits relatively high weathering intensities of evaporite and silicate rocks but low weathering intensity of carbonate rocks, likely resulting from prolonged water-rock interaction times and insufficient carbon dioxide supply. Conversely, due to short water-rock interaction times and adequate carbon dioxide supply, surface water shows relatively low weathering intensities of evaporite and silicate rocks but high weathering intensity of carbonate rocks.

Full Text

Hydrochemical Composition of Natural Waters and Its Affecting Factors in the East Hunshandake Sandy Land

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Abstract: The East Hunshandake Sandy Land is located in the Inner Mongolia Plateau. Compared with other deserts in western China, water resources in the Hunshandake Sandy Land are relatively abundant, with some rivers even originating from within the sandy land. In this study, 24 water samples—including 11 groundwater samples, 6 lake water samples, 5 river water samples, and 2 spring water samples—were collected from 2011 to 2012. Physical parameters including pH, oxidation-reduction potential (Eh), electrical conductivity (EC), total dissolved solids (TDS), and salinity were measured on-site using a portable instrument. Major anions (Cl , NO , SO^{2} , HCO) and cations (Na , K , Mg^{2} , Ca^{2} , NH) were determined by electrochemical detectors of ion chromatography at the Institute of Geology and Geophysics, Chinese Academy of Sciences. The concentration of HCO was measured by titration with HCl following the Gran Method. The results showed that TDS of water samples ranged from 67 mg·L^{1} to 660 mg·L^{1}, revealing that freshwater was dominant in the natural waters of Hunshandake Sandy Land. Moreover, the concentration of calcium was the highest among cations in almost all water samples, while that of bicarbonate was the highest among anions except for some groundwater and spring water samples. The pH values of groundwater were commonly slightly lower than 7, while those of other water types such as lake water, river water, and spring water were slightly higher than 7. In addition, almost all concentrations of cations and anions in groundwater were the highest among natural waters. Hydrochemical types were determined by the original Durov Diagram. The results showed that surface water was dominated by bicarbonate, but groundwater was dominated by bicarbonate, mixed type, or sulfate. Gibbs Diagram was used to determine the factors affecting the hydrochemical composition of natural waters. Different from the deserts in the western and central parts of China, where evaporation was so strong that evaporation-crystallization mainly affected the hydrochemical composition of natural waters, water-rock interaction was the main factor affecting natural waters in East Hunshandake Sandy Land. Ion ratios in samples indicated that the weathering degree of evaporative salt rock and silicate rock in groundwater is higher, while that of carbonate rock is lower, which may be caused by the insufficient supply of carbon dioxide due to the long water-rock interaction time in groundwater. Conversely, due to the short water-rock interaction time and sufficient supply of carbon dioxide, the degree of weathering of evaporative and silicate rocks in surface water is low, while that of carbonate rocks is high.

Keywords: hydrochemical composition; affecting factors; original Durov Diagram; Gibbs Diagram; ion ratio; Hunshandake Sandy Land

4 Discussion

4.1 Hydrochemical Types and Controlling Factors

The Gibbs Diagram is widely used to analyze the controlling factors of hydrochemical characteristics of natural waters. Gibbs [26] proposed using the relationships between TDS and Na /(Na +Ca^{2}) or Cl /(Cl +HCO) in natural waters to determine the main controlling factors of hydrochemical characteristics, which can be classified into three types: evaporation-crystallization, water-rock interaction, and atmospheric precipitation. The results show that the hydrochemical characteristics of natural waters in East Hunshandake Sandy Land are mainly controlled by water-rock interaction. Unlike the deserts in western and central China where evaporation-crystallization dominates, water-rock interaction is the primary factor controlling the hydrochemical composition in this region. The TDS values range from 67 mg · L^{1} to 660 mg · L^{1}, with Na content being relatively low and Ca^{2} content being relatively high, indicating that water-rock interaction is the dominant process affecting the hydrochemical characteristics of natural waters in East Hunshandake Sandy Land.

4.2 Water-Rock Interaction

The Gibbs Diagram (Figure 7) shows that all water samples plot in the water-rock interaction zone, indicating that water-rock interaction is the main factor controlling the hydrochemical composition of natural waters in East Hunshandake Sandy Land. In the water-rock interaction zone, the hydrochemical composition of natural waters is mainly affected by the dissolution of minerals in rocks. Previous studies have shown that the degree of rock weathering in waters is different. The weathering degree of evaporative salt rock and silicate rock in groundwater is higher, while that of carbonate rock is lower, which may be caused by the insufficient supply of carbon dioxide due to the long water-rock interaction time in groundwater. Conversely, due to the short water-rock interaction time and sufficient supply of carbon dioxide, the degree of weathering of evaporative and silicate rocks in surface water is low, while that of carbonate rocks is high.

[Figure 3: see original paper] Locations of the water sampling sites

[Figure 4: see original paper] Contents of the main ions in groundwater, lake water, river water, and spring water

[Figure 5: see original paper] Values of TDS and pH in groundwater, lake water, river water, and spring water

[Figure 6: see original paper] Hydrochemical types indicated by the original Durov Diagram

[Figure 7: see original paper] Gibbs Diagram showing the controlling factors of natural water chemistry

Hydrochemical parameters of the samples of groundwater, lake water, river water, and spring water

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