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Groundwater geochemistry of Ain Azel area, Algeria

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ABSTRACT

Hydrogeochemical data for 18 groundwater samples and 11 hydrochemical parameters were subjected to Q- and R-mode cluster analysis and inverse geochemical modeling. Q-mode cluster analysis resulted in three distinct water types (brackish water type, saline water type and highly saline water type). R-mode cluster analysis led to the conclusion that the water–rock interaction is the major source of contamination for the groundwater in the area. Geochemical modeling results show that carbonates, gypsum, halite, carbon dioxide (gas), and chlorite are dissolving, whereas Ca-montmorillonite, gibbsite, illite, K-mica, kaolinite, and quartz are mostly precipitating along different flow paths in the groundwater system of the area.

1. Introduction

Water quality gets modified in the course of movement of water through the hydrological cycle and through the operation of the following processes: evaporation, transpiration, selective uptake by vegetation, oxidation/reduction, cation exchange, dissociation of minerals, precipitation of secondary minerals, mixing of waters, leaching of fertilizers and manure, pollution and lake/sea, biological process (Appelo and Postma, 1993). The quality of water is of vital concern for mankind, since it is directly linked with human welfare. Poor quality of water adversely affects the plant growth and human health (Wilcox, 1948; Thorne and Peterson, 1954; US Salinity Laboratory Staff, 1954; Holden, 1971; Todd, 1980; ISI, 1983; WHO, 1984; Hem, 1991; Karanth, 1997). Groundwater quality data give important clues to the geologic history of rocks and indications of groundwater recharge, movement and storage (Walton, 1970). The knowledge of hydrochemistry is essential to determine the origin of chemical composition of groundwater (Zaporozec, 1972). The hydrology and geochemistry of waters have been further discussed in the classic works of Stumm and Morgan (1981), Hem (1991), Drever (1988), Domenico and Schwartz (1990). Adverse conditions increase investment in irrigations and health and decrease agricultural production, which, in turn, reduce agrarian economy and retard improvement in living conditions of rural people.

Geochemical modeling was developed in the 1960s on the basis of equilibrium thermodynamics. It primarily uses chemical and mathematical methods to express geochemical processes in natural water system and water–rock system, and to simulate and predict the geochemical reactions in multivariable and multi-component open system for solving a series of important theoretical and practical issues in geological and environmental sciences. Hydrogeochemical modeling of groundwater flow can explain the processes of groundwater and rock interactions and can also quantitatively describe the migration and transformation of various elements in groundwater to predict the evolution trend of groundwater chemical characteristics. It is an effective way to study the groundwater chemistry characteristics (Plummer and Back, 1980; Plummer et al., 1983; Kenoyer and Bowser, 1992; Deutsch, 1997; Parkhurst and Appelo, 1999).

The main objectives of this paper are: (1) to assess the chemistry of groundwater and (2) to identify the water–rock interaction factors that presently affect the water chemistry in the region by using multivariate statistical and geochemical modeling techniques.

2. Studied area

The area of study is located in the East of Algeria characterized by a semi-arid climate and an average precipitation and temperature of about 296 mm/year and 15.2 °C, respectively (Belkhiri, 2005). Most of its inhabitants (more than 30,000) are concentrated in the town of Ain Azel working mainly in the production of cereals (barley, corn).

According to many authors (Savornin, 1920; Galcon, 1967; Guiraud, 1973; Vila, 1980) the area of concern is distinguished by two geological sets. In the South, autochthonous Jurassic and Cretaceous carbonate lithologies are mainly observed in Djebels

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