

Full Length Research

Multivariate statistical techniques for the evaluation of spatial variation in groundwater quality of Soummam basin (Algeria)

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13 chemical and physical-chemical features of water of samples from 20 wells were analyzed by multivariate statistical tools to provide the characterization of the groundwater distribution of the Soummam basin, Algeria. The 13 parameters determined include: temperature, pH, conductivity and cations and anions (Ca, Mg, Na, K, Cl, SO₄, HCO₃, NO₃, Fe, Zn). Cluster analysis grouped 20 sampling wells into two clusters, i.e., relatively brackish water (group 1) and moderate saline water (group 2), based on the similarity of water quality characteristics. Factor analysis helped in identifying the factors or sources responsible for water quality variations. The varifactors obtained indicate that the parameters responsible for water quality variations are mainly related to water-rock interaction, agricultural activities and ion exchange.

Key words: Cluster analysis; Factor analysis; Groundwater quality; Soummam basin; Algeria.

1. Introduction

Water quality gets modified in the course of movement of water through the hydrological cycle and through 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 gives 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 (Zaparoze, 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).

The multivariate statistical techniques are the appropriate tool for a meaningful data reduction and interpretation of multi-constituent chemical and physical measurements (Massart et al., 1988). The multivariate statistical techniques such as cluster analysis (CA) and factor analysis (FA) have widely been used as unbiased methods in analysis of water quality data for drawing meaningful conclusions (Vega et al., 1998; Helena et al., 2000; Voncina et al., 2002; Raghunath et al., 2002; Simeonov et al., 2003; Simeonova et al., 2003; Simeonov et al., 2004; Singh et al., 2004). The

multivariate analysis is widely used to characterized and evaluate groundwater quality and it is useful for evidencing spatial variation caused by natural and anthropogenic processes (Jayakumar and Siraz, 1997; Vega et al., 1998; Reisenhofer et al., 1998; Helena et al., 2000; Singh et al., 2004; Belkhiri et al., 2010).

The objective of the present study is to analyze the 13 physico-chemical parameters in groundwater samples from the Soummam basin. The large dataset obtained was subjected to the CA and FA multivariate techniques to evaluate information about the similarities and dissimilarities present among the different sampling sites, to identify water quality variables for spatial dissimilarity, and to ascertain the influence of the pollution sources on the water quality parameters.

2. Methods

2.1. Study area

The Soummam basin is situated in the northeastern of Algeria and extends from 36°-36° 45' of latitude north to 3° 40'-5° 45' of longitude east (Fig. 1). This area is bounded by the Djurdjura mounts on the western, by the Babor mounts on the east and southeastern and by the Mediterranean Sea on the northern side. The climate of the Soummam basin shows a series of transition between humid climate in the mountains near the Mediterranean and semi-arid climate of high plains. The mean minimum and maximum temperatures are 11.8 and 24.8°C, respectively. The mean annual rainfall of the basin is about 700 mm (Mouni, 2004). Rocks and unconsolidated deposits in the area can be divided into four geologic formations (Perrier, 1964): (1) Oligocene; (2) Cretaceous; (3) Lower Miocene; (4) Alluvial terraces.