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Spatio-temporal evolution of the physico-chemical water characteristics of the Sebaou river valley (Great Kabylia, Algeria)

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ABSTRACT

The Sebaou river valley (SRV) is located in the northern Tell region of Algeria, and is a significant source of ground and surface waters because of its geographical context within the northern Algerian Tell region.

The water resources from the study area are important for both local people and environmental scientists since the area is undergoing significant industrial development. Therefore a quantitative and qualitative study of the surface and groundwater can help us to establish the current physico-chemical variables of the water resources, allowing comparisons with future studies.

In this study we present the most comprehensive survey of the hydrogeological properties of this region reported to date, including the spatio-temporal variation of physico-chemical variables as studied by principal component analysis. This method allowed us to confirm the principal chemical facies and to differentiate the waters of the middle and upper Sebaou river from the waters of river tributaries, specifically the Aissi and Bougdoura rivers. The quality of these water resources is declining as a result of local development and so this study is expected to provide a valuable resource for future water management strategies in the region.

1. Introduction

Water availability is becoming a problem in Algeria, as in most Mediterranean countries, due to a steady reduction in total rainfall (Djemai, 1985). This reduction, caused by irregularities in the amount of rainfall and longer dry seasons, has meant that underground reserves of water are not properly renewed. Compensating this shortfall by storing surface water is problematic since appropriate sites for building dams are limited by topographical, geological and hydrologic conditions. These natural problems are further aggravated by increasing public, industrial and agricultural demands (Djemai, 1985).

The problem of availability is exacerbated by a concomitant decline in quality. Public, industrial and agricultural users all contribute to this problem either directly, by means of their waste, or indirectly, by altering the physicochemical and bacteriological properties of water they do not use directly. It is therefore important to assess the extent of such problems in major water systems and we chose the Sebaou river valley because it is an important water resource, which supplies drinking water for a large region in north Algeria.

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In recent years, the overexploitataion of groundwater in the Sebaou valley for drinking and irrigation purposes has caused a lowering of the water table and waste discharge has caused degradation of water quality along the course of the river (Kadri et al., 2011). Hydrochemical studies of the waters will therefore help us to assess these effects from both a quantitative and a qualitative point of view. Because of its importance, the Sebaou river has been studied for three decades, meaning that we could take readily available data and combine it with our recent measurements to produce a synthesis of water quality studies covering a large physical and temporal range. This analysis allows us to present the most in-depth assessment of water quality so far produced for this region. Our particular contribution to this evaluation studies the spatio-temporal evolution of physico-chemical characteristics from upstream to downstream of the Sebaou river valley (SRV) and some of its tributaries.

Similar spatio-temporal studies have been carried out in other regions. Yadav et al. (2015) studied the variations of arsenic in the groundwater of the Ganges River basin (Nepal); Bu et al. (2014) studied the spatio-temporal water chemistry characteristics of the Taizi River (NE China), and Mehto and Chakrapani (2013) applied the same approach to the Tawa River (Central India). As examples of groundwater and surface water studies, Irawan et al. (2015) investigated the water chemistry of the Ciliwung River (Indonesia) to understand the groundwater-surface water interactions; Semar and Saibi (2014) studied the groundwater characteristics of the Soummam River basin (North Algeria); Dar et al. (2011) studied the groundwater chemistry of the Palar River basin (India), and Moshovchenko et al. (2009) studied the surface water quality of the Vatinsky Egan River (West Siberia). For pollution studies, Sundaray et al. (2012) investigated the pollution of the Mahanadi River by quantifying the dissolved heavy metals.

The SRV itself has been the subject of more specific hydrogeological and hydrochemical studies. For example, Benhassaine (1980) studied the geomorphology of superficial formations, Bouzar (1980), Djemai (1982, 1985), and Boumaza (2001) studied the hydrogeology of the SRV, Mellal (2001) studied the hydrochemistry of SRV waters, Hadjou (2008) developed a mathematical model of SRV characteristics, and Djemai and Mesbah (2008) studied the chemistry and bacteriology of the Aissi river (a tributary of the Sebaou river).

Our study relied on a large amount of data taken from several sources:

- Surface water data: period of 1985–1995 from Boubehir, Belloua and Bougdoura areas, and period of 1988–1997 from Freha and Aissi rivers (ANRH, 2000).
- Surface and groundwater data from June 1999 (low water period) and January 2000 (high water period) Mellal (2001).
- Surface water data from Boumaza (2001).
- Surface and groundwater data from Lakroun (1995).
- Surface water data from Djemai (2008).
- Groundwater data from Djemai (1985).
- Surface water data (Low water periods: October 2005, October 2006, October 2007 from the Aissi river, Upper Sebaou, Middle Sebaou, respectively. High water periods: May 2005, May 2006, May 2007 from the Aissi river, Upper Sebaou, and Middle Sebaou, respectively) and groundwater data (Low water periods: October 2006 from the Aissi river, Upper Sebaou and Middle Sebaou. High water periods: May 2006 from the Aissi river, Upper Sebaou and Middle Sebaou). The data from 2005 was published by Djemai and Mesbah in 2008.

Here, we present a hydrochemical study of the SRV, highlighting spatio-temporal changes of surface and groundwater. As part of the study, we discuss pollution levels and present principal component (PCA) and correlation analyses to make associations between the large collections of data.

2. Materials and methods

2.1. Study area

2.1.1. Geographic location, morphometric and hydroclimatic characteristics of the study area

The water basin of the Sebaou river belongs to the northern Tell region and is located between latitude N36°30′ and N37°00′ and longitude E03°30′ and E04°30′. It integrates with the coastal basins of Algiers of code (02), according to the nomenclature of the National Agency of Water Resources (ANRH; Fig. 1a).

To put the physico-chemical data into context, we collected data on the SRV's morphometry and hydroclimate. The river's morphometric parameters were determined by studies undertaken on the water sub-basins of the upper, middle and lower Sebaou river (Djemai, 1982; Djemai, 1985; Mellal, 2001) and the results are summarized in Table 1.

Abbreviations of the sampled waters in the SRV:
BH: Boubhir
BR: Boubroun
FR: Freha
TR = Tizi-RachedTA or TAM: Tamda
PT: Takhoukht bridge
BT: Taksebt dam
ABT: Upstream Taksebt dam
APB: Upstream of Bougie bridge
AvPSN: Downstream of Sidi Namane bridge