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Geochemical and isotopic tools to deciphering the origin of mineralization of the coastal aquifer of Essaouira basin, Morocco

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Abstract

The determination of the origin of salinity and mineralization of groundwater from the Plio-Quaternary aquifer of Essaouira Basin was the main goal of this research, investigated by the combined study of chemical (particularly Br and Cl) and isotopic (¹⁸O and ²H) compositions. The study of Br / Cl ratio vs Cl showed that mineralized waters of the shallow aquifer in the Essaouira Basin is the result of: (i) the marine influence (precipitation and aerosols directly from the ocean), (ii) dissolution of evaporite minerals (halite), (iii) seawater intrusion and iv) ion exchange mechanisms. The ¹⁸O-²H diagram showed that the groundwater recharge is maintained by direct precipitation without evaporation and runoff. The Cl/¹⁸O ratio showed the existence of a mixture trend of seawater-groundwater.

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Nomenclature

PQ	Plio-Quaternary
LMWL	Local Meteoric Water Line
GMWL	Global Meteoric Water Line

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1. Introduction

All over the world and particularly in arid and semi-arid regions, groundwater is extremely important for Human supply, agriculture and industry. In recent decades, in the research region was recognized a qualitative and quantitative deterioration of the regional water resources resulting from both natural and anthropogenic stresses¹. The aquifer used as an example here, is the PQ aquifer of Essaouira Basin, located south of Essaouira city, on the Moroccan Atlantic coast. This aquifer is limited to the north by the Ksob Wadi, south by the Tidzi Wadi by the Tidzi diapir to the east and by the Atlantic Ocean to the west (Fig.1). This area is under a Mediterranean climate of semi-arid type. The average annual rainfall does not exceed 300 mm and the average temperature hovers around 20 °C. From a geological and hydrogeological standpoint, this water system is housed in formations of PQ marine gray limestone matrix or dune with a primary hydraulic conductivity porosity $(3.2 \times 10^{-2} \text{ m/s})^2$. The natural flow path of the system is SE to NW. This investigation aims to determine the origin and understanding of the mechanisms controlling the groundwater salinization in the PQ aquifer of Essaouira Basin.

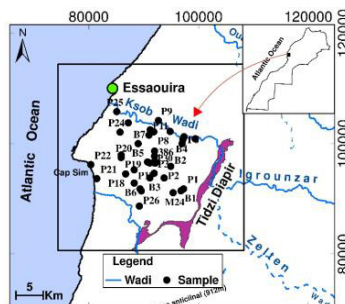


Fig.1. Location of study area

2. Methodology

In order to identify and understand the geochemical processes responsible for the water mineralization of the PQ aquifer of Essaouira Basin, a total of 29 groundwater samples were collected at boreholes and dugwells from the shallow aquifer during June 2015 for chemical and isotopic determinations. The physicochemical parameters (temperature, pH, electrical conductivity (EC)) were measured *in situ*. The major and minor elements (Cl, SO₄, NO₃, Br, Ca, Mg, Na, K) were determined by ion-exchange chromatography (Dionex ICS-1100 column) at the Center for Analysis and Characterization (CAC) in the Faculty of Science Semlalia Marrakech, Cadi Ayyad University. The contents of HCO₃ are analyzed by titration using HCl acid (0.1N). The isotopic compositions (¹⁸O, ²H) were determined by the isotope hydrology laboratory of the International Atomic Energy Agency (IAEA) in Vienna, Austria.

3. Results and discussion

3.1. Chemical Characteristics

The water chemistry depends on both mixing and chemical reactions (water-rock interaction), such as dissolution-precipitation, evaporation, ion exchange processes and seawater intrusion. In order to decipher the origin of the mineralization within PQ aquifer system some diagrams were made: (a) Na vs Cl; (b) Br vs Cl and (c) the ratio Br/Cl vs Cl (Fig. 2). The chloride and sodium are positively correlated ($r^2 = 0.91$) (Fig. 2a), indicating an important contribution of the halite dissolution in mineralization of groundwater. However, the majority of the groundwater samples reveal a depletion in Na⁺ content. All samples are undersaturated with respect to halite with SI_{halite} ranges from -4.74 and -7.47, corroborating the contribution of halite in the groundwater mineralization. Most samples are close to the theoretical line of the seawater – freshwater mixing line characterized by slope 0.67,

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