Origin of Salinity of Water Resources: Climatic and Anthropogenic Impacts (Western Morocco)

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Abstract

The southern part of the Rharb basin is represented by the Mamora basin. Thanks to its hydraulic potentialities, the Mamora groundwater supplies not only Rabat (the capital) and Kenitra cities, but also the economic city of Morocco: Casablanca, as well as industrial and agricultural sectors. Along with this heavy sollicitation, and like other basins belonging to the Atlantic margin of Morocco such as the Essaouira Basin (Laftouhi et al. 2003; Mennan et al., 2001), the Doukkala Basin (El Achheb, 2000) and the plain of Souss (Hsissou et al., 1999), the declining groundwater levels and rainfall fluctuations expose the water to salt pollution.

This work aims to monitor the spatial quality of hydrochemical groundwater and to understand the process of the mineralization in according to the saltwater intrusion, the hydraulic gradient and the water-aquifer interaction. Hydrochemical correlations which are realized in the coastal area showed contamination by seawater. The analysis and the interpretation wells highlights benches salt which may explain the mineralization of water in the zone far from the cost. The seawater intrusion and the identification of the Pre-Rifean complex were identified by the electrical and seismic methods.

Key words: hydrochemical evolution, saltwater, correlation, interaction, geophysics

1. INTRODUCTION

The Rharb–Mamora Basin is bounded in the east and north by the frontal ranges of the Rif Cordillera (Figure 1a), and to the west by the Atlantic coast. Hydrogeological investigations realized in the study area (Zouhri, 2002) revealed a heterogeneous permeable Plio-Quaternary facies mainly composed of sandstones, conglomerates, limestones and sandy clay more or less depending on location. The basement is composed by the Mio-Pliocene blue marls.

In order to study the origin of salinity of groundwater resources of this aquifer, the study area has been the subject of the hydrogeoloical, hydrochemical and geophysicals studies.

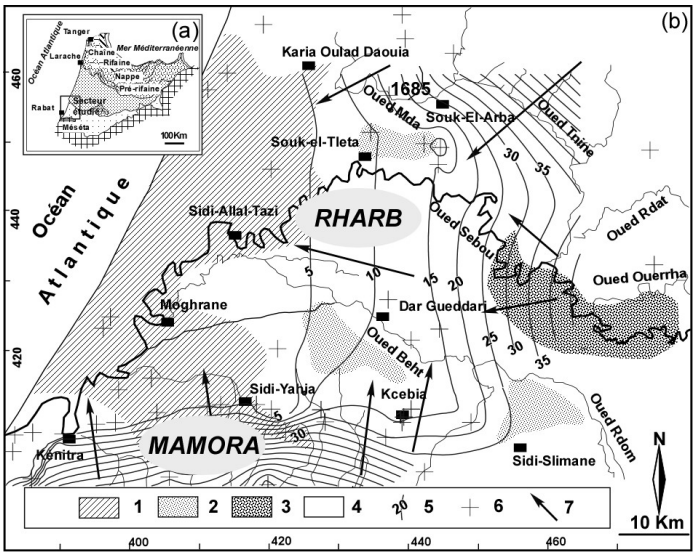

Fig. 1 (a) Location of structural domains in the north of Morocco**.** (b) Piezometry of the Rharb Basin and the alimentation zones (1. Levels sandstone and sandy clay, 2. Artesian groundwater, 3. Pebbles and gravels, 4. Sand and gravels, 5. Isopiez, 6. Samples, 7. Groundwater flow).

2. PIEZOMETRIC STUDY

The analysis and interpretation of the piezometric map showed two divinding limits: i) the first one in the west, which guides the direction of groundwater toward the northeast and north-west. The second one is located in the eastern part of the region of Sidi Yahia (Figure 1b) where the flow takes the same direction (north-east and north-west). In the western area, the groundwater flow toward the Atlantic Ocean. The groundwater flow is generally northward and westward. Comparisons between the groundwater level in the low water (1999 and 2000) have identified the drawdown of about 0.5 m. This reduction is related to the effect of drought years. The reversal of hydraulic gradient founded along the coast, over two kilometers of it are produced at the downstream drainage axes, which helps explain the existence of seawater intrusion.

3. HYDROCHEMICAL INVESTIGATION

The groundwater chemistry of the Mamora aquifer system has been studied in terms of the major ionic constituents Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, HCO_3^{-}, NO_3^{-}, and of the physical parameters (pH, electrical conductivity, *EC*, and temperature, *T*). The water intrusion has been studied by using the spatial distribution of the Cl/electrical Conductivity. In the western part, some wells are recorded an electrical conductivity about 1500 $\mu S\ cm^{-1}$ and Chloride concentrations about 952 mg/L.

The description of the hydrochemical facies has been presented in the Piper diagram and show the dominance of two main facies: ($Ca+Mg-CO_3+HCO_3$) and (Na+K-Cl). The first facies is due to the presence of sand. The second could be coming from the seawater intrusion given the density of wells in the coastal zone.

3. GEOPHYSICAL AND SEISMIC APPROACHES

The electrical method has been used in order to delineate the interface salt/fresh water. The behavior of the advancing wedge of saltwater to the continent could be affected by the dip of the basement. The work in this area have revealed a tectonic block. The correlations in hydrogeological boreholes showed a deepening of Mio-Pliocene blue marls to the north-west (Zouhri, 2002). This extension is controlled by synsedimentary faults NW-SE and NE-SW. This advance is limited to less than one kilometer in the south of Mehdia where the basement has an average gradient of 2.5% to the ocean. The analysis and the interpretation of the seismic lines highlight the saline bench in the aquifer system of the Rhab Basin.

4. CONCLUSION

In the framework of the North-South collaboration, we will couple the geoelectrical informations with hydrochemical modelling and tracers investigations in order to understand the behaviour of the saltwater intrusion in the aquifer of the Rharb Basin.

4. REFERENCES

Laftouhi, N., Vanclooster, M., Jalal, M., Witam, O., Aboufirassi, M., Bahir, M., Persoons., E. (2003): Groundwater nitrate in the Essaouira Basin (Morocco). *Comptes Rendus Geoscience* 3335, 307-317.

Mennani, A., Blavoux, B., Bahir, M ., Bellion, Y., Jalal, M., Daniel., M. (2001) : Apports des analyses chimiques et isotopiques & la connaissance du fonctionnement des aquiferes plio-quaternaire et turonien de la zone synclinale d'Essaouira, Maroc occidental. *Journal of African Earth Sciences,* 32(4) 919-835.

El Achheb, A., Mania, J., Mudry, M., Chauve, P., Ouaaka, A. (2000) : Les nitrates dans les eaux souterraines du bassin sahel-Doukkala (maroc) : distribution spatio-temporelle et bilan d'azote dans les périmètres irriguées. Colloque International, ESRA, Poitiers, 71-76.

Hssissou Y, Mudry J, Mania J, Bouchaou L, Chauve P (1999) : Utilisation du rapprot Br/Cl pour déterminer la salinté des eaux souterraines : exemple la Plaine de Souss (Maroc). *Comptes Rendus* Académies des Sciences 328, 381-386.

Zouhri, L : (2002) Hétérogénéité des cotes piézométriques et structurations en blocs dans les aquifères côtiers. *Hydrological Sciences Journal* 47(6) 969-981.