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GEOCHEMICAL AND ISOTOPIC CHARACTERIZATION OF GROUNDWATER RESOURCES IN EL HICHA REGION, GABES, SOUTHERN TUNISIA

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The groundwater study area is located in the southern part of Tunisia at some kilometers from the Mediterranean Sea, about 35 km north of the town Gabes. It extends over 300 km^2 and is bounded by the Gulf of Gabes in the East, El Hamma in the West and Skhira in the North. This region is characterized by a semi-arid climate with an average annual rainfall of about 180 mm and a potential evaporation of 2130 mm per year.

The groundwater resources of the region are represented by four hydrogeological units: the Continental Intercalaire, the Sfax Aquifer, the Jeffara Aquifer (north of Gabès) and the shallow aquifer of El Hicha. The dug wells and boreholes used for groundwater abstraction in this region reach depths between a few meters and about 170m. The upper zone of 50m depths is formed by sandy clay and gypsum, and the lower zone of 50 to 70m depths consists of sandy layers.

The salinity measured in groundwater samples from this area is rather high; the values range between 5 and 7g/l. Since the water will be used to grow salt-tolerant plants, it is important to know the origin of the groundwater (to assess its availability) and the source(s) of its salinity. To this end, groundwater samples for isotope and chemical analysis were taken from 6 dug wells, 6 boreholes (one of them is an artesian well), a spring and a drainage canal. Each site was sampled in March, June, July, September and December 1999. During these sampling campaigns, in-situ measurements of temperature and electrolytic conductivity were carried out.

The hydrochemical analysis of the groundwater samples indicates the presence of Cl^-, SO_4^{2-} Ca^{2+}, Mg^{2+}. The Piper diagram shows the dominance of sodium, chloride and potassium. Observed slight changes of the chemical composition of the water after a rainy period have been attributed to rainwater infiltration into the groundwater.

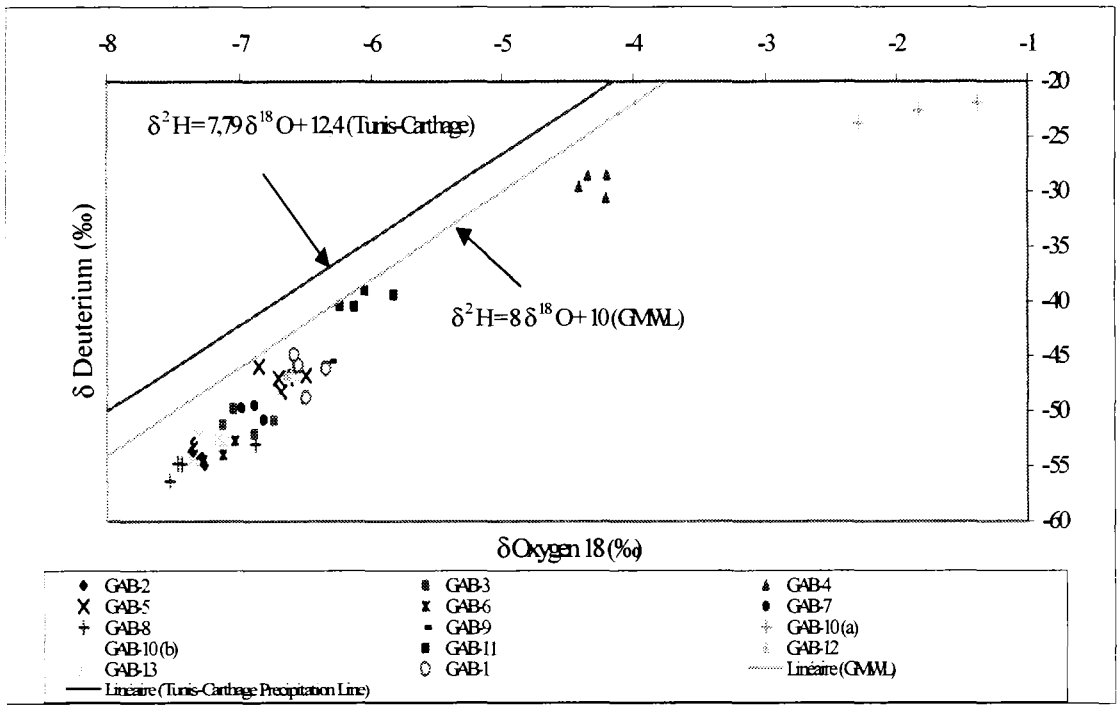

FIG.1. $\delta^{18}O$- $\delta^{2}H$ Diagram of the groundwater samples from the study area.

The $\delta^{18}O$ values of the individual water samples vary from –7,53 ‰ to – 4,2 ‰ while the $\delta^{2}H$ values range from –56,4 ‰ to –28,52 ‰ (Fig. 1). The deuterium excess of the majority of the samples is remarkably constant; the individual values cluster round 5 ‰, the deuterium excess value characteristic for palaeo-groundwater in northern Africa [1]. This finding is also substantiated by the ^{14}C values so far available for some of the collected water samples. The apparent ^{14}C age ranges from about 9000 to 14 000 years B.P. A slightly higher deuterium excess was found for groundwater collected from the dug well GAB-11. The increase of both the deuterium excess and the oxygen-18 value points to an admixture of some rainwater with present-day deuterium excess of about 10 ‰. A small contribution of rainwater is also suggested by the tritium values for this well, which average about 0,4 TU. The water samples taken from dug well GAB-4 appear to contain a higher fraction of recent (rain) water (Fig. 1), as also suggested by the relatively high tritium values (around 1.2 TU). Water from the dug well GAB-10 (a) seems to represent rather young water, because its tritium content is about 1.6 TU. Furthermore, evaporation effects appear to mask the original stable isotope composition, as indicated by the very low deuterium excess and high oxygen-18 values (Fig. 1). Therefore, this water is excluded from the following considerations.

The plot of the average values of electrical conductivity (EC) versus the respective average oxygen-18 values clearly indicates two different types of groundwater: type 1 with an EC around 4.5 mS/cm and $\delta^{18}O$ between -7.5 and –7 ‰; type 2 with EC around 7.5 mS/cm and $\delta^{18}O$ around –6.5‰. Examining the spatial distribution of the EC and oxygen-18 values, it can clearly be seen that the groundwater south of 37°90' (south of GAB-3) belongs to type 1 while north of this region the groundwater is of type 2.

Taking into account results from earlier isotope investigations in the South of Tunisia [2] – [4], the above findings can be interpreted as follows:

1. The groundwater of type 1 and 2 represents palaeo-groundwater. Type 1 preferentially occurs in the southern part of the study area and can be attributed to the Continental Intercalaire (and/or the Jeffara aquifer), while type 2 seems to belong to the Sfax aquifer.

2. Thus, the salinity of the groundwater is mainly the result of the chemical evolution of the groundwater (water-rock interaction) during the flow through the large confined aquifers. The contribution to the salinity by local infiltration of recent rainfall through the saline soil appears to be comparatively small. Such a contribution is probably manifested in the observed spread of the measured values around the primary salinity and isotopic composition of the palaeo-groundwater (Fig. 2).

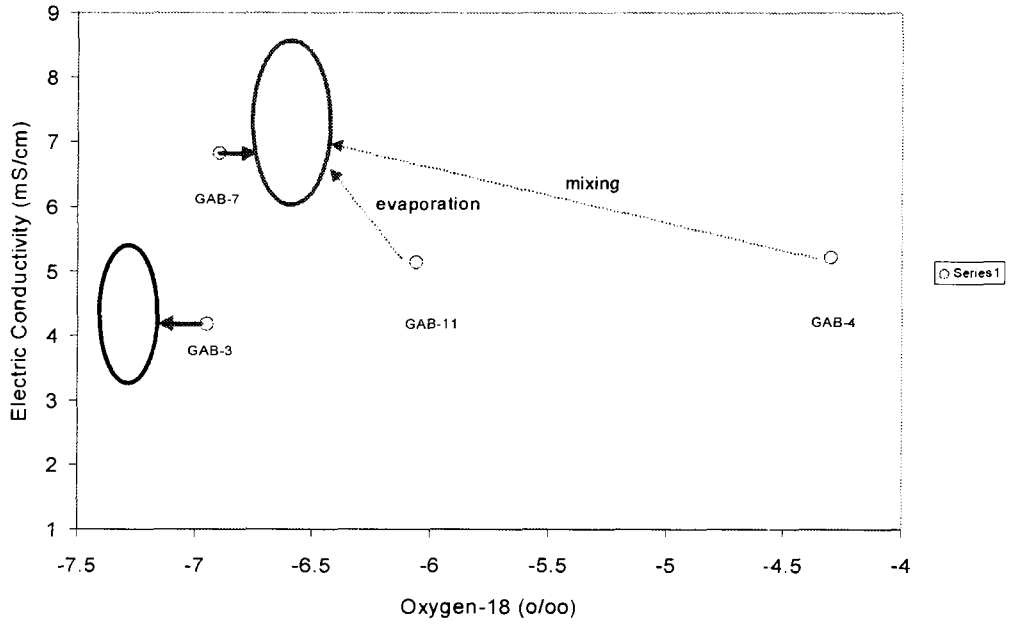

FIG. 2. Plot of the average electric conductivity (EC) and oxygen-18 values of the sampling sites.

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