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POSTER N°283 - HYDROCHEMICAL, ANALYTICAL AND ISOTOPIC METHODS FOR THE GROUNDWATER ASSESSMENT IN ARID AGRICULTURAL REGIONS: THE CASE OF THE DOUARA BASIN IN CENTRAL TUNISIA

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I-Introduction

The **Douara** region is located in the **Mezzouna delegation** in the **South East** of the state of **Sidi Bouzid** in **Central Tunisia**. It has become an active acricultural area since 2018 (**Fig.1**). Consequently, the groundwater ressources are very stressed with the over exploitation. The first aquifer level is exhausted and it is actually no longer targeted by farmers . Accordingly, the remaining 6 wells exploiting it are included in this study to better understand the aquifer system of the region.

Besides, the next two aquifer levels (DLs) are simultaneouly exploited and they drop down to the West of the basin (**Fig.2**) where the water extraction is maximized and the agriculture is more developped.

Therefore, we aim to study the water mineralization process, the phenomenon in relation with the water life-cycle and the potential relationship between the aquifer levels.

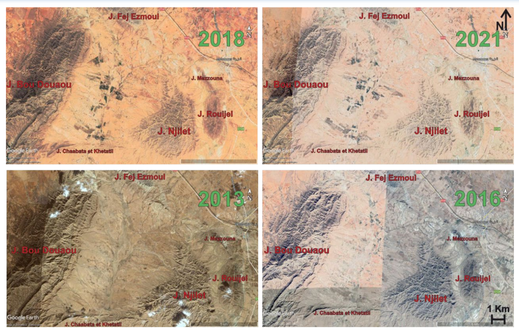

Figure 1: Agricultural evolution over the years

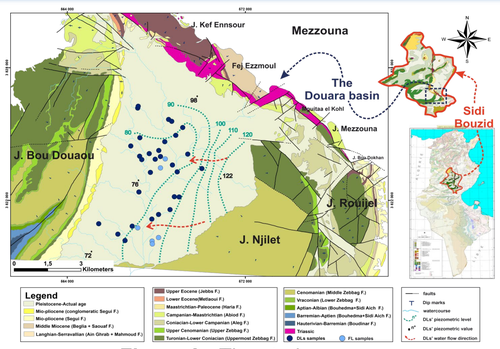

Figure 2: The study area

II-Material and methods

The study is conducted on 36 water samples in the **Laboratory of Radio-Analyses and Environement** (LRAE) in the **National School of Engineers of Sfax** (ENIS)-**Tunisia**:

✓**6 samlpes** are taken from the first aquifer level **FL**;
✓**30 samples** are taken from both of the deeper aquifer levels **DLs**.
→**Major elements** contents were determined by ion liquid chromatography **HPLC** .
→**Oxygen 18 and deuterium** analyses were performed with the Laser Absorption Spectrometer.
→**Tritium** content was measured by electrolytic enrichment and liquid scintillation counter

The Data was evaluated by different methods:
✓The trilinear DIAGRAM software plot (Piper diagram) for the water chemical facies;
✓Statistical PCA method using XLSTAT software for the mineralization origin;
✓The kriging ArcGis maps for the spatial distribution of the some of the chemical elements;
✓The binary Excel plots for the isotopic data interpretaions.

III-Results and discussion

1- Water chemical Facies

The Piper diagram (**Fig.3**) reveals :
✓No cation dominance for most of the water samples
✓ Slight sodium and potassium enrichment for 9 of the DLs samples that can give an idea about a cation exchange phenomenon.
✓The sulfate dominates the chloride and the bicarbonate elements. In conclusion, all aquifer levels have **sulfate water facies**.

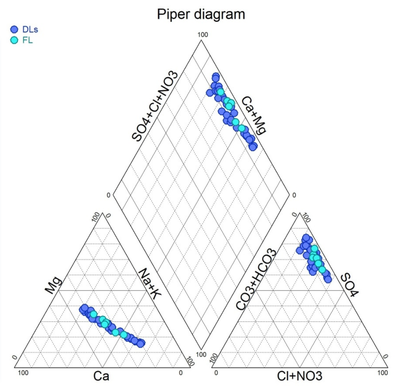

Figure 3: Piper diagram

2- Principal component analysis PCA

a. Description

✓It involves 9 variables: Conductivity, HCO_3^-, Cl^-, NO_3^-, SO_4^{2-}, Na^+, K^+, Mg^{2+} and Ca^{2+}.
✓The horizontal axis is the first PCA dimension F1 that is linked to the TDS and SO_4^{2-} on the right and to the HCO_3^- on the left → when the TDS increases with the SO_4^{2-} on the right, the HCO_3^- decreases and vice versa.
✓The vertical axis is the second PCA dimension F2 that is related to Mg^{2+} and Ca^{2+}on top and to Na^+ and Cl^- on the bottom → high magnesium and calcium content with low sodium and chloride content on the top of the axis and vice versa.

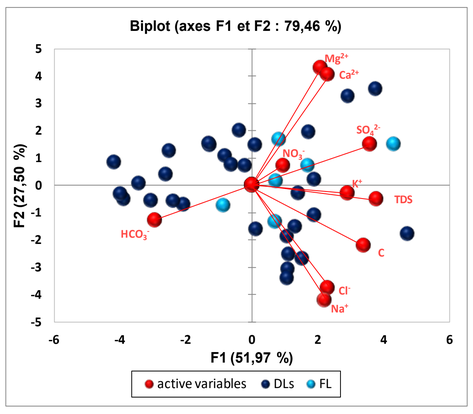

Figure 4: The PCA correlation circle

b. Interpretation

✓The narrow angles between (Na^+ and Cl^-), (Mg^{2+} and Ca^{2+}) and (SO_4^{2-} and TDS) reveal the origin of these elements:
• Na^+ and Cl^- are coming from halite dissolution
• Mg^{2+} and Ca^{2+} are originated from the weathering of the silicate minerals
•The salinity in the aquifer system is mainly generated by the SO_4^{2-}

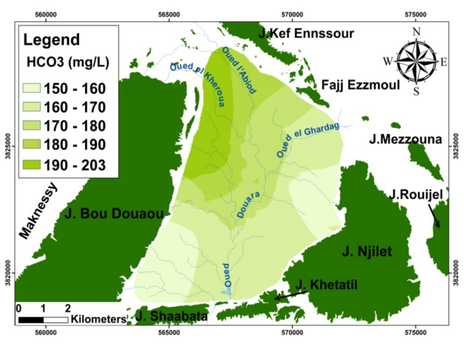

Figure 5: Spatial bicarbonate distribution for the DLs samples

✓In contrast, the obtuse angle between (Mg^{2+}, Ca^{2+}) and HCO_3^- shows that these two elements have a negative correlation with the carbonate in the water → This highlights the fact that the mentioned elements do not come from carbonate minerals.
✓The negative correlation between the TDS and the bicarbonate for the DLs samples can be observed in the kriging maps in **figures 5 and 6**: The intersection of the areas with lower salinity (TDS<2500 mg/l) with high HCO_3^- content (190 to 203 mg/l) presents a potential recharge area for the deep aquifer levels.

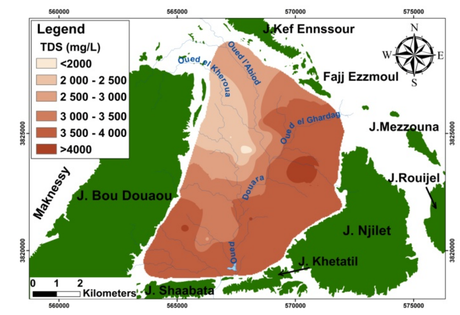

Figure 6: Spatial salinity distribution for the DLs samples

3- Water isotopes

a. Stable isotopes

✓All the samples are homogeneous in the diagram → a mixing process between the 3 aquifer levels
✓18 samples are in between the GMWL and the LMWL (**Fig.7**) → a fast and recent recharge [1].
Remarque: the DLs samples of this group are **located in the potential recharge area** (**Fig.5 and 6)**
✓The most depleted stable isotope content is related to old water in the aquifer or to a mixture between old and recently recharged water.
✓The enriched isotope content is related to the evaporation phenomenon that is significant in the arid zones.
Remarque: This evaporation of the water is one of the causes of the salinity increase → This process is confirmed by the positive correlation of some of the samples between δ ^{18}O and sulfate SO_4^{2-} in **Fig.8**.
In the case where the salinity is due to the dissolution of evaporate salts, there is an increase of the sulfate content with no alteration in the stable isotope composition and without correlation [2].

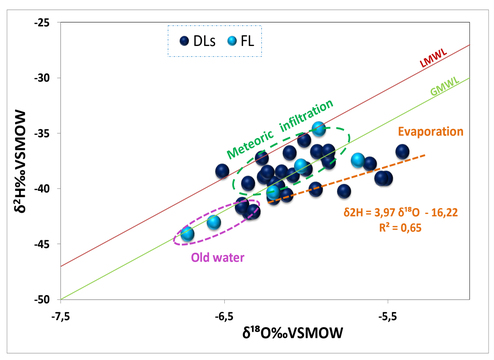

Figure 7: Stable isotopes diagram for all water samples

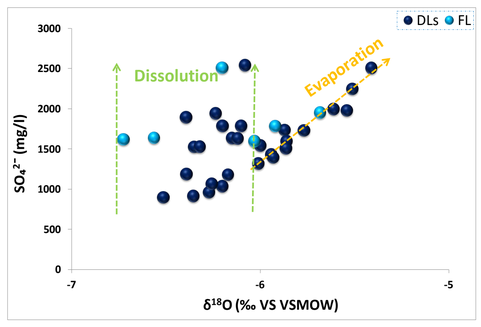

Figure 8: Correlation plot of gypsum and oxygen 18 of all the water samples

b. Tritium

✓Most of the analyzed samples have tritium content <0,5 TU.
✓Only 4 DLs samples have tritium content ≥1TU → they are **located in the potential recharge area** (**Fig.5 and 6).**
✓The scarcity of rain events and/or the isolation of the aquifer levels can be the cause of the low tritium content in the water samples.

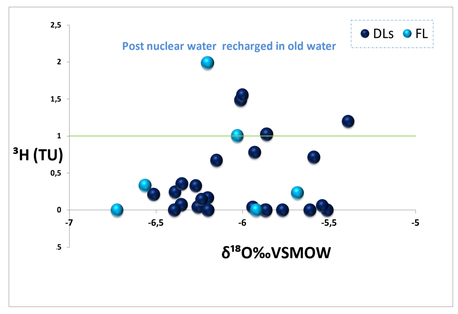

Figure 9: Tritium content Vs Oxygen-18 of all the water samples

IV-Conclusion

➢Salinity for all the aquifer levels is due to dissolution of halite, to a cation exchange phenomenon but mainly to the Gypsum dissolution and to the evaporation process.
➢The recharge area for the two deep aquifer levels is located in the NW of the basin.
➢Most of the water samples have been recharged under modern climate conditions.
➢The three aquifer levels are communicating and are deprived from the recent meteoric recharge: they are relatively old and non renewable.

V-References

[1] Hamouda, M. F. Ben, Tarhouni, J., Leduc, C., & Zouari, K. (2010). Understanding the origin of salinization of the Plio-quaternary eastern coastal aquifer of Cap Bon (Tunisia) using geochemical and isotope investigations. Environmental Earth Sciences, 63(5), 889–901. https://doi.org/10.1007/s12665-010-0758-1
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