EVALUATION OF GROUNDWATER QUALITY IN INTENSIVE IRRIGATED AREA: CENTRAL WEST TUNISIA

K. KHMILA[a], K. ZOUARI [a], R. TRABELSI [a]

[a] Laboratory of Radio-Analysis and Environment, National School of Engineering of Sfax, ENIS, Tunisia

CONTEXT

• Groundwater is one of the most important water resources in **Tunisia.** In many arid and semi-arid regions, water supplies for **domestic, irrigation and industry uses** primarily depend on existing groundwater resources.

• Moreover, groundwater potential is under serious treat, due to increasing population density, mechanized agricultural practices, rapid urbanization, as well as domestic and industrial usage.

• However, there has been limited attempt to study the water quality and mechanisms that contribute to groundwater mineralization in this context.

OBJECTIVE

The objective of this study is to integrate major ion geochemistry, stable and radioactive isotopes in order (i) to asses the **groundwater quality**, (ii) to identify the geochemical **processes** contributing to **water salinization** and (iii) to study the **aquifer recharge** for its proper management.

STUDY AREA

- Sidi Marzoug-Sbiba basin: Central West of Tunisia
- 35° 37′ - 35° 16′ N ; 8° 41′ - 9° 21′ E.
- Area ∽ 1185 km²
- Climate: Aride to semi aride region
- Rainfall∽ 300 mm
- Main rivers: El Hatob, Sbiba, El Breck and Lamedje
- Geology: Quaternary, Miocene, Eocene, Cretaceous, Trias…

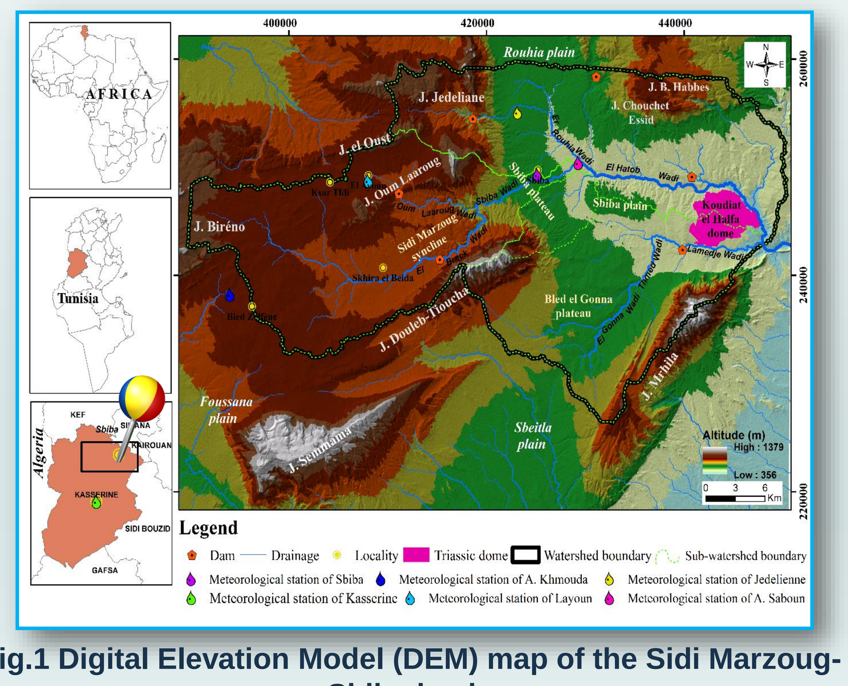


Fig.1 Digital Elevation Model (DEM) map of the Sidi Marzoug-Sbiba basin

SAMPLING

101 groundwater samples tapping public and private boreholes were investigated (Fig. 2):

44 from MPQ aquifer; 45 from Miocene and 12 Campano-Maastrichtian aquifer

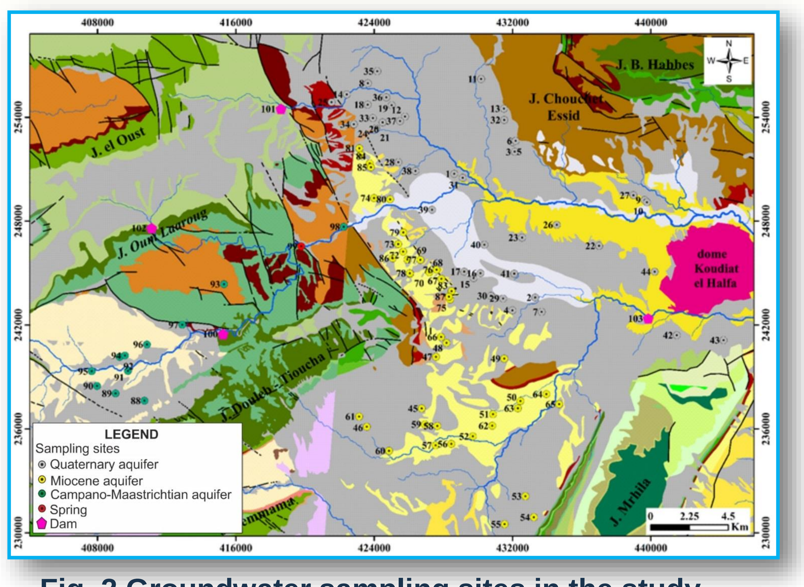
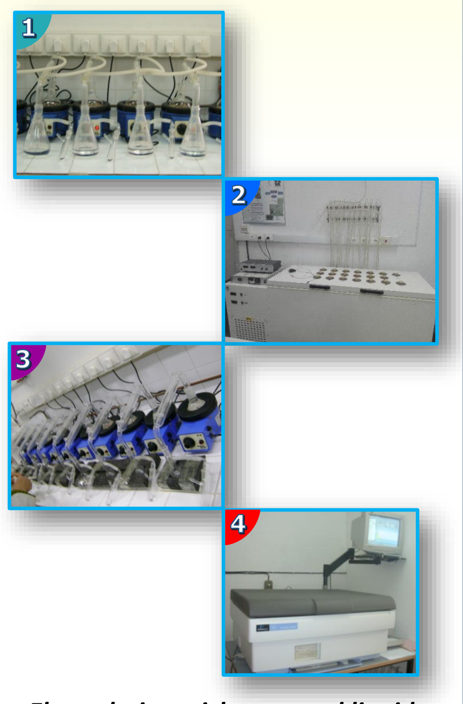


Fig. 2 Groundwater sampling sites in the study area

METHODS

Liquid-ion chromatography (HPLC): Cations and anions

Laser spectrometry, LGR-ABB (LWIA-45-EP): $^{18}O/^{16}O$ and $^{2}H/^{1}H$



Electrolytic enrichment and liquid scintillation counter: Tritium (^{3}H)

RESULTS AND DISCUSSION

1. Chemical investigation

1.1. Spatial distribution of total mineralization

TDS values range from **390** mg/L to **5525** mg/L.

➢**high salinity values** are measured in the MPQ aquifer especially near Triassic and/or Eocene outcrops respectively of Kodiat el Halfa dome, Jedeliane and Chouchet Essid mountains.

➢**Low values** are observed in the Miocene and Campano-Maastrichtian aquifers.

➢ This preliminary evaluation of groundwater chemistry may reflect that the **rainfall infiltration** through **wadis** and **faults** affecting the outcrop parts of these two aquifer has reduced the groundwater salinity.

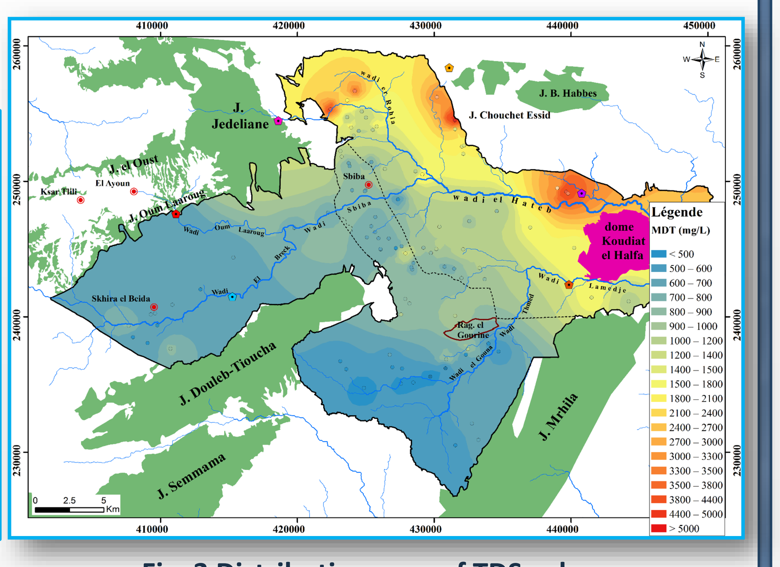


Fig. 3 Distribution map of TDS values

1.2. Hydrochemical facies

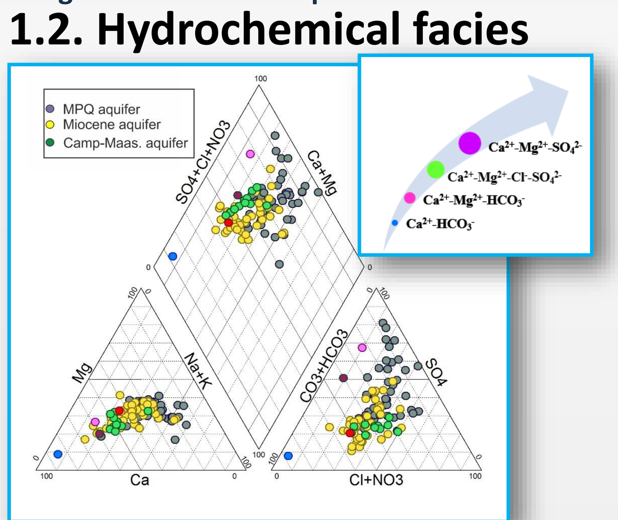


Fig. 4 Piper diagram

1.3. Mechanisms controlling groundwater chemistry

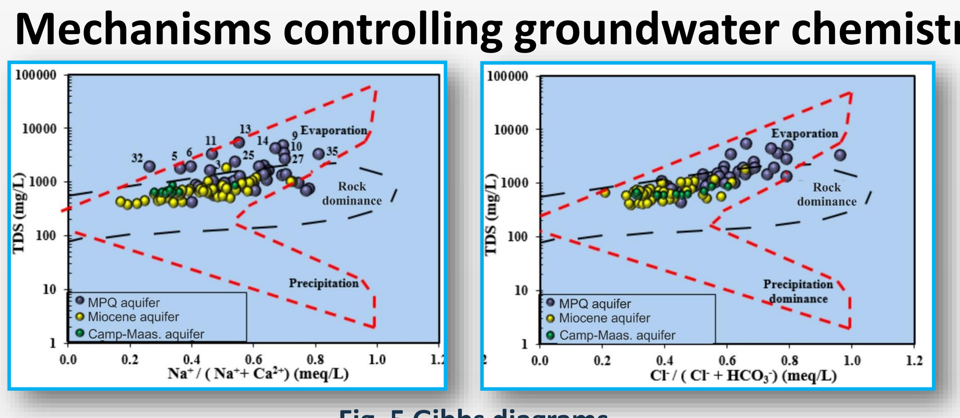


Fig. 5 Gibbs diagrams

The Gibbs diagrams show that the geochemical evolution of groundwater is controlled by two factors such as water-rock interactions and evaporation.

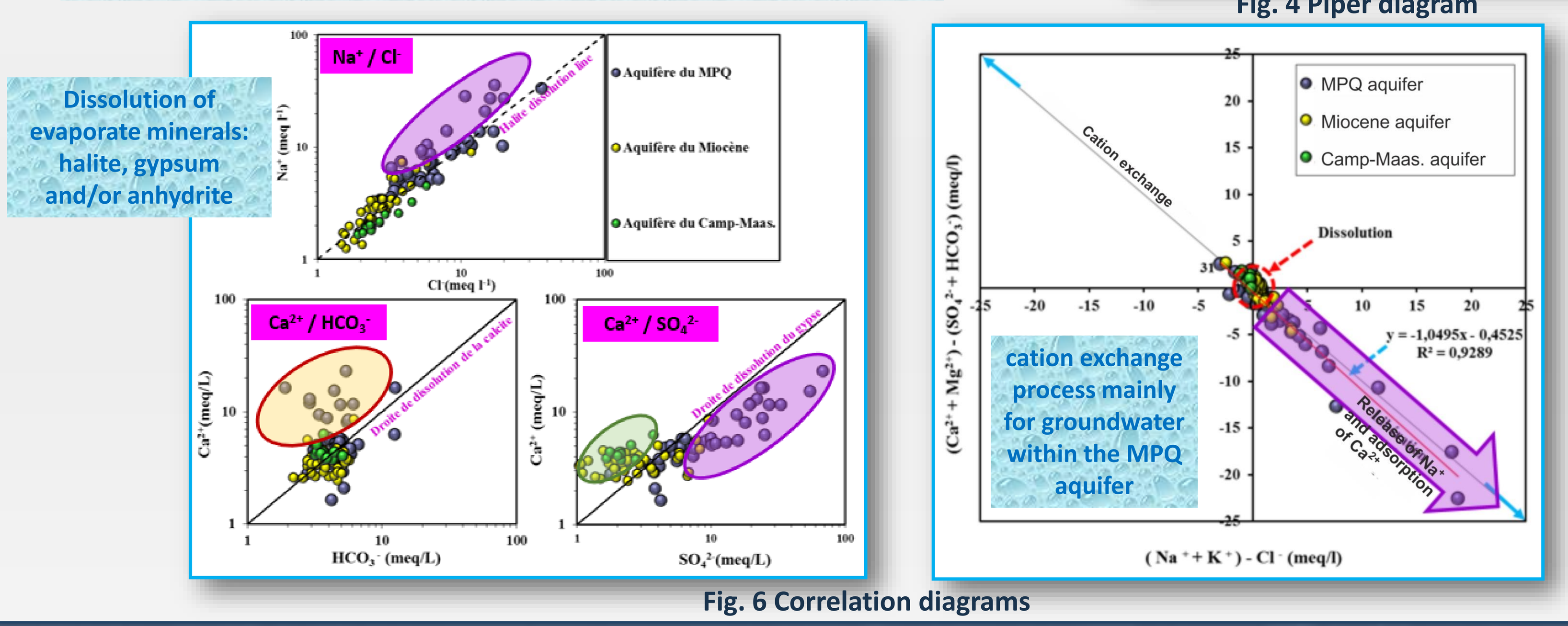


Fig. 6 Correlation diagrams

2. Assessment of groundwater quality

2.1. Water quality for drinking purposes

38 < WQI < 356

According to the Water Quality Index (**WQI**), the majority of groundwater in the Sidi Marzoug Sbiba basin is suitable for drinking purpose.

77 % of water samples represent WQI values < 100, reflecting "excellent" and "good" water types.

23 % of water samples with high salinity and WQI values >100, are "poor" to "bad" quality.

2.2. Water quality for irrigation purposes

Water samples from boreholes tapping the MPQ aquifer in the NE part of the basin are unsuitable for drinking and irrigation uses.

The deterioration of groundwater quality in this area is linked both to natural processes causing high salinity and to high nitrate concentration > 50 mg/L.

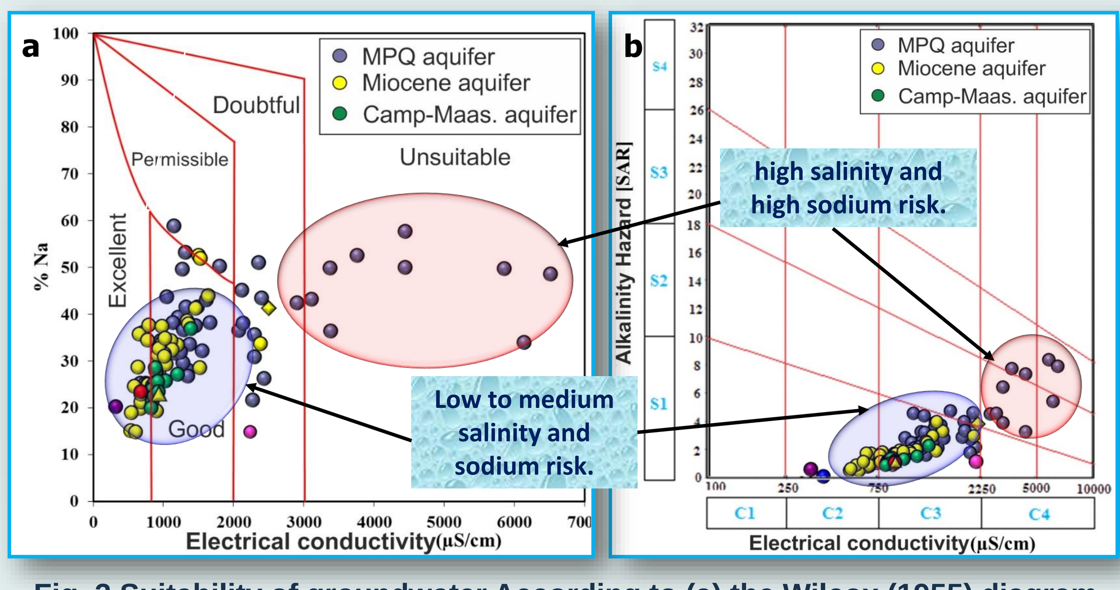


Fig. 3 Suitability of groundwater According to (a) the Wilcox (1955) diagram and (b) USSL classification (1954).

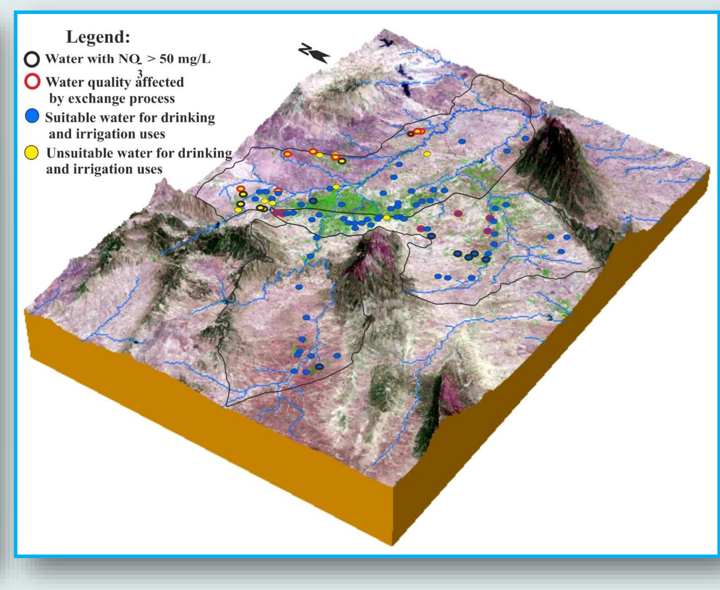


Fig. 4 Schematic diagram for groundwater quality

3. Isotopic investigation

3.1. Origin of groundwater

The majority of groundwater close to the global meteoric water line and to the local rain (-6,5 ‰ VSMOW) showing that groundwater is recharged by rainwater without evaporation effect.

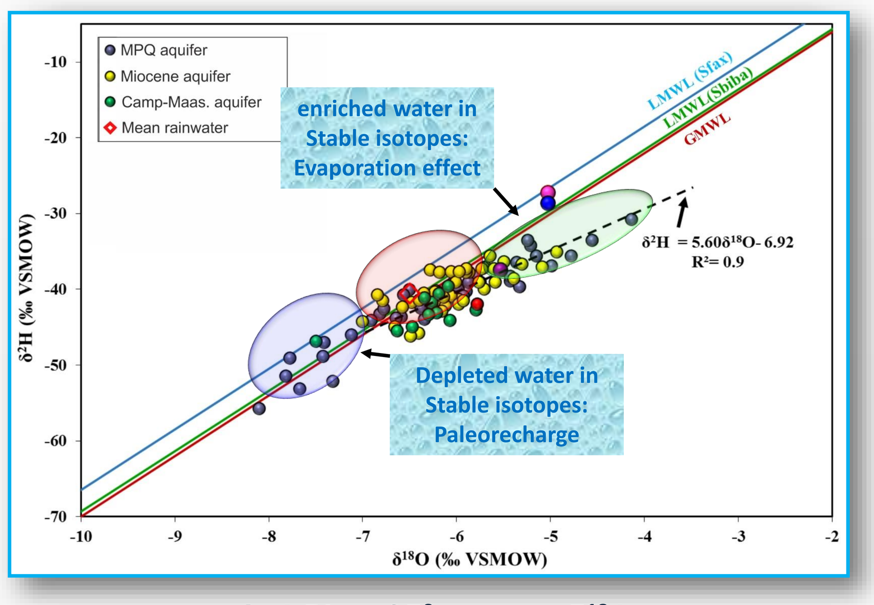


Fig.8 Plot of δ²H versus δ¹⁸O

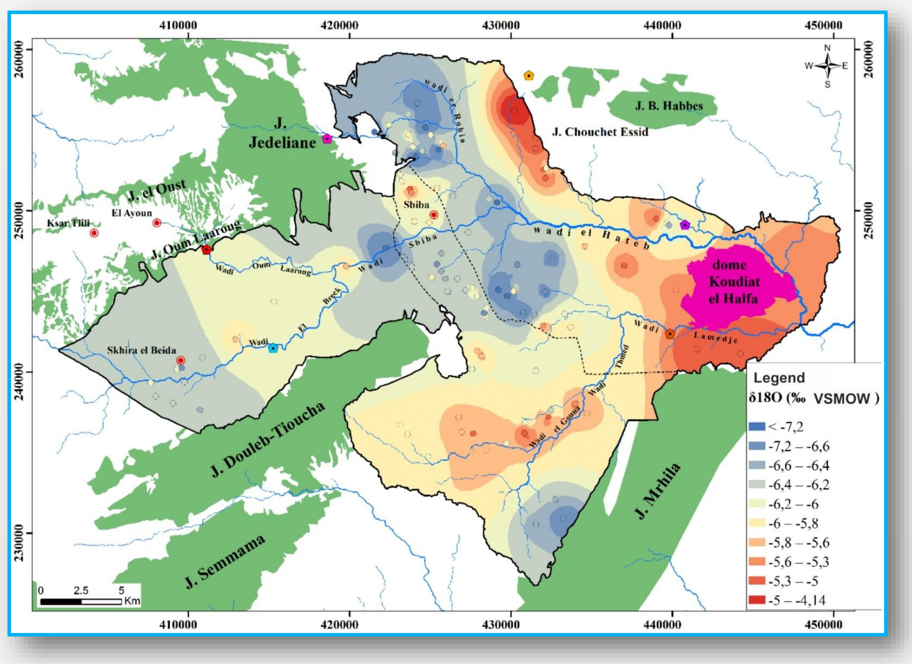


Fig.10 Spatial distribution of δ¹⁸O in the Sidi Marzoug-Sbiba basin

3.2. Anthropogenic inputs

High nitrate concentration (NO_3^- >50 mg/L) indicates polluted groundwater by anthropogenic point sources. This significant concentration of nitrate is a result of agricultural practices in the study area.

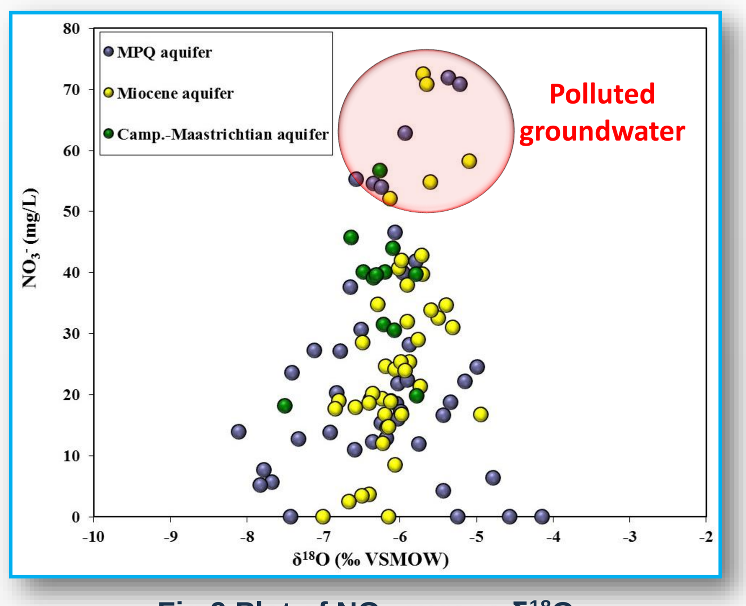


Fig.9 Plot of NO_3^- versus δ¹⁸O

Groundwater with enriched contents, related to the **evaporation process,** is essentially affecting the MPQ groundwater and some Miocene groundwater respectively in the NE and South of the Sidi Marzoug-Sbiba basin.

Groundwater with depleted contents in the Central part of the basin may be explained as direct and rapid recharge of the aquifer with depleted rainwater and/or mixing process with old water.

The Spatial distribution of ^{3}H contents and ^{14}C activities in Sidi Marzoug-Sbiba basin indicate a recent recharge by rainwater infiltrated directly through rivers and the outcrops of Cretaceous and Miocene.

Low **^{3}H contents and ^{14}C activities,** depleted isotopic compositions of some MPQ groundwater indicate probably a mixing between old and modern groundwater in the central part of the basin.

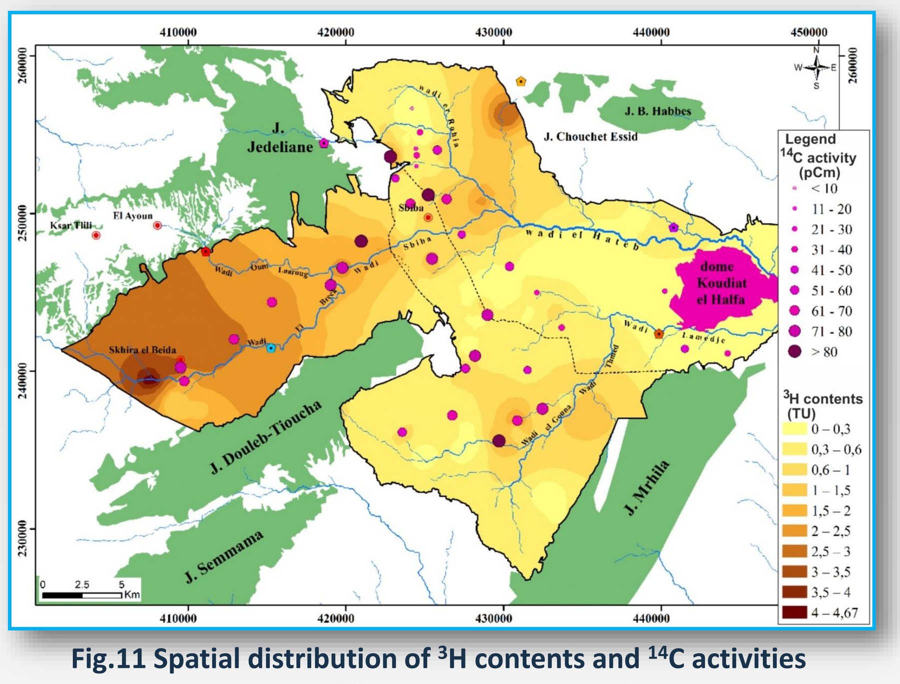


Fig.11 Spatial distribution of ^{3}H contents and ^{14}C activities in the Sidi Marzoug-Sbiba basin

CONCLUSION

- **Sidi Marzoug-Sbiba basin** is characterized by different groundwater bodies, the highest salinity is clearly observed in the Mio-Plio-Quaternary aquifer, whilst, the lowest salinity is observed in Miocene and Campano-Maastrichtian aquifers which are closely connected with streams originating in the high Mountains.
- **Three major processes control the chemical composition**: i) dissolution of evaporate minerals, ii) cation exchange reactions and iii) evaporation process.
- **Stable isotopes** indicate that most groundwater samples originate from infiltration of modern precipitation. A significant infiltration before evaporation takes place, indicating a major recharge directly from Cretaceous and Miocene formations outcropping in the center of Sidi Marzoug-Sbiba basin and in surrounding mountains and infiltration of surface water through rivers.
- **The isotopic signature and Tritium** contents in MPQ aquifer clearly indicate a recent recharge by evaporated precipitation in some areas (northeastern part), additionally to recharge by depleted precipitation from the El Hateb and Sbiba rivers.
- The identification of groundwater recharge zones and more specifically nitrate vulnerable zones represents a reliable cost-effective tool for groundwater management. In this context, the assessment of groundwater vulnerability to pollution caused by nitrates from agricultural sources raises awareness regarding the protection and conservation of critical recharge zones in order to find solutions for nitrate problems and to prevent such pollution in the future.

REFERENCES

K. Khmila, et al. "Application of geochemical and isotopic tracers for the evaluation of groundwater quality in the irrigated area of the Sbiba plain (Central West Tunisia) (2020).

https://doi.org/10.1016/j.agee.2021.107298

INTERNATIONAL CONFERENCE GROUNDWATER, KEY TO THE SUSTAINABLE DEVELOPMENT GOALS
PARIS - May 18 -20, 2022