Isotopic approach for a new insight on groundwater conditions in the Lake Chad basin region: Management strategies of a vulnerable transboundary resource

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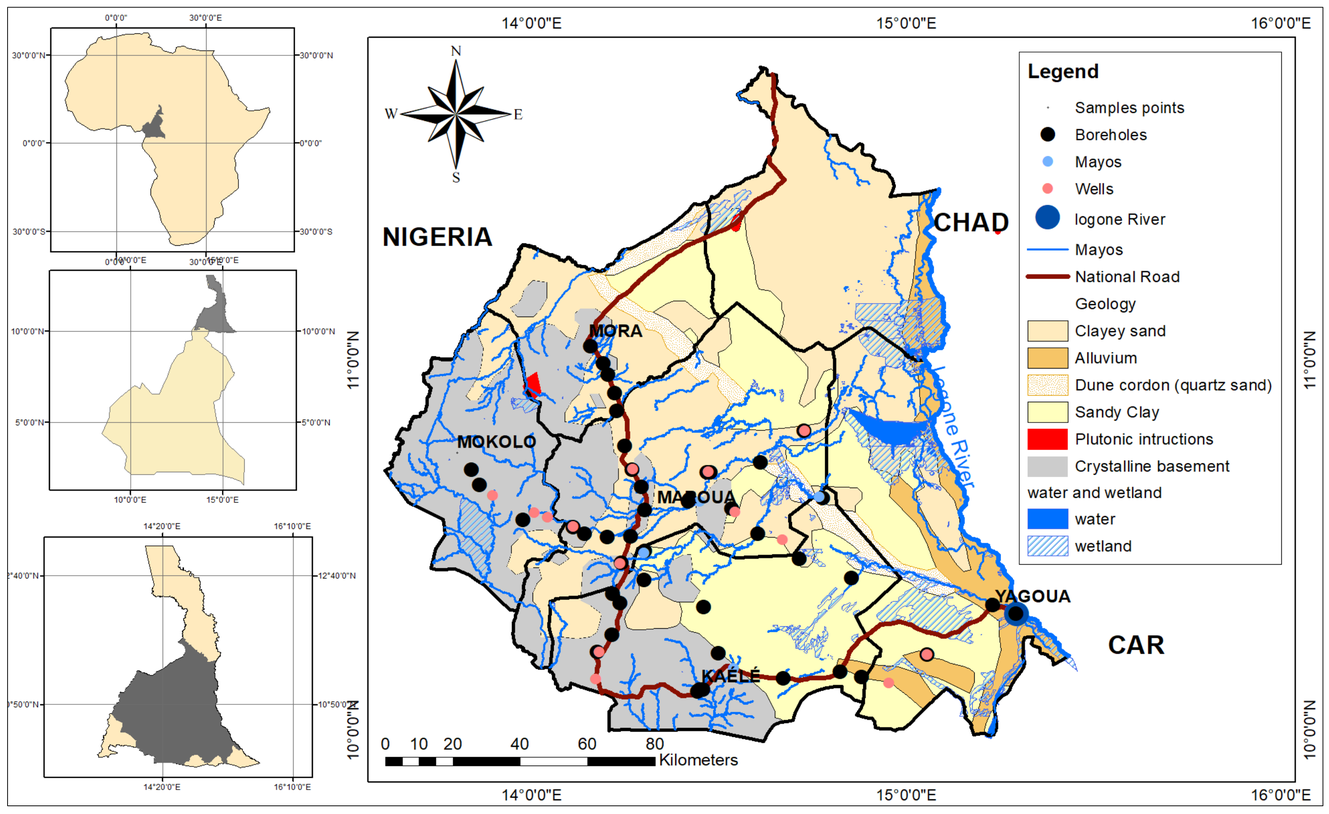
INTRODUCTION

The **Lake Chad Basin** is located in the eastern part of the **Sahelian region** and covers about 8% of the African continent, or about 2,381,000 km². It is one of the largest sedimentary basins with an estimated population of 47 million. In addition, this regional basin is also an important water **resource reservoir shared by several countries**, including Cameroon (Far North of Cameroon). However, the combined effects of climate change, population growth, reduced and irregular rainfall have contributed to a **reduction in the availability of water resources**, which is now causing numerous **conflicts between the different users, but is also contributing to the degradation of its qualitative potential**. Thus, facing with these qualitative and quantitative challenges, it is essential to **manage this resource** in order to promote the sustainability and socio-economic development of the populations. In addition, the objective of our study is to provide knowledge on the **functioning and qualitative potential of groundwater** in a context of global changes.

STUDY SITE

The study area is located in the southern part of the Lake Chad Basin in the Sudano-Sahelian climatic zone characterized by a long dry season from October to April, and a shorter rainy season from May to September. It covers an area of 3,4263 km² and is drained by numerous intermittent rivers called mayos and by the Logone River which acts as a natural border with Chad along the eastern margin.

The geology is formed in south-west by a fractured basement formation (1/3 of the area); whereas the northern and south-eastern part corresponds to the extension of the Lake Chad plain composed of Quaternary alluvium, corresponding to the main aquifer of the region. Groundwater is the main source of water supply for the population, with increasing demands in relation with the strong demographic growth and the development of irrigated agriculture.



Fig,1: Location, hydrography and simplified geological map of the study area

METHODOLOGY

A total of 63 points i.e.
35 samples in the Quaternary and 22 in the basement were sampled:

- 45 boreholes,
- 12 wells,
- 5 mayos
- 1 point in the Logone River,

The following stable and radioactive isotopes have been analyzed:

- $\delta^{18}O$ and $\delta^{2}H$,
- $\delta^{3}H$,
- $\delta^{14}C$,
- $\delta^{15}N$-NO3 and $\delta^{18}O$-NO3

	Number of samples	objective	LABORATORY
$\delta^{18}O$ et $\delta^{2}H$	63	Characterising recharge and water mixing processes	Laboratoire de Radio-Analyses et Environnement de Sfax (Tunisia)
^{3}H	42	Dating of recent water	Laboratoire de Radio Analyses et Environnement de Sfax (Tunisia)
^{14}C	05	Dating of old groundwater	Centrum voor isotopenonderzoek, Groningen University
$\delta^{15}N\text{-}NO_3$ $\delta^{18}O\text{-}NO_3$	20	Identifying the source of nitrates in groundwater	IAEA

***Table 1:** Isotopic tracers used*

RESULTS

1. Aquifer recharge

- Shallow aquifer is recharged on the one hand by recent rainfall and on the other hand by rapid infiltration without evaporation of the rain
- Interconnectivity within the aquifer is evidenced by **mixing processes** between old water and surface water with evaporative tendencies
- **The deep aquifer** is made up of the **most depleted** and **oldest waters** of our aquifer system

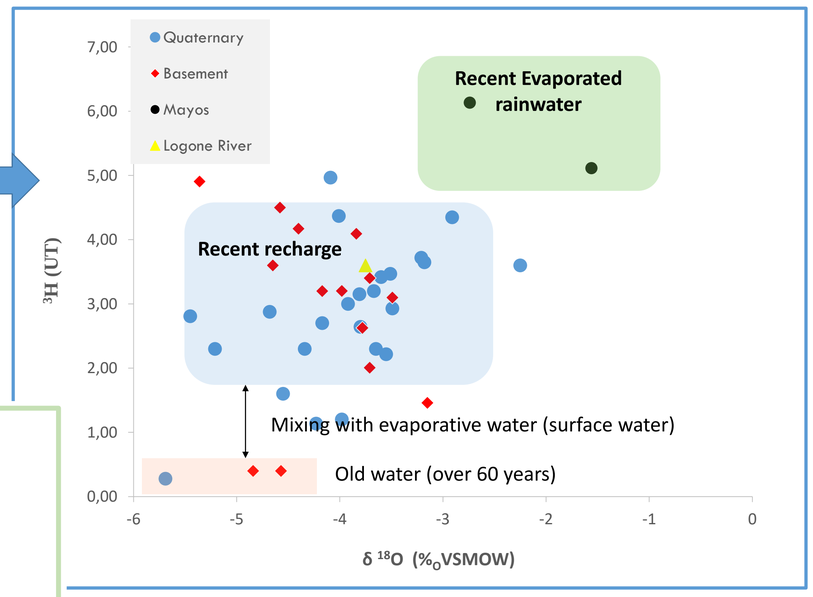


***Fig. 2**: ^{3}H vs $\delta^{18}O$ to highlight recharge processes*

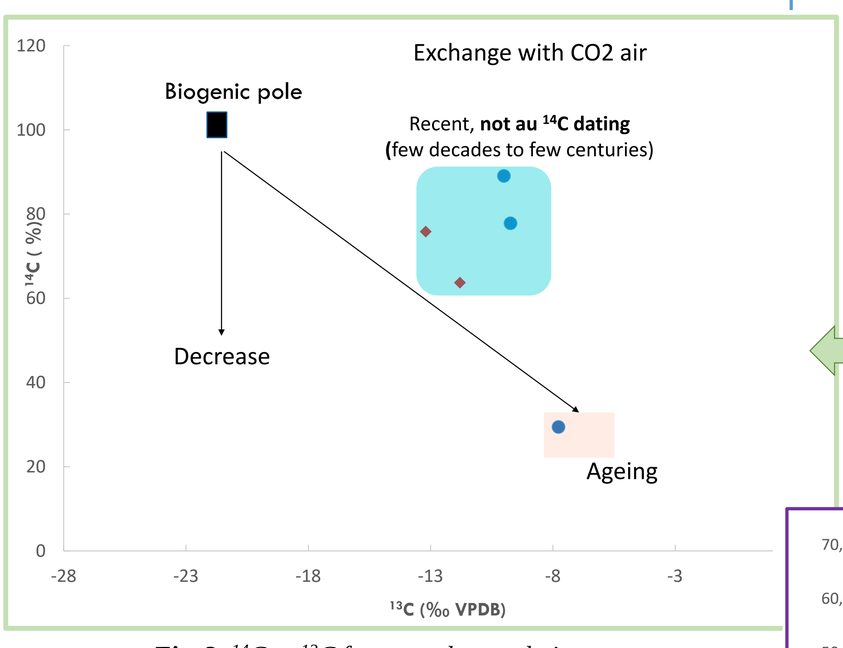


***Fig. 3**: ^{14}C vs ^{13}C for groundwater dating*

2. Ressource stratégique peu renouvelable

The **deep aquifer** is a **much older resource** (about 1500 years) revealed by the maturation effect in contact with the rock matrix (-7.7 ‰ of 13C) and the radioactive decrese (29.45% of 14C) of the resource following prolonged contact with the surrounding rock

3. Sources of nitrogen pollution

Some groundwater samples show significant changes in nitrate concentrations, highlighting a certain vulnerability of the aquifer to human activities.

Using **$\delta^{15}N\text{-}NO_3$** and **$\delta^{18}O\text{-}NO_3$**, two main sources of nitrate were identified:

(i) deposits of nitrogenous organic matter (animal excrement, manure, household waste);
(ii) nitrates synthesised naturally in the soil

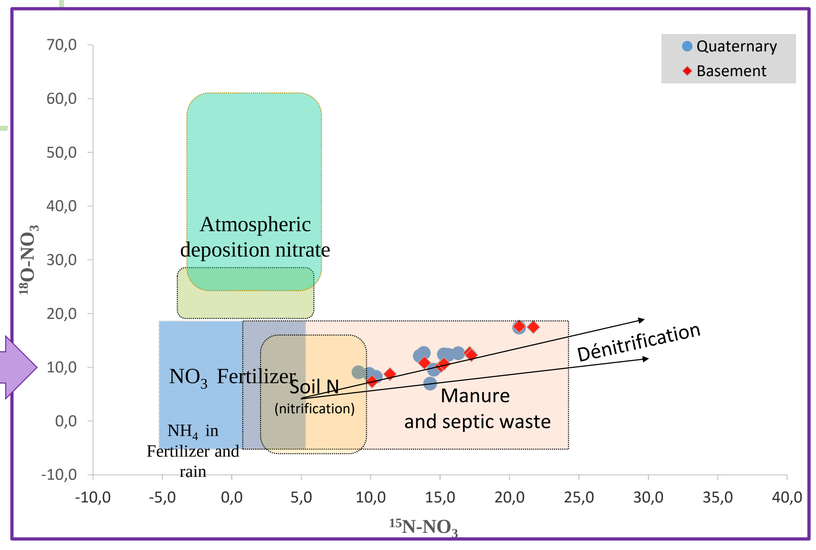


***Fig. 4:** $\delta^{18}O$-NO3 vs δ^{15}NO3 shows main sources of nitrogen pollution*

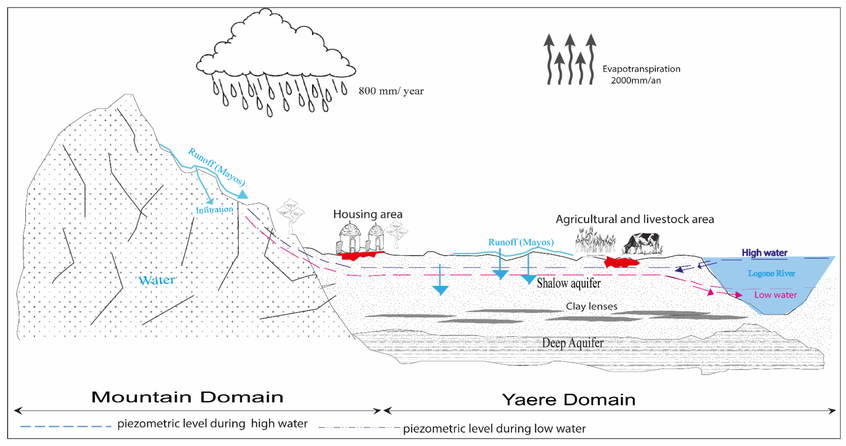


***Fig. 5**: Schematic functioning of the Quaternary aquifer*

CONCLUSION

The results of this approach show a multi-layer aquifer system consisting of a: (1) a surface aquifer recharged on the one hand by recent evaporated rainwater and on the other hand by rapid infiltration without evaporation of the rain and
(2) a deep aquifer which constitutes a strategic resource that is not very renewable and less vulnerable to global variations (climatic and human).

Pollution, which results in high nitrate concentrations (up to 1500 mg/l) recorded in the aquifer, is mainly linked to manure, household waste and septic waste in the vicinity of wells and boreholes and to very poor maintenance conditions around boreholes and wells.

This **new knowledge** will help providing **new regulation strategies** to **manage and protect** the groundwater resource. Among them, any activity that could contaminate groundwater **should be prohibited** or **controlled** in the immediate vicinity of boreholes and wells by setting up **protection perimeters** around water pumping points.