Combining hydrogeochemical and stable isotopes approach to investigate groundwater mineralization within the Volta River Basin in Benin (West Africa)

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1. Background of the study

Groundwater is the major source of water supply in many rural and urban areas located within the Volta river basin in Benin [1] (**Fig.1**). This river basin is located in the Sudano-Sahelian zone, which is characterized by a contrasting geomorphology of hill chains extending from the East to the Center, and a lowland in its western part. The mean annual rainfall and potential evapotranspiration is 1173 mm and 1494 mm, respectively [2].

In the West, the sedimentary sequences are monoclinic and comprise the sedimentary basin of Pendjari. They become gradually folded towards the East [3].

Four geological sub-units can be distinguished within the studied area, namely (from West to East): the Pendjari sedimentary basin, Buem, Atacora and the basement s.s. formation.

The northern area is occupied by the Pendjari National Park surrounded by rural areas where intensive population growth occurs .

A better assessment of groundwater resources in this area is a strategic point for the sustainable management of water resources as since the mid-twentieth century this area has experienced long-lasting droughts [4].

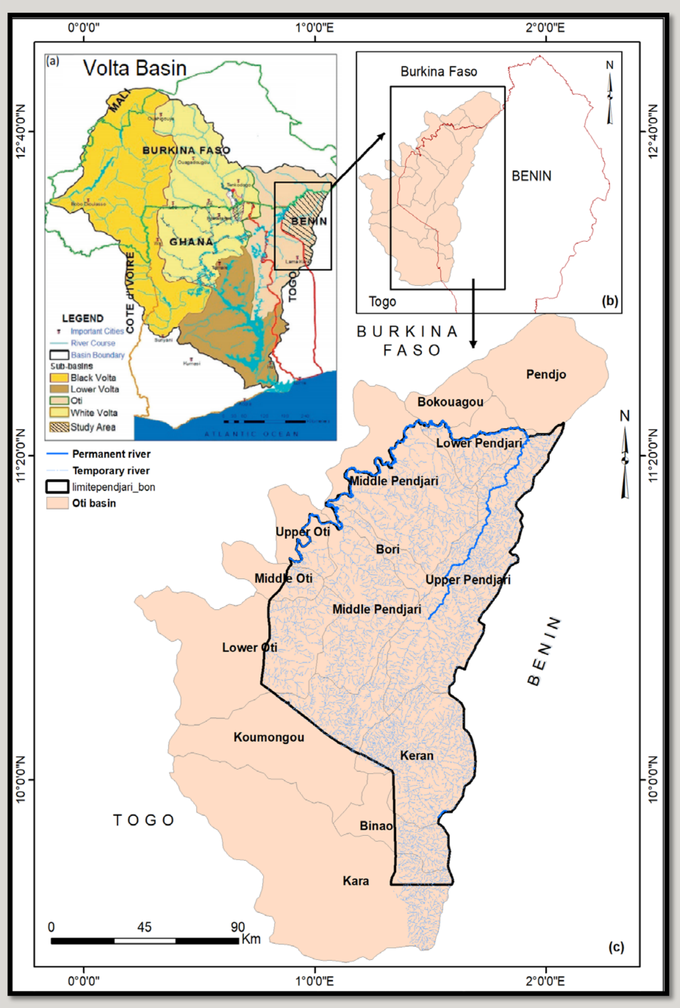

Fig.1 : Location of the studied area

OBJECTIVES

This study aims to obtain better insight into hydrogeochemical processes that control groundwater mineralization and its vulnerability.

2. METHODOLOGY

Around 90 water samples (from aquifers and surface water) were collected. In particular, 30 samples were collected during the February-March 2012 campaign and 63 samples during the October-November 2013 season. The samples were analyzed at the Radio-Analysis and Environment Laboratory of Sfax (Tunisia) for the range of parameters such as major ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-} , HCO_3^{-},NO_3^{-}) and stable isotopes (^{2}H and ^{18}O) using Liquid-Phase Chromatography and laser absorption spectrometer, respectively.

3. RESULTS

Hydrochemical investigations show that waters in this basin are of low to moderate mineralization where two main evolutions occur. Firstly, the evolution from Ca-HCO_3 to Na-K-HCO_3 indicates interaction between groundwater and clay minerals due to isomorphic substitutions and cation exchange processes and/or alteration of silicates [5].

Secondly, HCO_3 to Cl-NO_3 evolution shows the anthropogenic influence on groundwater due to intensive use of chemical fertilizers in agriculture (**Fig.2**).

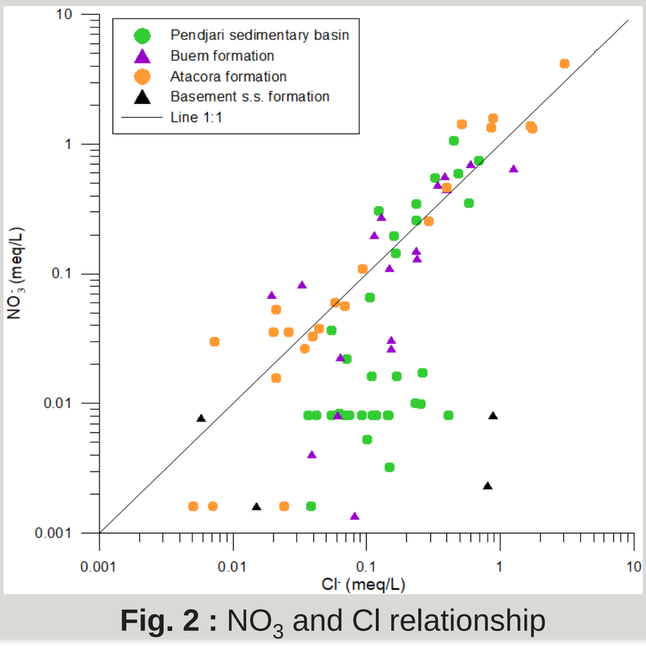

Fig. 2 : NO_3 and Cl relationship

Moreover, the isotope analyses revealed that the enrichment of stable isotopes in water was accompanied by high nitrate levels (**Fig. 3**) which sometimes exceeded 50 mg/L. The same tendency was observed within the boreholes of less than 40 m.

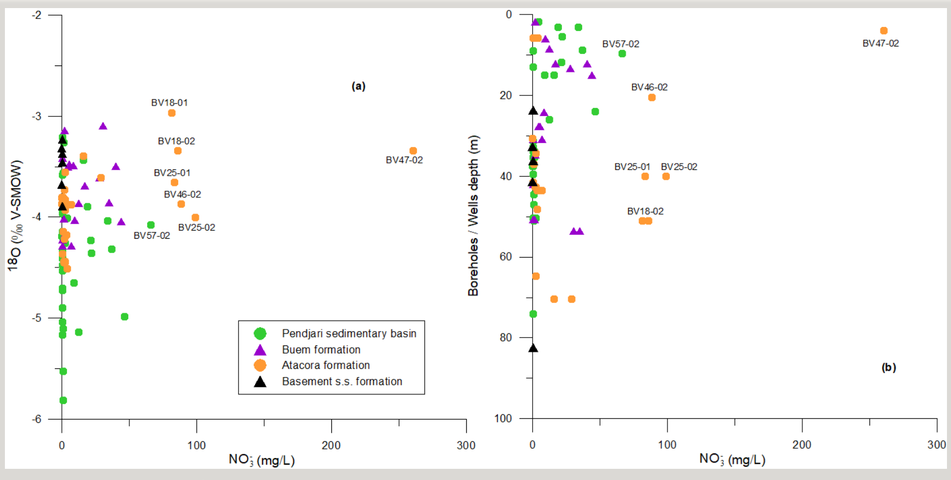

Fig. 3 : Relations $\delta^{18}O/NO_3^{-}$ **(a)** and depth/NO_3^{-} **(b)**

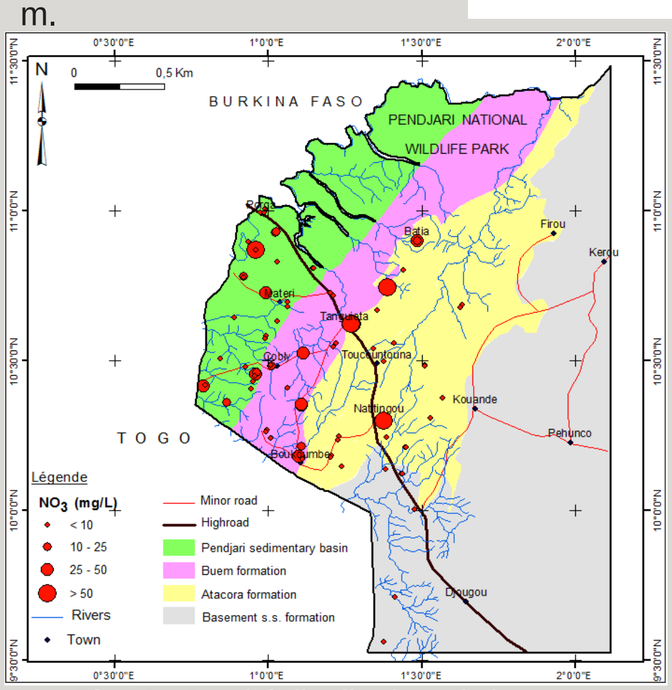

Fig. 4 : Spatial distribution of nitrates

The spatial distribution of nitrates (**Fig.4**) confirms that some towns, namely Nambouli, Natitingou, Tanguieta and Tchanwassaga are affected by pollution related to agricultural and even tourist activities.

4. CONCLUSIONS

1. In this basin groundwater is of low to moderate mineralization
2. Groundwater vulnerability study revealed that Nambouli, Natitingou, Tanguieta and Tchanwassaga towns are affected by agricultural and tourist activities.

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