Hydrogeochemical evolution and flow mechanisms of groundwater in Yaounde, Cameroon

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CONTEXT

• Groundwater is one of the most important water resources in Cameroon. In many rural and urban communities, water supplies for domestic, irrigation and industrial uses primarily depends 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.

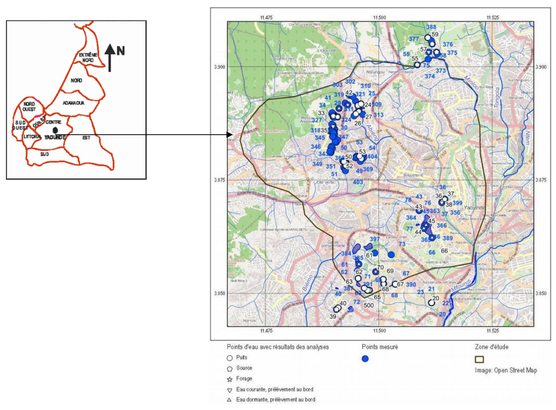
• However, there has been limited attempt to study the mechanisms that contribute to groundwater mineralization and flow mechanism in this context.

OBJECTIVE

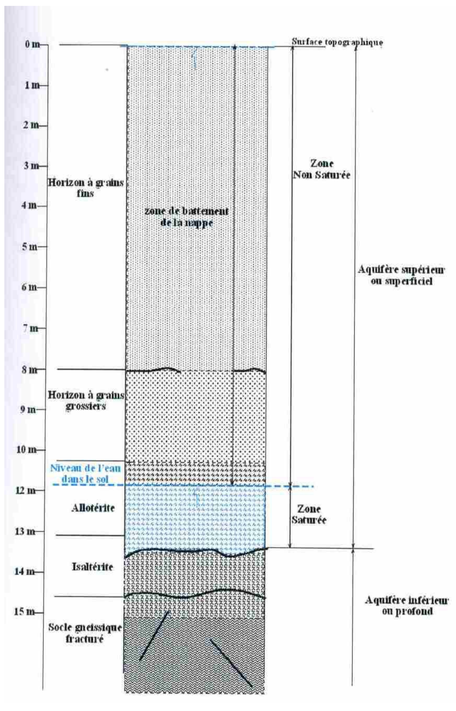
The objective of this study is to integrate major ion geochemistry, stable environmental isotopes and aquifer hydrodynamical properties in order to identify both the hydrogeochemical processes and flow mechanism of groundwater within the aquifer of the urban area of Yaounde.

METHOD

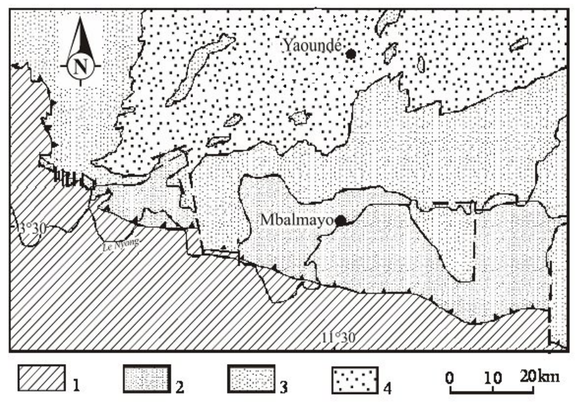
Study area



Yaounde: politic capital of Cameroon
- 250 km east of the Atlantic ocean
- 03°45' - 04°00' N; 11°20' - 11°40' E.
- Area ~ 300 km².
- Climate: equatorially humid with 4 seasons: 2 rainy seasons and 2 dry seasons.
- Rainfall: ~ 1600 mm
- Rivers: Mfoundi, Mefou, Mfoulou
- Soils: lateritic and hydromorphous
- Geology: granite, gneiss, schist…
- Population: ~ 2 million



Cross section of lateritic soil in Yaounde (Kalla, 2008)



Geological map of Yaounde. 1 = Congo Craton; 2 = Mbalmayo Group; 3 and 4 = Yaounde Group (micaschist with garnet and migmatitic gneiss respectively (Nzenti et al., 1988; Ngnotué et al., 2012)

Sampling

Forty-five (35) groundwater samples were investigated :
- 12 springs
- 19 wells
- 4 boreholes

Spring →

Well →

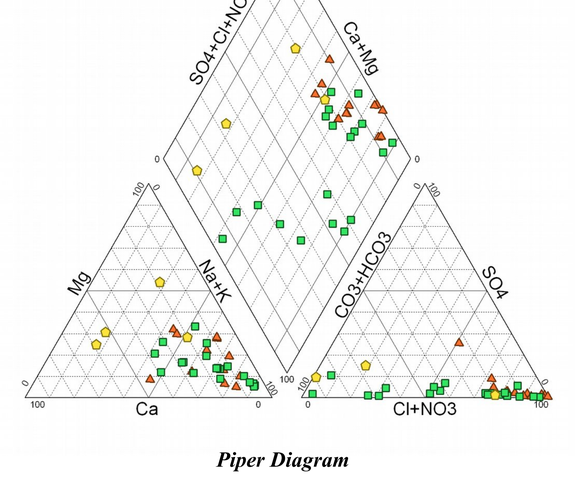
Borehole →

Chromatography: cations and anions

Laser spectrometer ^{18}O and ^{2}H

RESULT and DISCUSSION

1. Hydrochemical facies

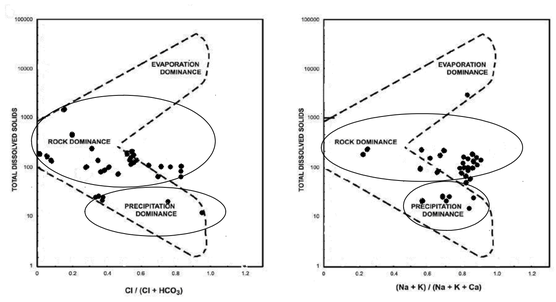


Piper Diagram

Na+K–Cl	66%
Ca/Mg–HCO3	14%
Ca/Mg–SO4/Cl	14%
Na+K–HCO3	6%

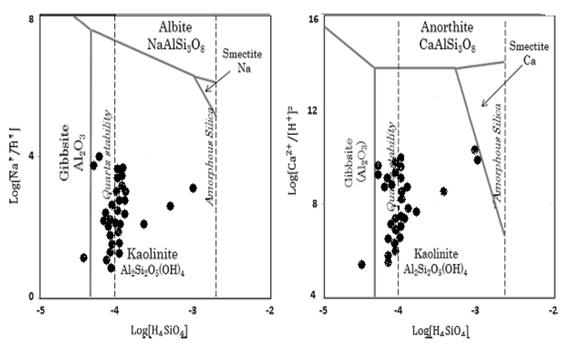
2. Mechanisms controlling groundwater chemistry

2.1. *Geochemical processes*



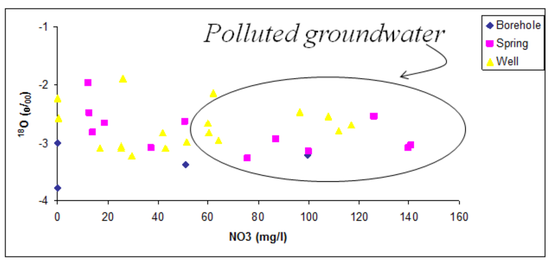
The Gibbs diagram shows that the geochemical evolution of groundwater is controlled by two factors such as water-rock interactions and precipitation.

- *Water-rock interaction processes*



Dissolved silica concentration appears to be controlled by the stable silicate mineral phases in the aquifers which are kaolinite, followed by quartz.

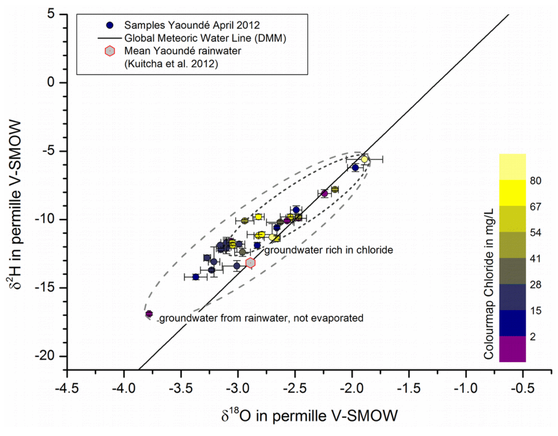
2.2. *Anthropogenic inputs*



Elevated concentration of nitrate (NO3) >50 mg/l indicate polluted groundwater by anthropogenic point sources. This significant concentration of nitrate is a result of the unconfined nature of the aquifer system.

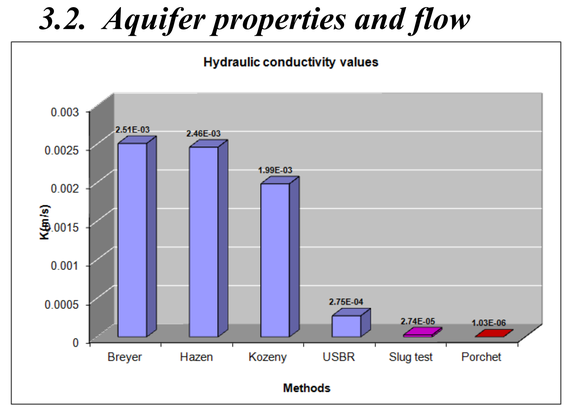
3. Origin of groundwater and flow mechanisms

3.1. Origin of groundwater

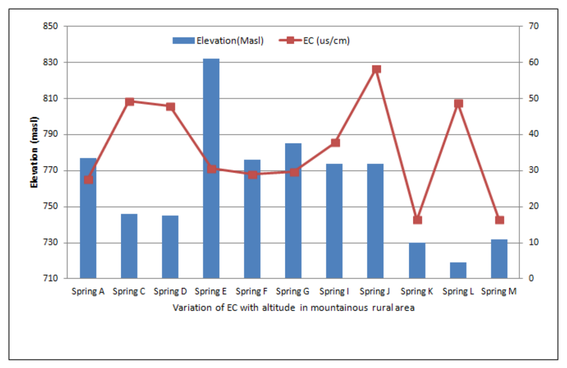


All groundwater is above the global meteoric water line. $\delta^{18}O$ of groundwater (-2.96 ‰) is close to the local rain (-2.47 ‰) showing that groundwater is recharged by rainwater without evaporation (Kuitcha *et al.*, 2013).

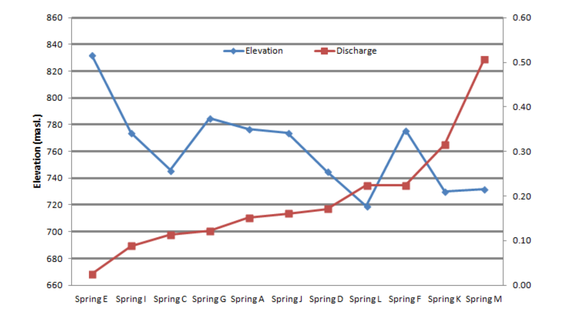
3.2. *Aquifer properties and flow*



Hydraulic conductivity (K) estimated from field slug tests indicates that results appear to be one order in magnitude higher (4.96×10^{-5} m/s) than estimates based on the Porchet test (1.16×10^{-6} m/s) (Fouépé *et al.*, 2012).



The correlation between electrical conductivity (EC) and altitude in mountainous rural area shows that EC increases with flow direction (Fantong *et al.*, 2013). This is not observed in urban area where mineralization can be high at any location in relation to sources.



Fantong *et al.*, (2013) found that the discharge of springs, which important waterpoints for the local population, increases with the size of the catchment areas

CONCLUSION

- The abundance of the major ions in groundwater is as follows: Na > Ca > K > Mg and NO3 > Cl > HCO3 > SO4.
- Groundwater chemistry is influenced by a) anthropogenic pollution (nitrate, chloride…) b) geochemical processes (water/rock interaction) are largely concealed by human input.
- Groundwater is recharged by rainwater without evaporation.
- The urban groundwater is young and twice annually recharged.

COOPERATION PARTNERS

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