Hydrodynamics and hydrogeochemistry of the coastal sedimentary basin of Douala/Cameroon

by

Dr Huguette C. EMVOUTOU

University of Douala/Cameroon – UCAD of Dakar/Senegal

huguetteemvoutou@yahoo.fr

Introduction:
Presentation of the study area

Figure 1: Presentation of the study area

Gulf of Guinea, Central Africa
DCSB, 7,000km^2
Lithostratigraphy Albian-Aptian to Quaternary

Tropical humid climate
4m/year of rainfall
T°m: 27°C
Relative humidity: > 85%

Douala city
Economic capital
Strategic town
Densely populated
2.8 Millions inhabitants (2015)
Density of 3,000 inhbts/km^2

Introduction:
Context & Problematic

In one hand:

Old water network distribution:
High demand
Increasing boreholes drilling

All hydraulic boreholes by now
MDGs & SDGs
Uncontrolled exploitation

Unknown potential & functioning system

Pressures on water resources

Economical obstruction on the town & the whole region

In another hand:

Increasing industrialization and demography

Unhealthty environmental conditions with reccurence of water borne deaseses

Appropriate tools for policymakers for a controlled groundwater resources

New management approaches of groundwater resources

Introduction:
Objectives

Lead a hydrogeological study for the comprehension of the DCSB functioning for a better sustainable management of groundwater

OB1
- Update the hydrosystem relative to the geometrical configuration and hydrodynamic

OB2
- Identify and highligh geochemical processes and their spatio-temporal variation relative to hydrogeological conditions and hydrodynamic

OB3
- Stand out a conceptual system functioning of the system through the hydrogeochemistry (major ions and isotopes)

Methodology

ME1

- ***Geology and hydrogeology overview***
- **petroleum and**
- **hydraulic boreholes stragraphic data**

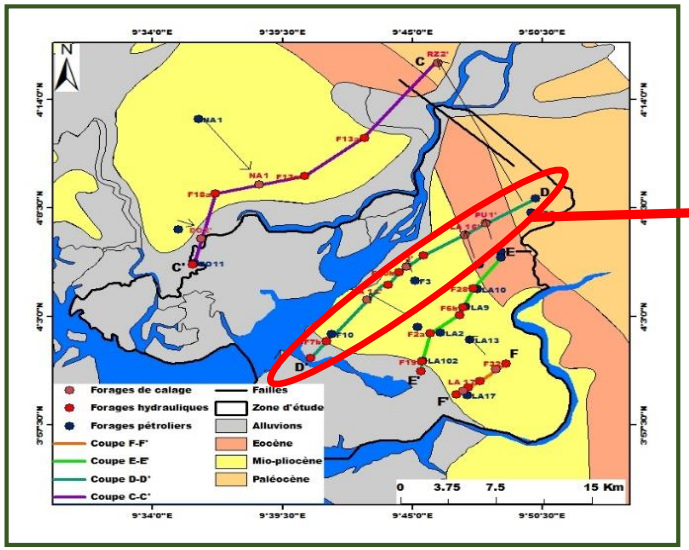
ME2

- ***Sampling strategy and analyses***
- **Sampling network: 4 streams, 13 springs, 40 dug-wells and 52 hydraulic boreholes (225 samples)**
- **Analyses: 130 analyszed samples for major ions and isotopes ($\delta^{2}H$, $\delta^{18}O$, ^{3}H, $\delta^{13}C$, ^{14}C)**

ME3

- ***Data treatment***
- **Classical hydrogeology tools (bivariate, Piper and Stiff diagrams)**
- **Geostatistical tools (HCA and FA)**

Results:
Geology & hydrogeology update



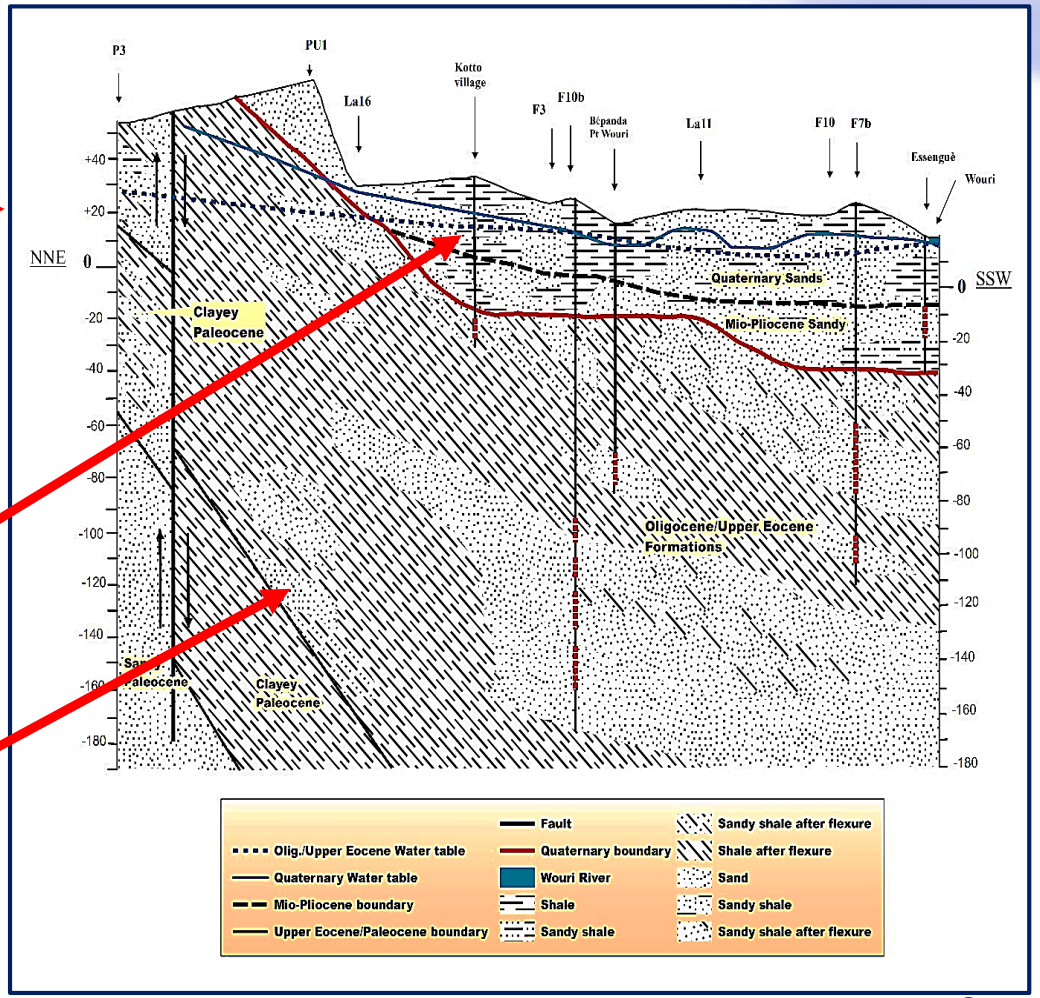


Figure 2 : Cross section D-D'

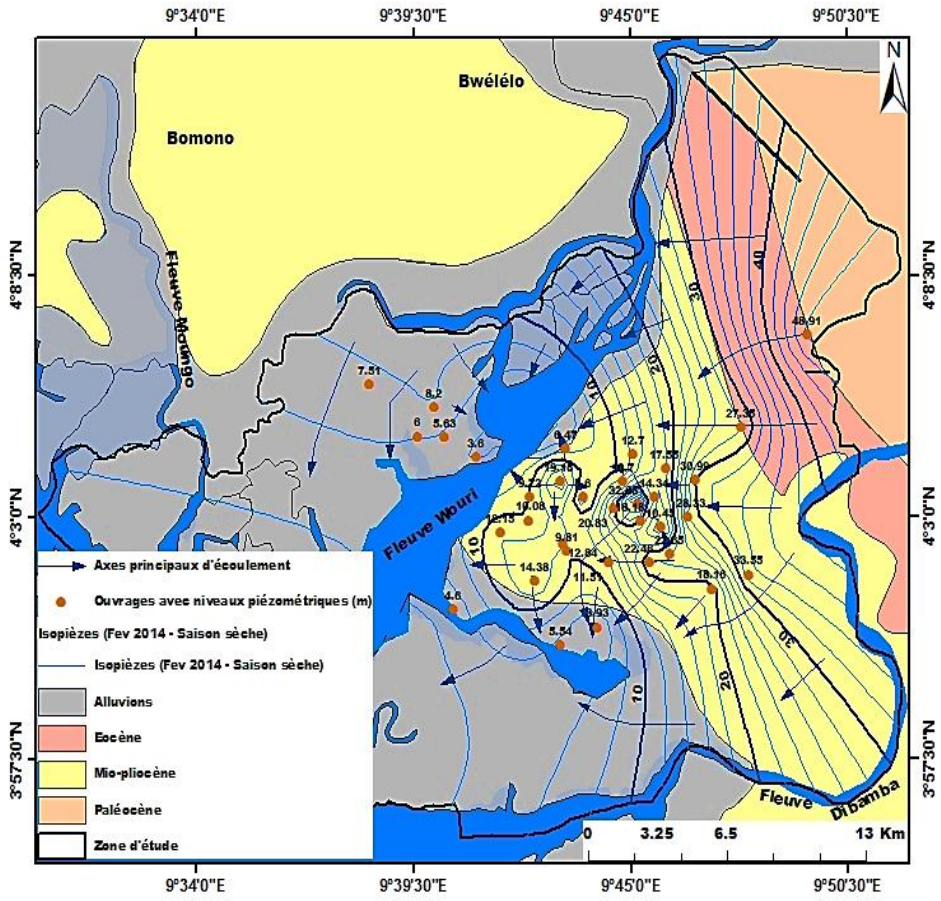
Mio-Pliocene/Quaternary Formations

- **Tabular deposits of shales, sands & gravels**
- **Numerous stratigraphical bevels**
- **Depth ≈ 70 m**
- **Lateral variations facies overlay on angular discordance ,**

Upper Eocene/Oligocene Formations

- Outcrops in the NE; fault and with a high dip
- Gully erosion, top of Eoc/Olig, sedimentation hiatus and tectonic phases
- Faulted and inclined structures towards atlantic ocean
- Depth of 270 m
- Inclined deposits of sands, marls/shales

Results:
Hydrodynamic characterization



Piezometry:

- Divergent radial aquifer where streams feed the Wouri River

Hydrodynamic parameters:

Aquifers		Q (m^3/h)	s (m)	SL (m)	PL (m)
MP / Q	Mean	12.93	4.77	11.76	9.52
Up Eoc / Olig	Mean	112.26	20.07	22.00	16.26

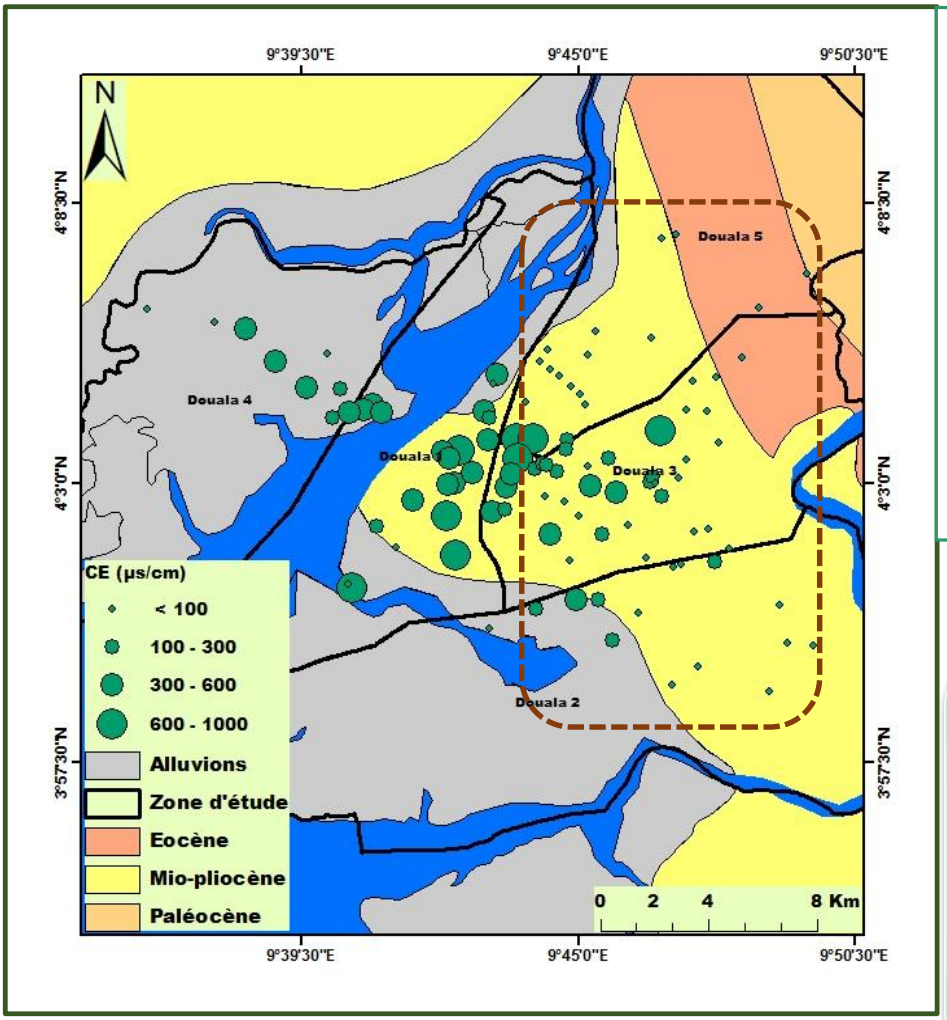
Rate of recharge:

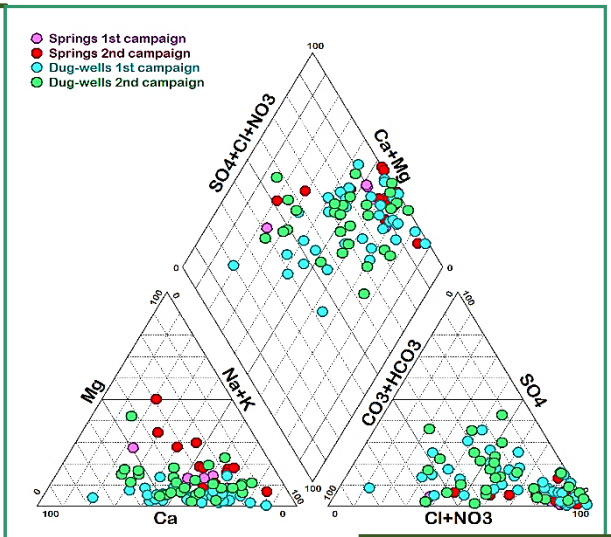
- Mean value of 71 mm/year (CMB & Thornthwaite methods)
- WIOA indicates high recharge areas in lower parts of the town & areas along the Wouri River

Figure 3 : Potentiometric map of the unconfined aquifer (February, 2014)

Results:

Hydrogeochemistry – Major ions





Unconfined aquifer

- No exceed ions except NO_3^-

- Water types:

Na-Cl, mixed-Cl, Ca-HCO_3 to mixed-HCO_3

Semi-confined & confined

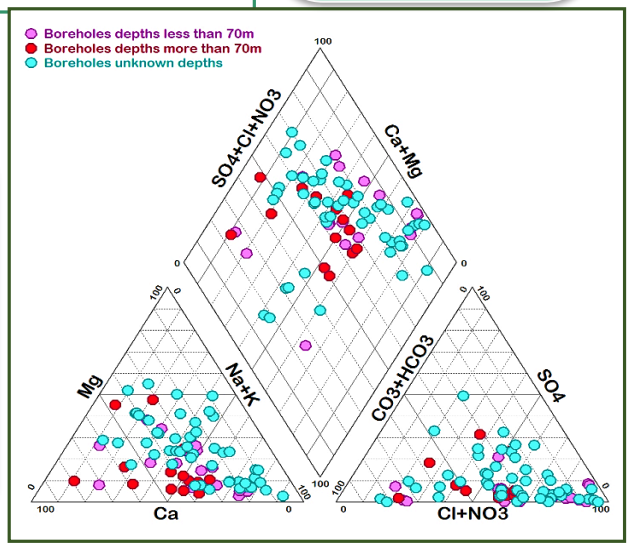
- No exceed ions

- Water types:

Na-Cl, Ca-Cl, Mg-Cl

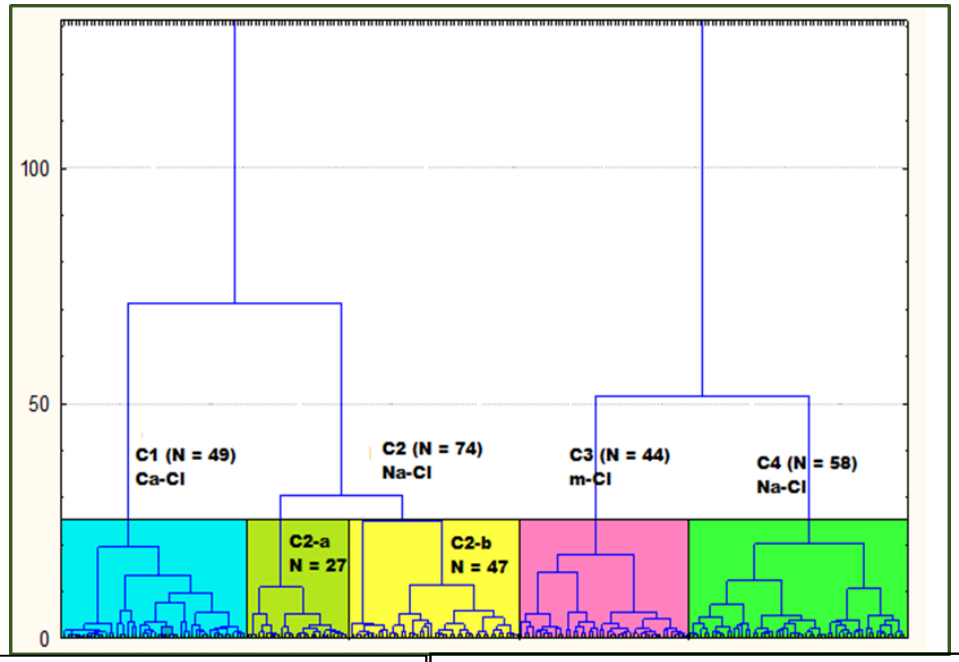
Na-HCO_3, Ca-HCO_3

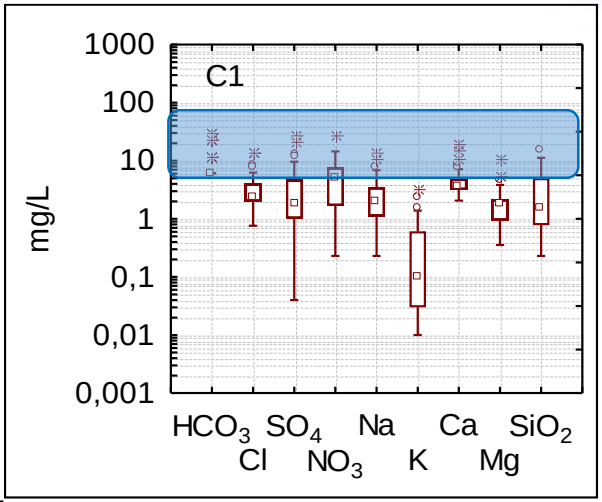
m-HCO_3, Na-m

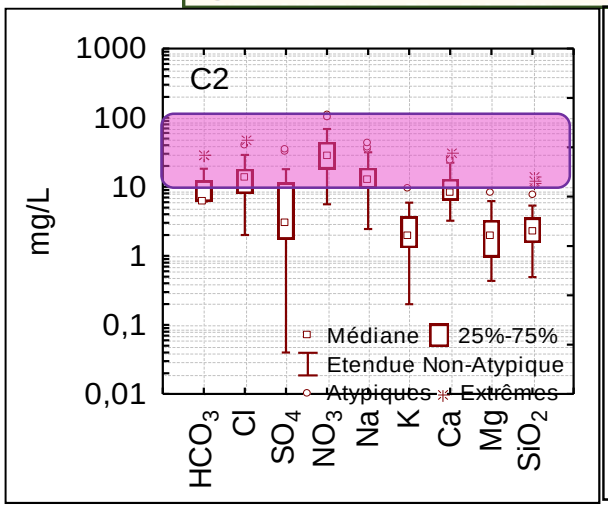


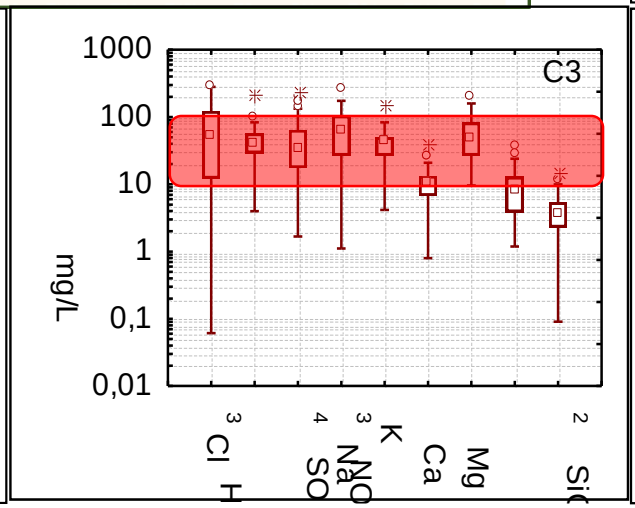
Results:

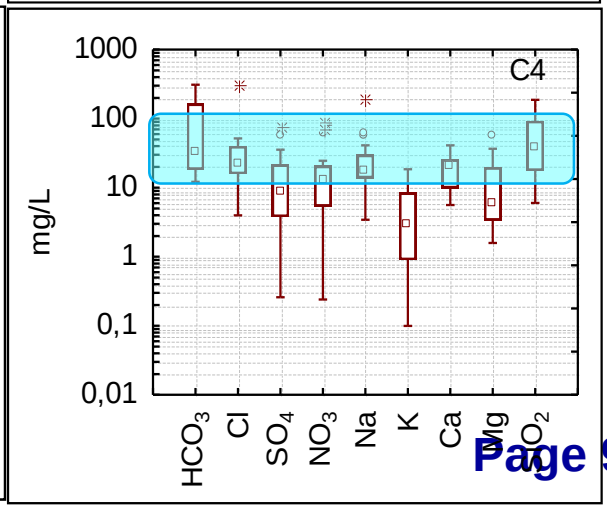
Hydrogeochemistry – Major ions









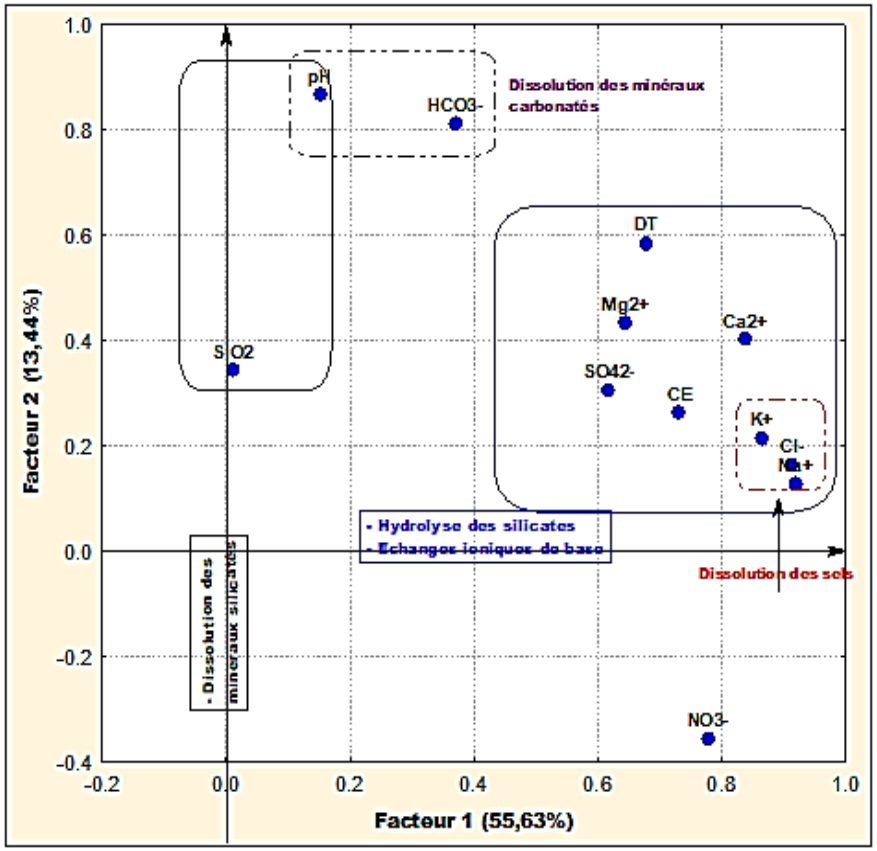


Results:
Hydrogeochemistry – Major ions

Table 1 : FA & explained variance (Rotation : varimax normalized)

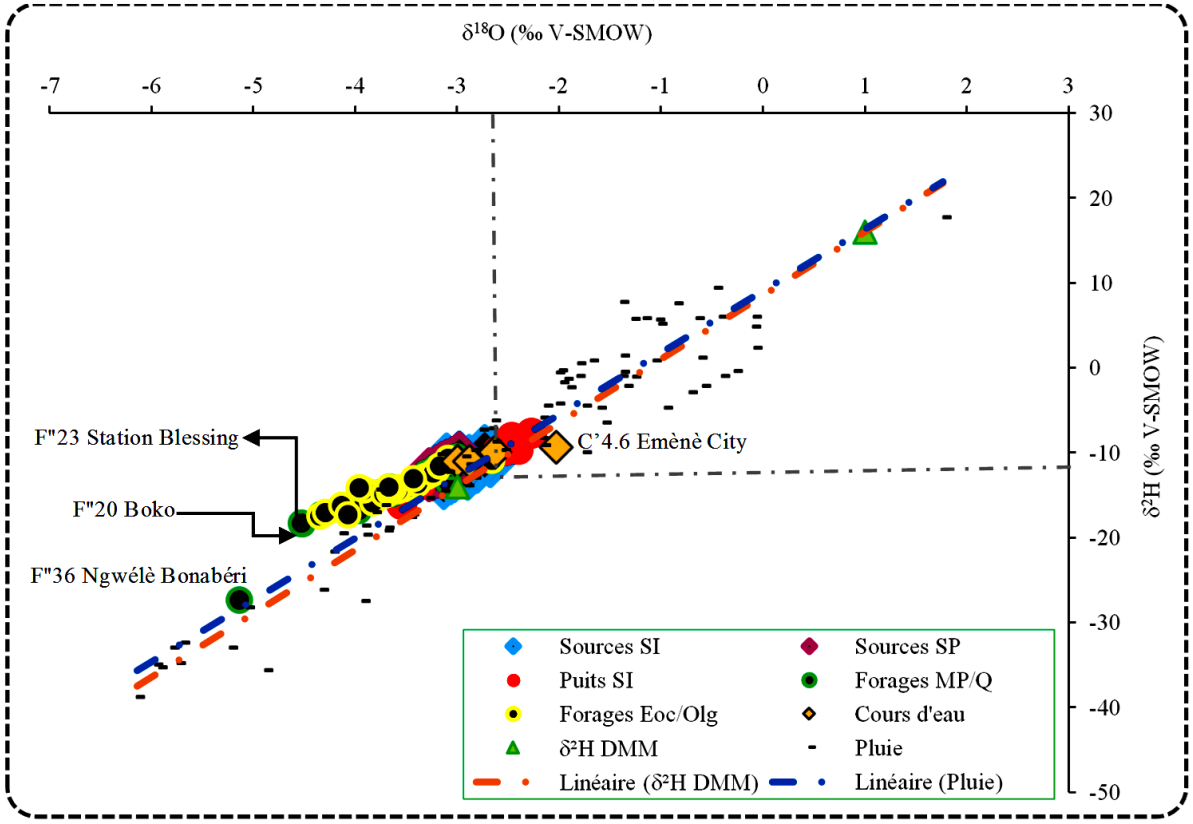
Paramètres	Facteur 1	Facteur 2	Facteur 3
DT	0,58	0,68	0,04
pH	0,03	*0,86*	0,17
CE	*0,70*	0,24	0,42
HCO_3^-	0,24	*0,89*	-0,003
Cl^-	*0,88*	0,29	-0,01
SO_4^{2-}	0,56	0,41	-0,04
NO_3^-	*0,82*	-0,24	-0,04
Na^+	*0,89*	0,25	0,02
K^+	*0,83*	0,30	0,11
Ca^{2+}	*0,76*	0,53	-0,02
Mg^{2+}	0,58	0,47	0,21
SiO_2	0,007	0,07	*0,95*
Variance Explicative	5,10	3,07	1,19
Variance Explicative (%)	55,63	13,44	9,02
Variance Explicative Cumulée	55,63	69,07	78,10

Poids dominants (>0,7) soulignés en rouge et en italic



Parameters vs factor 1 & factor 2 (Rotation : varimax normalisé)

Results:
Hydrogeochemistry – Isotope input



Surface water
- Evaporation, flowpath, NE-SW, estuary
- Enrichiment, fractionation processes.

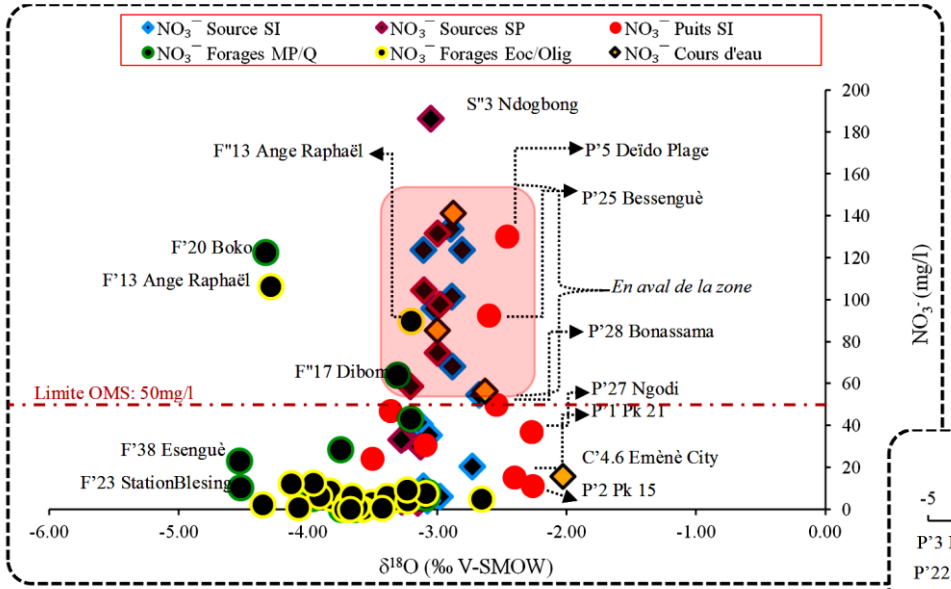
Shallow aquifer MP/Q
- Local evaporation processes
- Fractionation processes
- Direct infiltration

Semi-confined aquifer: MP/Q & Eoc/Olig
- Depleted water,
- Fractionation processes,
- Impact of proximity Wouri & Dibamba Rivers.

Confined aquifer: Upper Eoc/Olig
- More depleted water,
- Less evaporation,
- Recharge in NE parts,

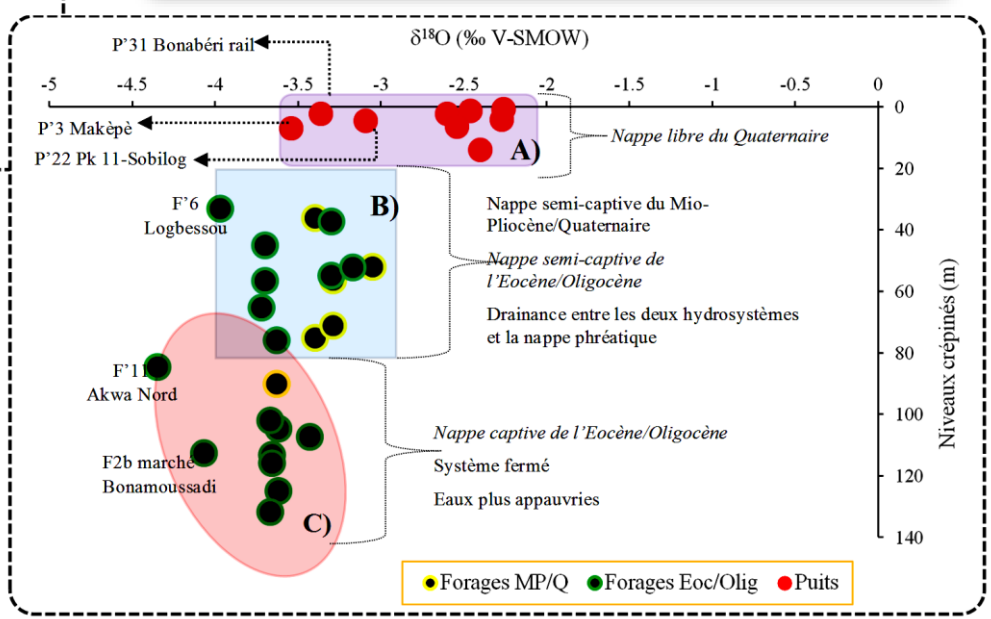
Plotted samples on the δ^2H vs $\delta^{18}O$ conventional diagram

Results:
Hydrogeochemistry – Isotope input



I) 18-Oxygene & anthropogenic effects (NO_3^-/Cl^-)

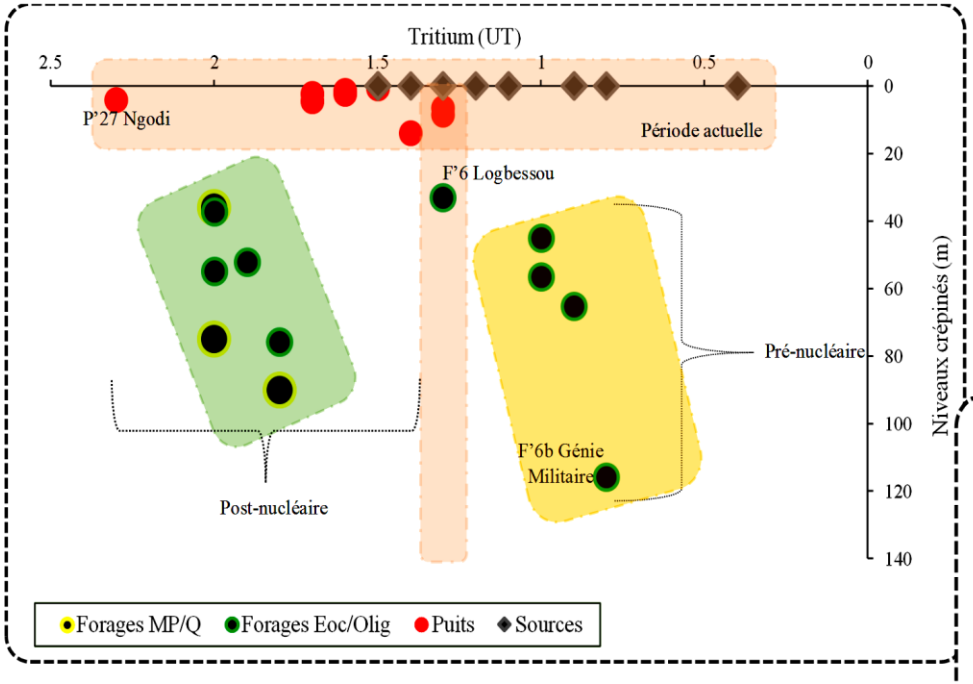
- Depleted or less values (NO_3^-/Cl^-) upstream
- Incresasing mineralization downstream
- Case of pollution due to leakage processes (MP sands and Oligocene sands)
- Confirmation of the semi-confined aquifer



II) 18-Oxygene et depth -II

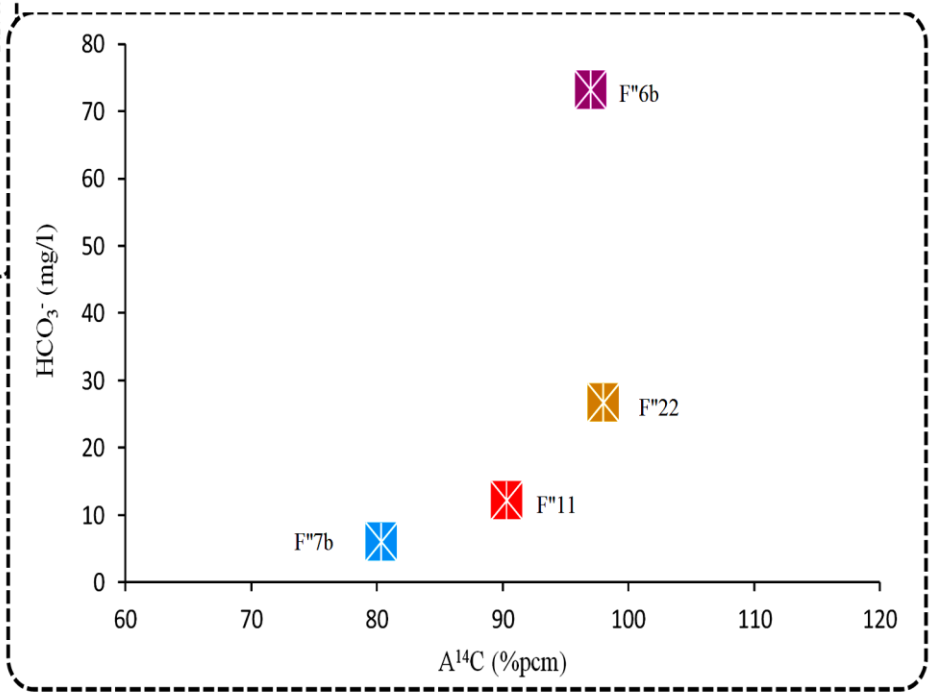
- 3 distingushed groups
- Degre of depletion is proportional to the depth
- Defining shallow, semi-confined & confined aquifers

Results:
Hydrogeochemistry – Isotope input



I) Tritium contents

- 1 TU < T < 2 TU
- 1,3 TU, estimated mean value
- Post nuclear, modern and recent groundwater
- Variation of tritium contents relative to the depth



II) Radiocarbon

- High $A^{14}C$ (F"6b), radiocarbon decay
- Dissolution of « death carbon" in in the system
- ^{13}C contents proof of absence of carbonates dissolution
- Less HCO_3^- contents, confined system
- F"6b, HCO_3^- communication with vadose zone, direct infiltration
- Hundreds (160 years) to thousands (1760 years)

Conclusion

- *two renewed aquifer systems (superficial and intermediate)*
- *receive direct infiltration of precipitation*
- *partially in hydraulic connexion*
- *vulnerable system especially the superficial system*
- *more analyses (trace elements, isotopes and major ions)*
- *more tools (geochemical, hydraulic and mathematical management models)*

Acknwoledgements

- *PACODEL, University of Liege/Belgium*
- *Wallonie-Bruxelles International*
- *Laboratories:*
- *FST, UCAD Dakar/Senegal*
- *Helmholtz Center, Munich/Germain*
- *Gliwice Radiocarbon, Krakow/Poland*

Thank you!