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University Cheikh Anta Diop Dakar

IDENTIFICATION OF GROUNDWATER NATURAL RECHARGE AREAS IN THE PRODUCTIVE THIAROYE URBAN AQUIFER (DAKAR, SENEGAL)

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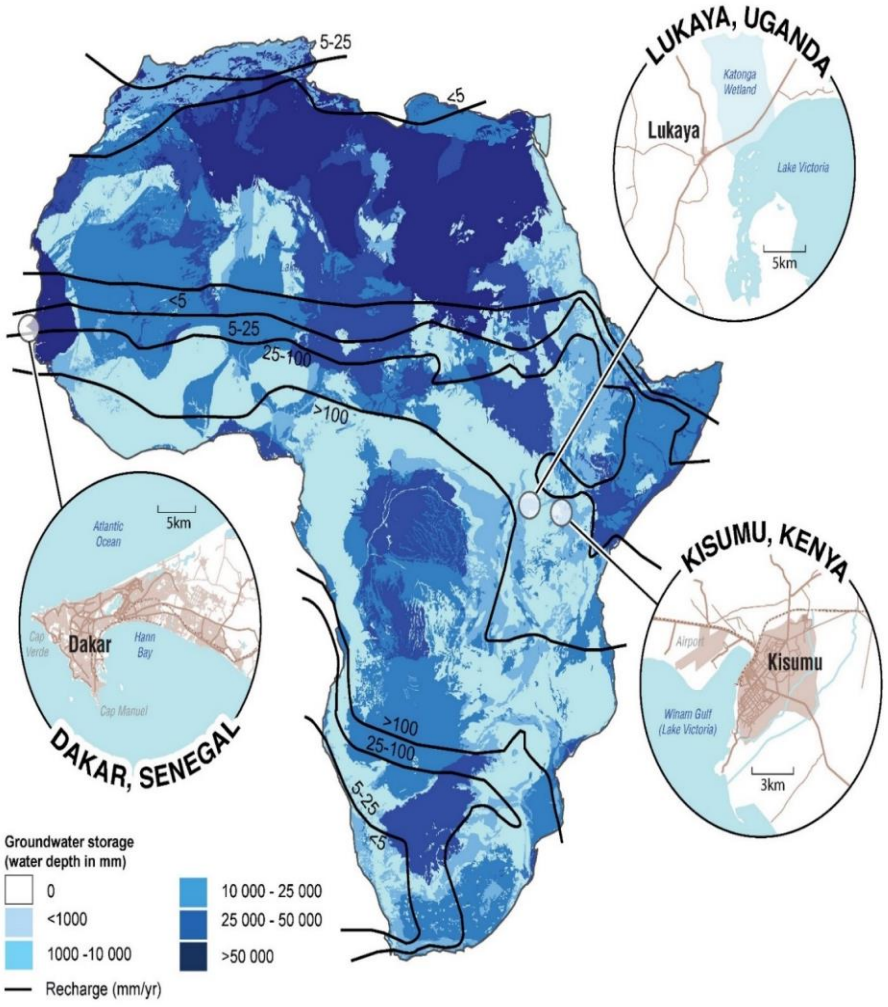
Abstract 1800

AfriWatSan Project



Contribution N° 16 – 6 of the AfriWatSan five years research project funded by the Royal Society and UK government (DFID) during period 2015 - 2020

"Sustainable low-cost, urban water supply and sanitation systems in Africa"

Consortium partners :

Université Cheikh Anta Diop, Dakar Senegal (UCAD)
Makere University, Uganda (MUK)
University of Nairobi, Kenya (UoN)
University College London (UCL)

Objective

Scientific evidence required to inform policies and practices that sustain the quantity and quality of urban low cost water supply and sanitation systems exploiting the sub-surface in Sub-Saharan Africa

Network of Urban Groundwater Observatories in Africa

Objective of this study and how it relates to the AfriWatsan research project

✓**Objective**: This contribution presents previous research applying hydrochemical and isotopes tracers to identify the origin and sources of the urban groundwater; the recharge zones in the Thiaroye aquifer and characterize groundwater flow regime (i. e recharge and discharge)

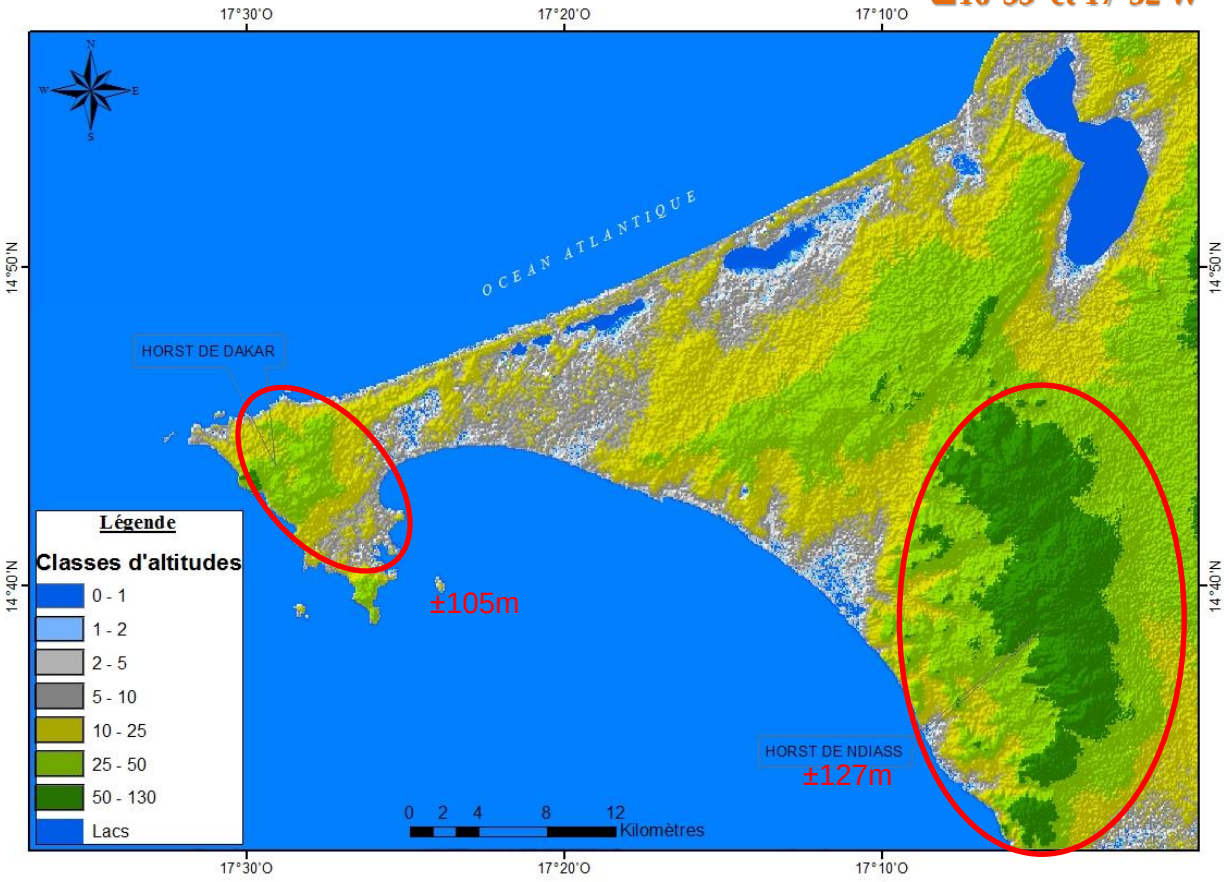
For planed research under AfriWatSan

Provide framework for :

✓More detailed aquifer and dynamics characterisation;
✓Modelling investigation studies (groundwater flow and contaminant transport) under **AfriWatSan** project, that seeks to inform a new adaptive strategy of using polluted urban groundwater for irrigation needs in peri-urban areas of Dakar.
✓Contribution from the different recharge sources to the urban groundwater budget

Study area

- 14°25' et 15°5' N
- 16°55' et 17°32 W



Elevations of the Cap-vert peninsula (SRTM-USGS / NASA)

✓Geology / Geomorphology

Senegal-Mauritanian sedimentary basin : Tertiary igneous rocks covered by Quaternary sediments

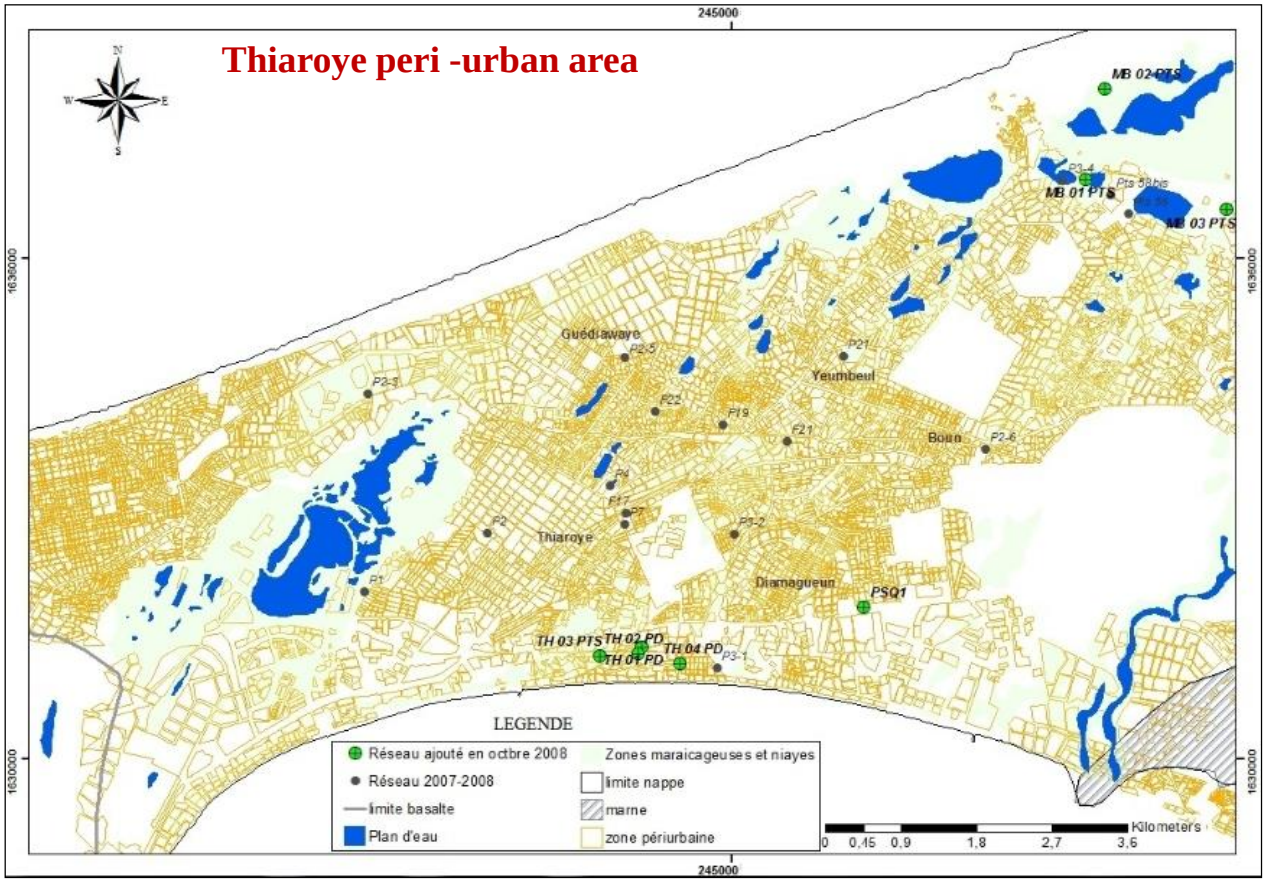
Depressed area between the Extreme westward peninsula with an uplift of the sedimentary deposits (105m) and the cliff of Ndiass (127m)

✓Hydrogeology

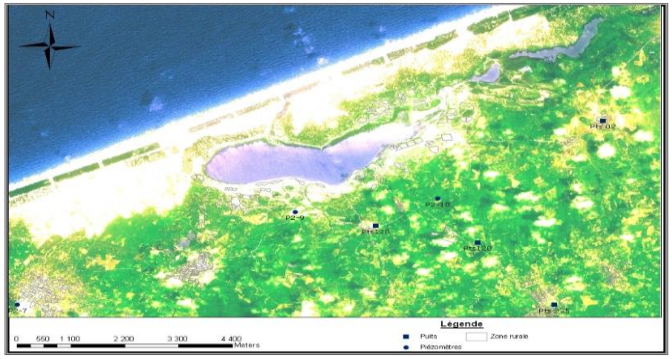
studied hydraulic system is the Thiaroye unconfined quaternary sand aquifer, located between Dakar and Kayar on approximately 300 Km²

✓Environmental setting

Thiaroye peri -urban area



Coastal zone & Lac Retba



« Niayes » : Agricultural practices

Results

Groundwater dating by Tritium ^3H

Groundwater replenished by rainwater prior to the 1960's is supposed to have very low ^3H values :

^3H contents measured in groundwater and rainwater (2008)

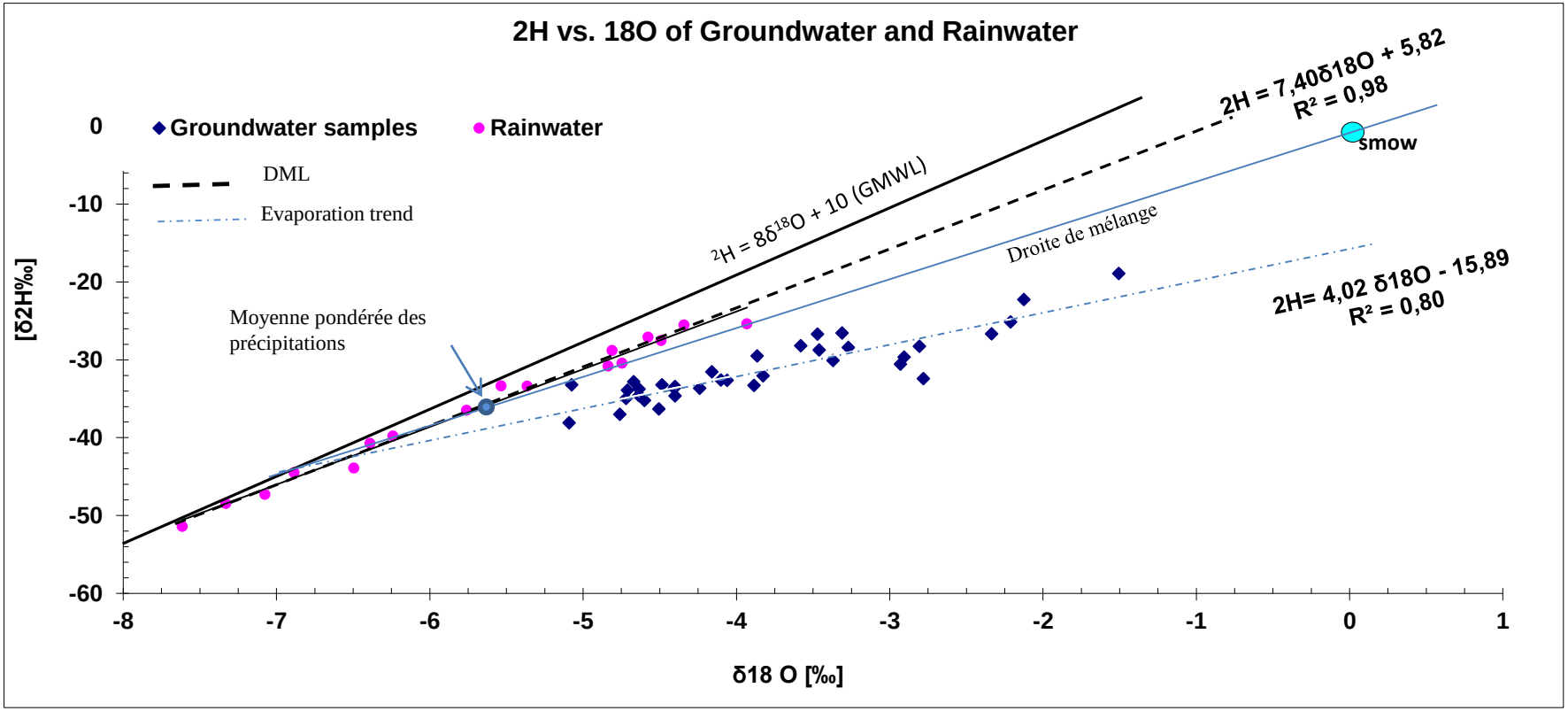
Rainwater	
• 1.5 to 2.8 ± 0.7 UT	
• Mean = 2.25 UT (considered as Input signal)	
Groundwater	
• 1.1 < ^3H < 3.5 UT	78%
• < 1 UT	7%
• 4 < ^3H < 5.3 UT	15%

✓ **93% of the sampled groundwater have a modern component**

✓ **While 7% appear not to have been affected by recent recharge**

Results

Recharge source identification through stable isotopes (^{18}O ; ^{2}H)



Correlation between $^{18}O/^{2}H$ with $\delta^{2}H = 7,40\delta^{18}O + 5.82$ close to the LMWL $\delta^{2}H = 7,93\ \delta^{18}O + 10,09$ (Travi, 1987) which is quite similar to the GMWL. That reflect the ocean origin of vapor which condense in the Senegalese coast

➢ **<u>Groundwater</u> : Distinguish trend and data deviate significantly from the GMWL with $\delta^{2}H = 4.02\delta^{18}O$ - 15.89 Slope (4,02). An evaporative enrichment of ^{18}O occurs and groundwater samples have been subjected to evaporation;**

Results

Recharge source identification through stable isotopes (^{18}O ; ^{2}H)

Groundwater isotopic signatures do not regress to the weighted mean composition of rainwater and suggest that groundwater is not the mean product of all rainfalls but preferentially derives from isotopically depleted heavy rainfalls

Characteristic isotopic equation of groundwater and their distribution zones

Equation	n	Data range (‰) Min ($\delta^{18}O$, $\delta^{2}H$)	Max ($\delta^{18}O$, $\delta^{2}H$)	Spatial distribution
$\delta^{2}H = 4.73\delta^{18}O - 12.35$ (R= 0.94)	11	(-5.35, -37)	(-1.51, -18.9)	South-western part (Peri-urban area)
$\delta^{2}H = 4.22\delta^{18}O - 14.81$(R= 0.83)	7	(-5.09, -38.1)	(-2.21, -25.2)	Coastal zone
$\delta^{2}H = 2.82\delta^{18}O - 20.37$(R= 0.73)	14	(-5.01, -36.2)	(-2.34, -26.7)	•"Niayes"
$\delta^{2}H = 3.25\delta^{18}O - 19.12$(R= 0.64)	12	(-4.90, -38.3)	(-2.78, -26.6)	•North-eastern part (Sand dune)

- **Wide isotopic range in South-western part of the system coinciding to the Peri-urban area compared to the rest of the system; such a large variation may be consistent with contribution of recharge sources other than rainfall**

- **Contribution of saline sources which should be hydrochemically detected if it has taken place is not ruled out;**

Results

Hydrochemical zones

EC: significant variability 222 to 4480 µS/cm which differentiate :

- **Saline waters** High EC (1100 < CE < 4480 µS/cm)

✓*Na-Cl or Na/Ca-Cl Water types*

✓***Relative abundance of ions :***

✓***Cations: $Na^+ > Ca^+ > Mg^+ > K^+$;***

✓**Anions**: ***$Cl^- > SO_4^{2-} > HCO_3^-$***

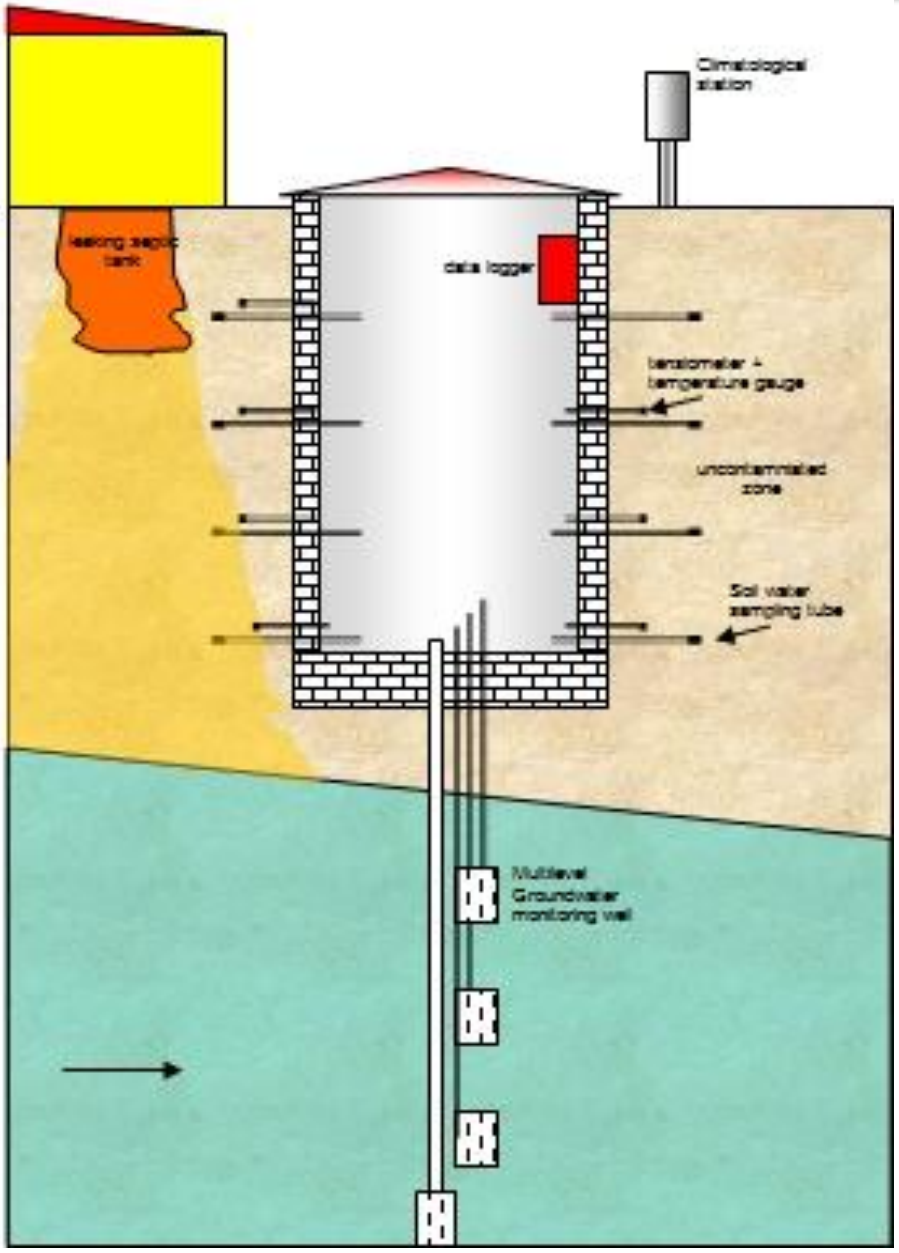
✓ ***High NO_3 content up to 500 mg/L Represented in the peri - urban area impacted by anthropogenic effects,***

✓*Saline waters enriched in both Cl and SO4 in the coastal zone*

- **Fresh waters** EC (222 < CE < 884 µS/cm)

✓*Groundwater is predominantly Ca – HCO_3 facies and correspond to the discharge zone*

Planed research under AfriWatSan project



✓ In the future research this Design and installation will be set so that interstitial water will be collected to monitor water and pollutant migration to shallow groundwater;

✓Multilevel groundwater monitoring

Objective:

✓Evaluate the migration process for NO_3 compounds and other pollutants
✓ Modeling of the reactive transport of sanitation related pollutants (NO_3; NO_2; NO_4)
✓Estimation of recharges from septic tank leakage

Soil and groundwater monitoring station

Summary & Conclusion

✓ ^{3}H activities of Groundwater reflect predominance of modern component of groundwater in the Thiaroye system; Only 7% of sampled groundwater appear not to have been affected by recent recharge

✓ Results on recharge source identification through stable isotopes (^{18}O ; ^{2}H) are consistent with meteoric water as source of recharge in Dakar region; but preferentially groundwater derive from isotopically depleted heavy rainfalls;

➢ Isotopic composition of groundwater and their spatial distribution show wide isotopic range in the Peri-urban context ; compared to the rest of the aquifer; suggest contribution of recharge sources other than rainfall ;

➢ Additional hydrochemical data showing high nitrate concentrations (500 mg/L) clearly indicate that corresponds to significant contribution of leakage from septic tanks improperly build in the area as source of recharge;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