

The impacts of on-site sanitation on groundwater quality in the unconfined Thiaroye aquifer of Dakar, Senegal

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GW and UN SDGs in Urban Africa



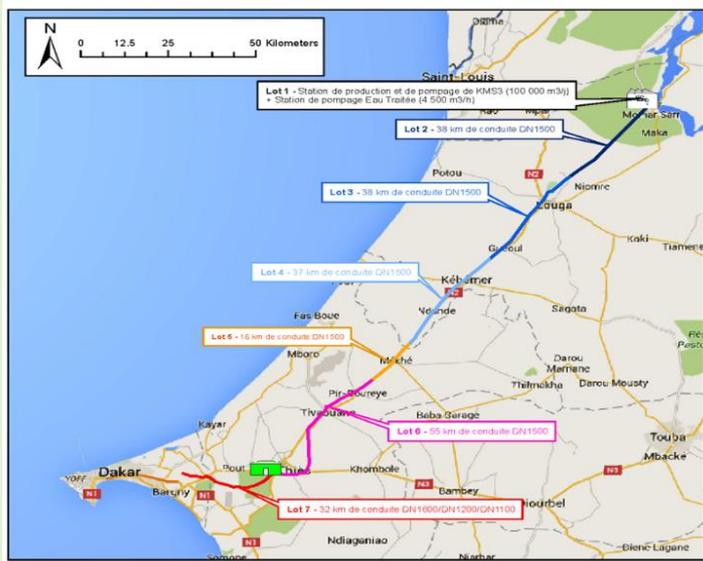
Thiaroye suburb Quickbird view (2005)

Rapid, unplanned urban growth constrain the realization of UN Sustainable Development Goal (UN SDG) 6

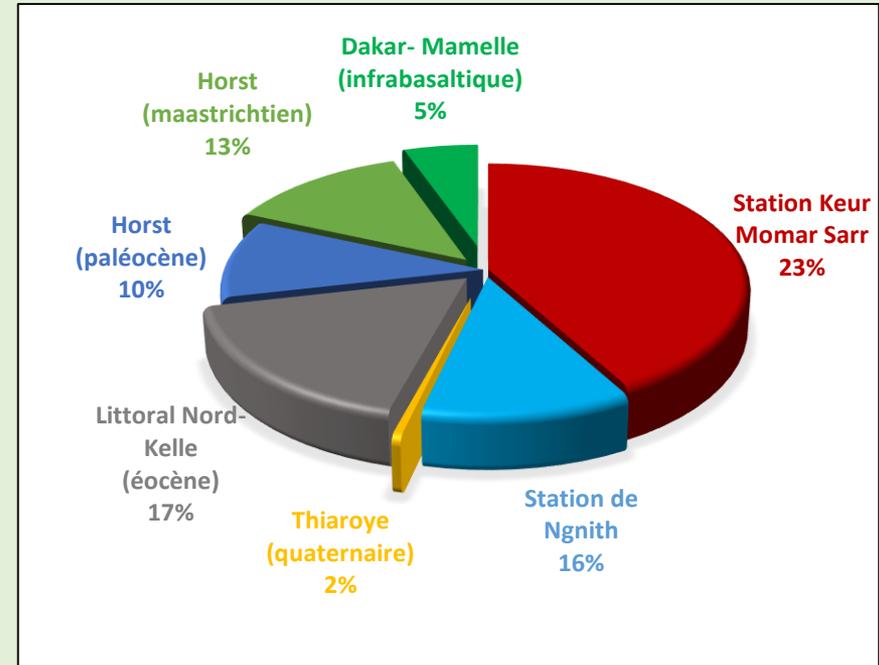
- Under accelerating urbanisation & more variable and contaminated river flow, Urban GW represents a vital, strategic freshwater resource (Foster et al., 2018)

- Risk of pollution from inadequate sanitation systems remains key constraint to the sustainability of urban groundwater use

Water Supply to Dakar



- daily production: 421 580 m³/day
- 39% derives from surface waters (e.g. Lac de Guiers)



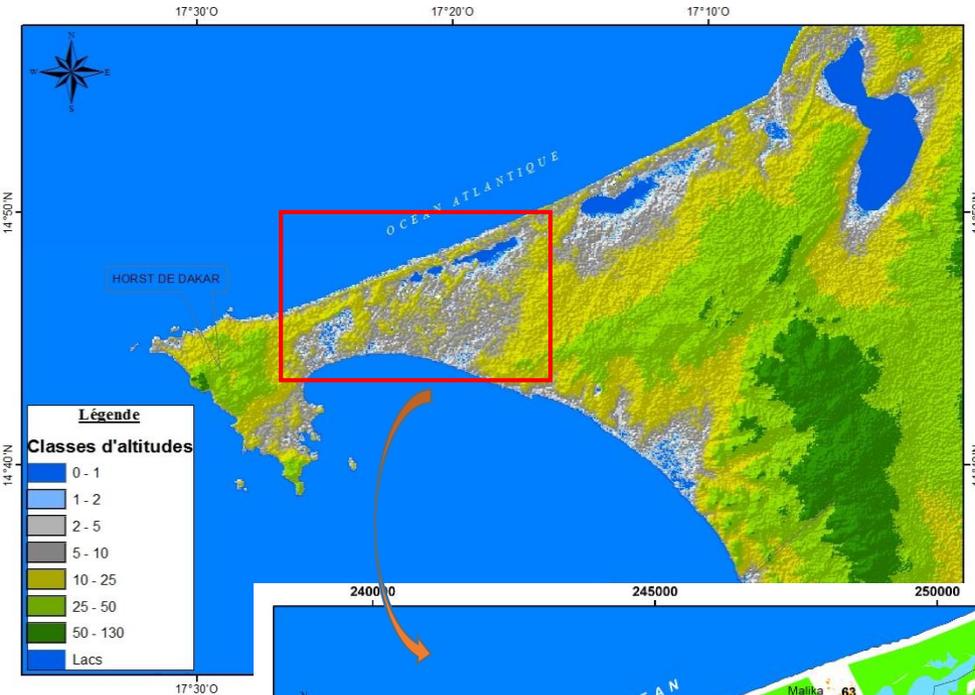
Production capacity in 2016 (SONES, 2016)

61% derives from GW:

- 54% from coastal littoral aquifers
- **7% from local aquifers (e.g. Thiaroye)**

Drastic reduction of GW abstraction from the Thiaroye aquifer due to substantial quality deterioration with nitrate concentrations **> 500 mg·L⁻¹**

Urban Thiaroye Aquifer of Dakar



Geology / Geomorphology

Low-lying area between westward peninsula with an uplift of the sedimentary deposits (**105m**) and eastern cliff of Ndiass (**127m**)

Hydrogeology / Hydrology

shallow, unconfined Quaternary sand aquifer occupying a low-lying area of $\sim 300 \text{ km}^2$ that is prone to flooding

Dakar and its suburb represent 54% of the total urban population of Senegal

Automated high-frequency monitoring of GW levels and salinity

1. Installation of probes for continuous high-frequency monitoring



2. Seasonal monitoring:

a) Tracing groundwater movement from piezometry, hand-pumped wells, and production boreholes that enable sampling of $\delta^{18}\text{O}$, $\delta^2\text{H}$ and residence-time indicators

b) Impact of on-site sanitation systems on groundwater quality using chemical tracers and microbiological parameters (*Escherichia coli*, TTCs)

Sanitary block



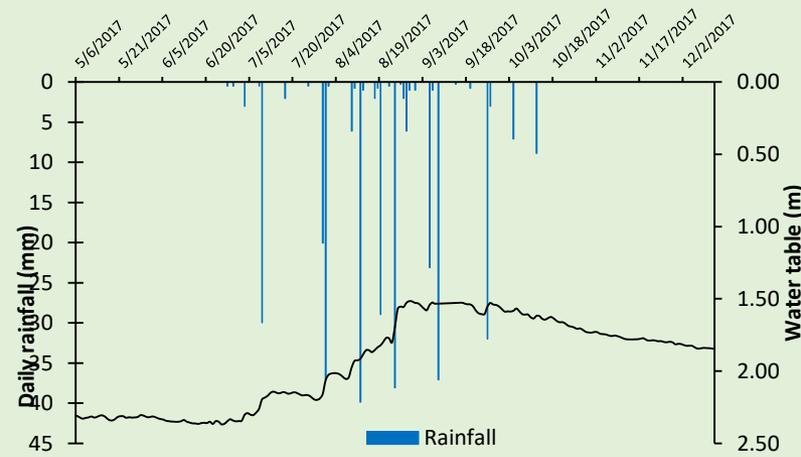
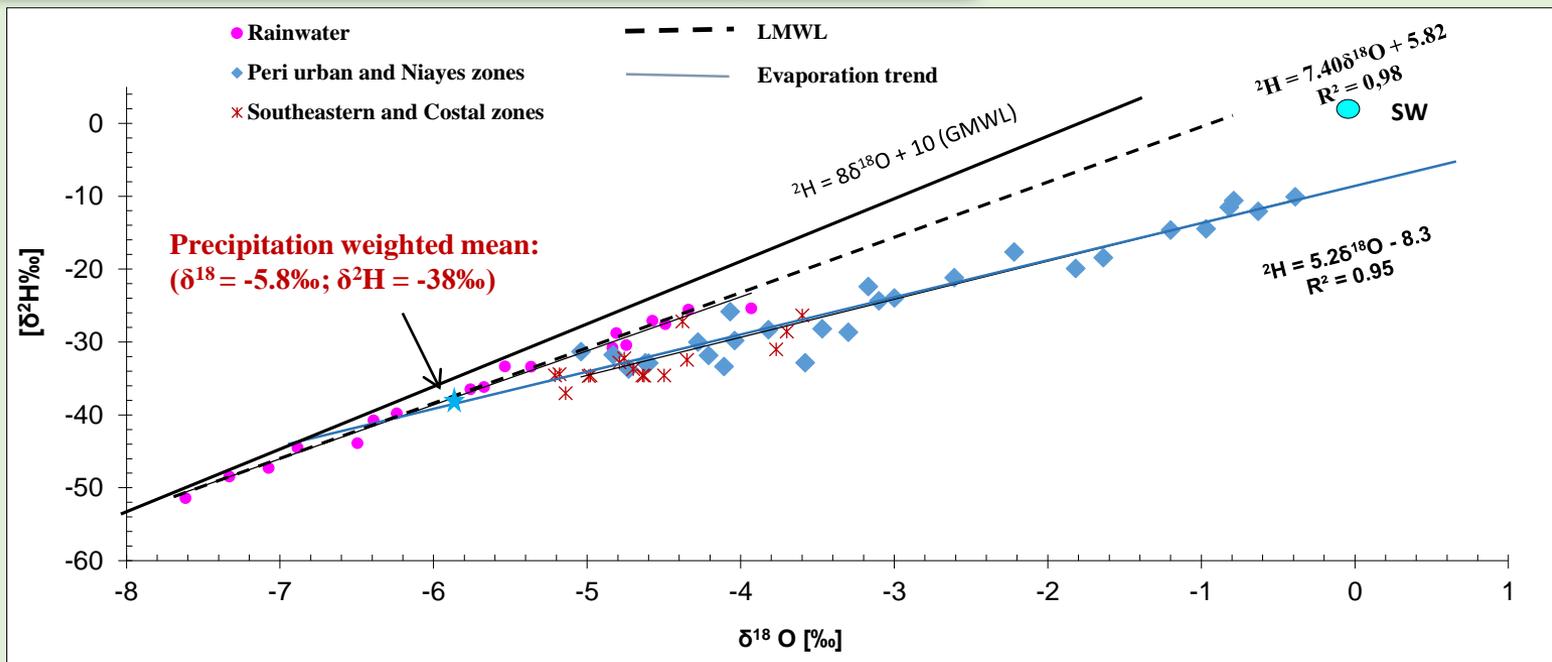
3. Research includes:

Improved awareness and understanding of linkages among sanitation and health through the establishment of monitoring stations on the grounds of educational institutions.

leaky septic tank



RESULTS – TRACING SOURCES OF GROUNDWATER



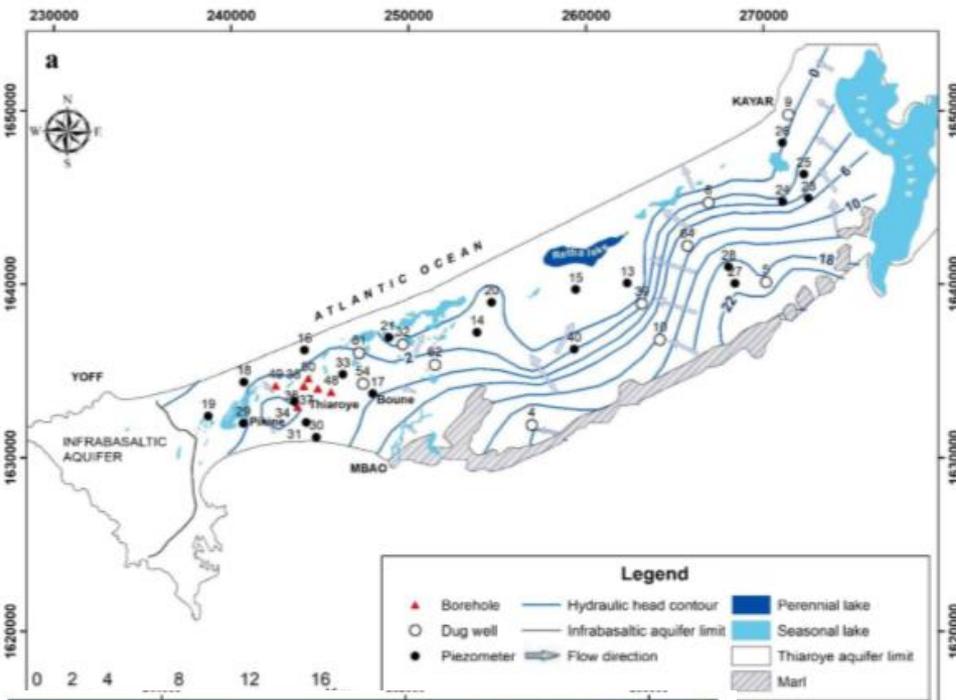
Daily water table fluctuations and rainfall from May to December 2017

- GWs regress along a slope of **5.2** consistent with evaporative enrichment in the heavy isotope of O and H
- GWs intercept LMWL at ($\delta^{18}\text{O} = -6.3\text{‰}$), depleted relative to weighted mean composition of rainfall ($\delta^{18}\text{O} = -5.8\text{‰}$), suggesting bias to heavy, isotopically depleted rainfalls
- high-frequency GW levels monitoring evidence direct (diffuse) recharge in this semi arid environment

Cisse Faye et al., 2019. Hydrogeol. J. 27: 1067-1080.

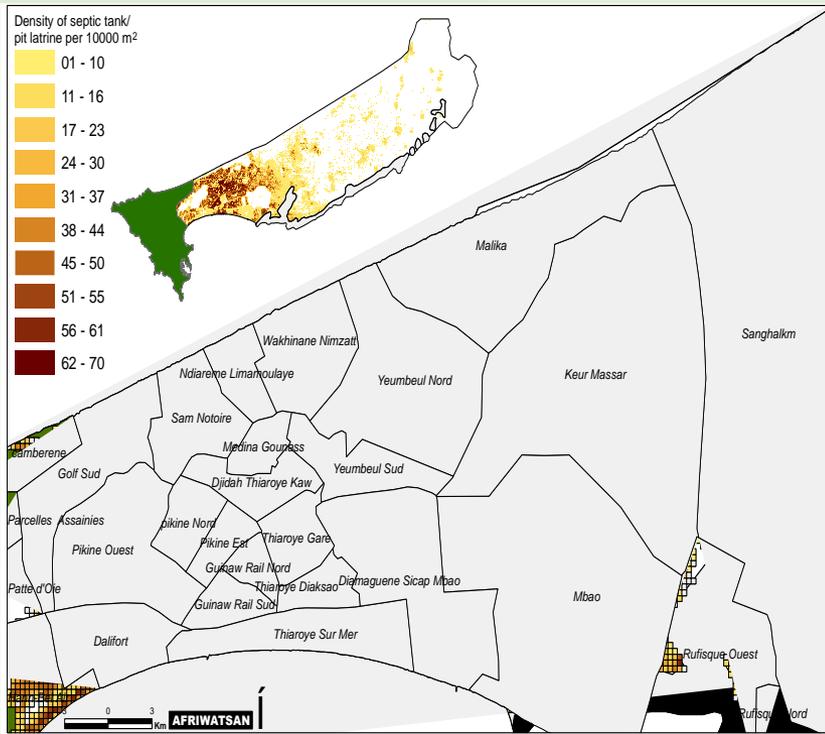
RESULTS – Hydraulic head distribution

General groundwater flow direction is from South to North (towards seasonal lakes)

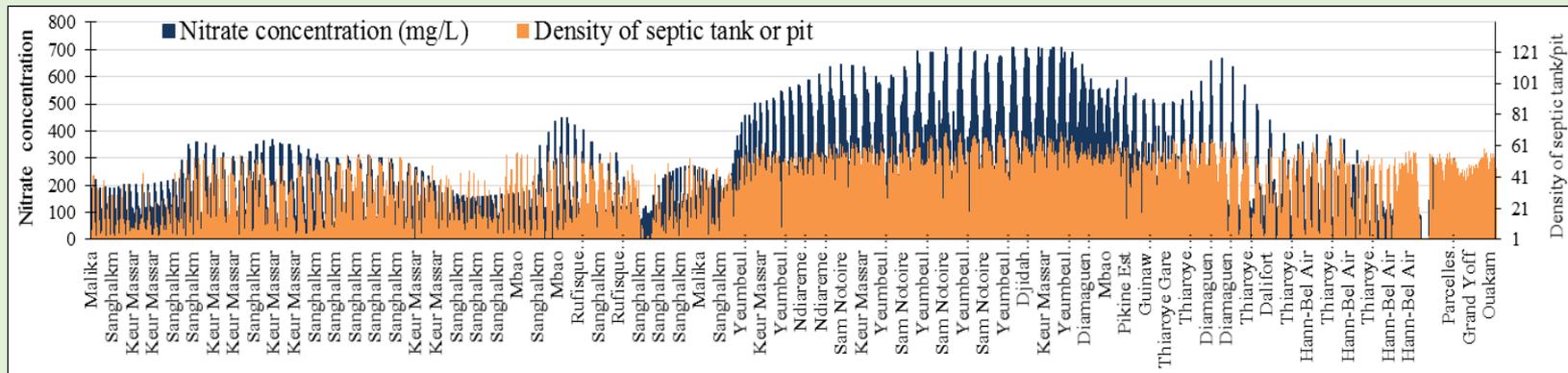


Reduction in urban groundwater abstraction has lowered hydraulic gradients and exacerbated rising groundwater levels

Hydraulic head distribution and flowpaths in the Thiaroye aquifer of Dakar in a March 2007 and b September 2017



- urban recharge is supplemented by (effectively) diffuse flows from on-site sanitation facilities (*i.e.* 234 000 septic tanks) draining to Thiaroye aquifer
- ¹⁵N/¹⁴N ratios in NO₃⁻ range from + 9 to +22‰, indicative of faecal sources of N found in 87% of sampled groundwaters (*Re et al., 2010; Diedhou et al., 2012*)



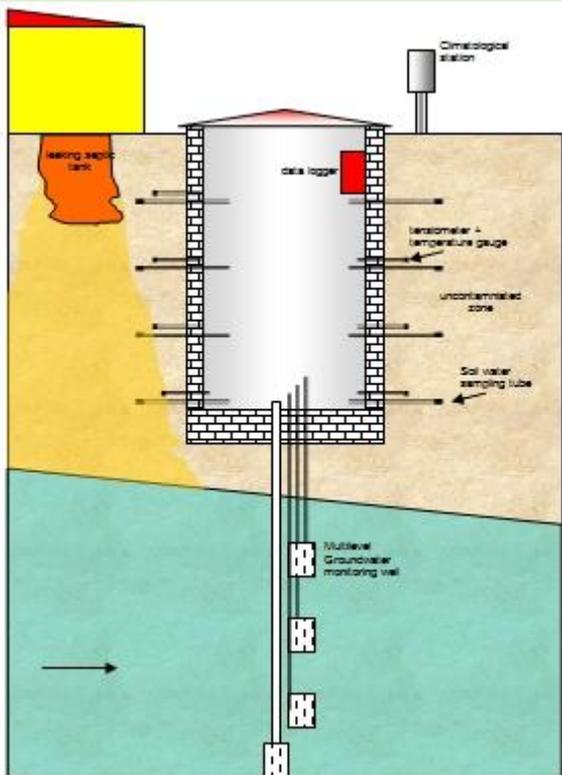
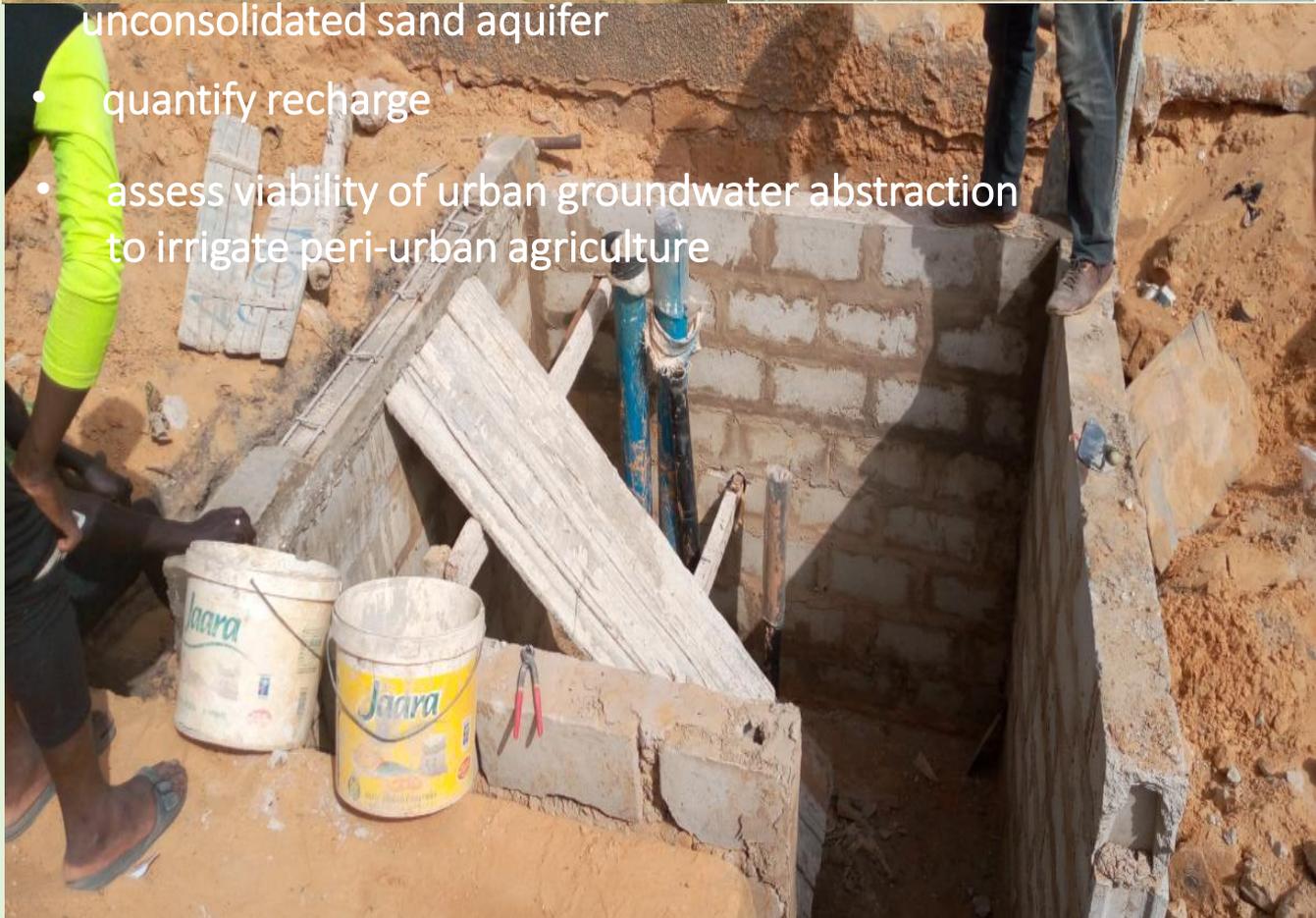
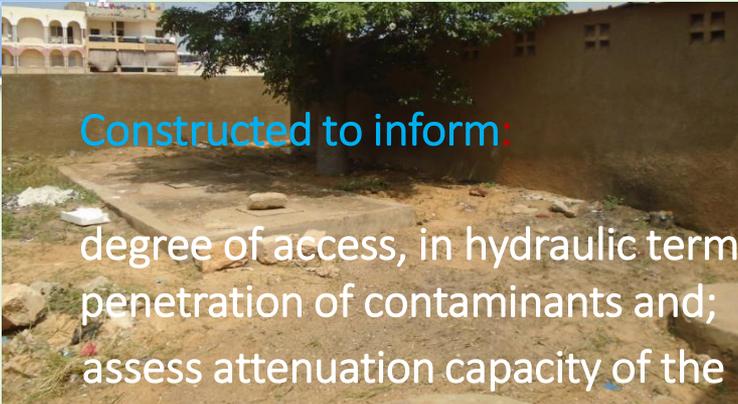
density of on-site sanitation directly correlated to nitrate concentrations in Thiaroye aquifer
 => see poster 312 (Diaw et al.) this afternoon in poster session 2 (S02b + S04 + S06)

ON-GOING RESEARCH

Constructed to inform:

degree of access, in hydraulic terms provided for penetration of contaminants and; assess attenuation capacity of the unconsolidated sand aquifer

- quantify recharge
- assess viability of urban groundwater abstraction to irrigate peri-urban agriculture



Urban groundwater observatories monitor effluent migration from septic tanks to shallow groundwater
See poster 313 (Pouye et al.)

SUMMARY - CONCLUSIONS

- combined use of isotopic and bacteriological tracers provides new insight into sources of recharge to the Thiaroye aquifer of Dakar;
- groundwater derives from diffuse recharge and faecal effluent from a vast network of septic tanks that exacerbate frequency and duration of groundwater flooding in Dakar;
- pathways by which faecal effluent causing nitrate concentrations exceeding 500 mg/L examined using newly constructed field observatories to monitor pollutant migration through thin unsaturated zone from septic tanks to shallow groundwater.

**THANK YOU FOR YOUR
KIND ATTENTION**

Acknowledgments to :



**THE
ROYAL
SOCIETY**

Africa Capacity Building Initiative