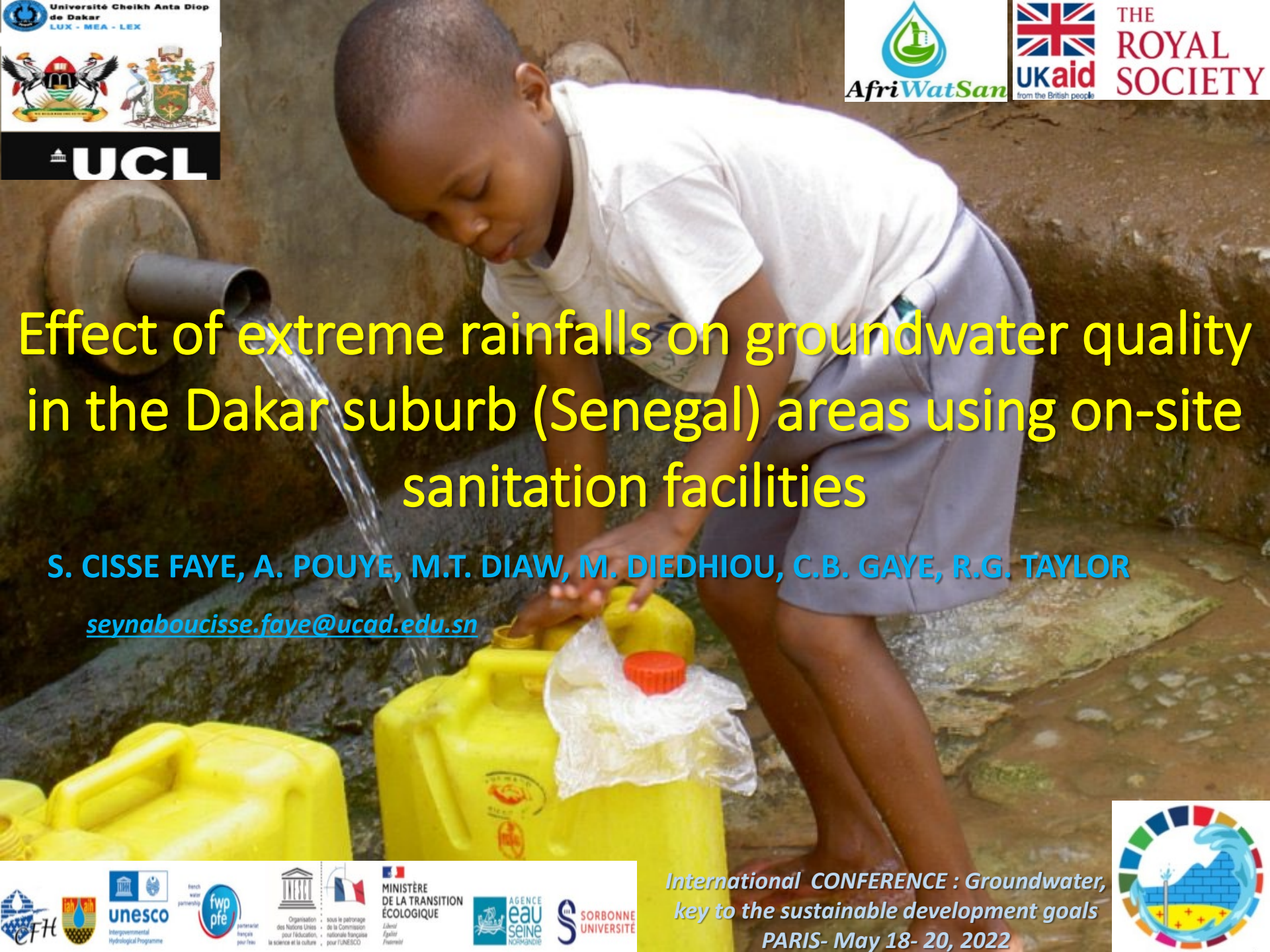

Effect of extreme rainfalls on groundwater quality in the Dakar suburb (Senegal) areas using on-site sanitation facilities

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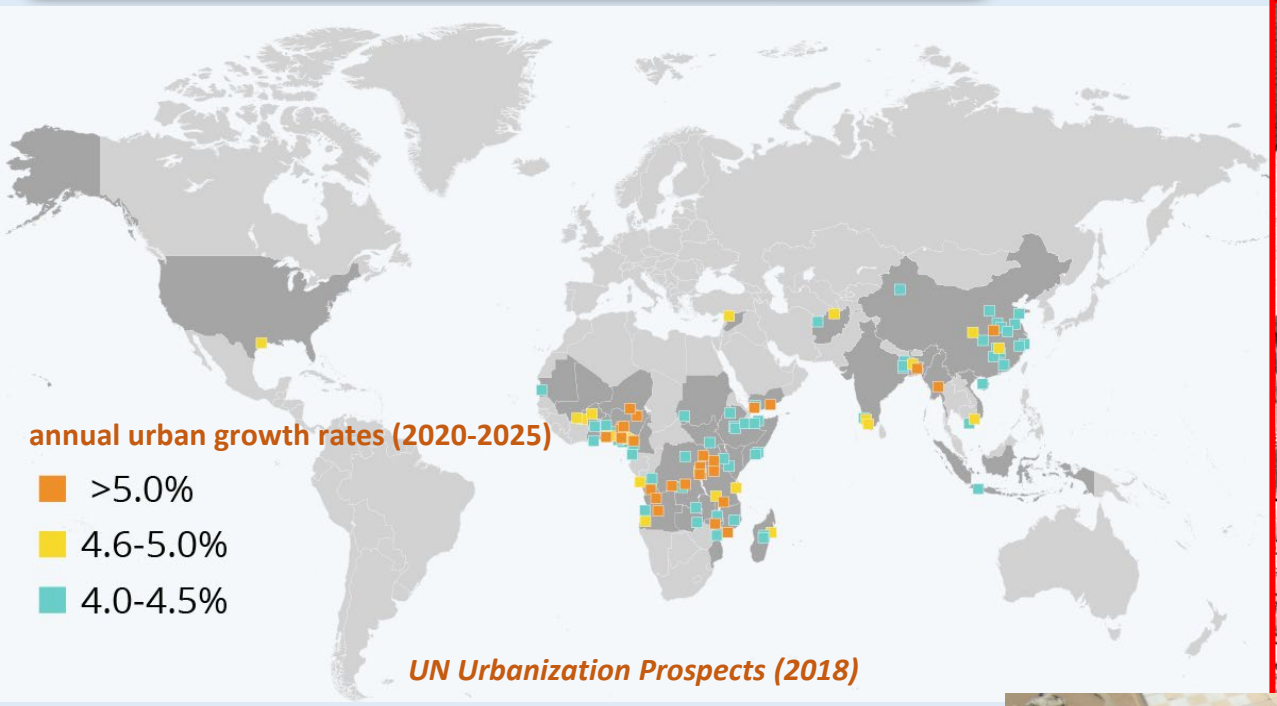
International CONFERENCE : Groundwater, key to the sustainable development goals
PARIS- May 18- 20, 2022

GW and UN SDGs in Urban Africa



UN Urbanization Prospects (2018)

Thiaroye suburb Quickbird view (2005)

Rapid, unplanned urban growth and inadequacies in urban planning constrain provision of universal access to safe water and sanitation by 2030 – UN SDG 6

Urban groundwater represents a substantial, strategic freshwater resource to meet rising demand under accelerating rates of urbanisation and reduced river-intake security due to pollution and climate change

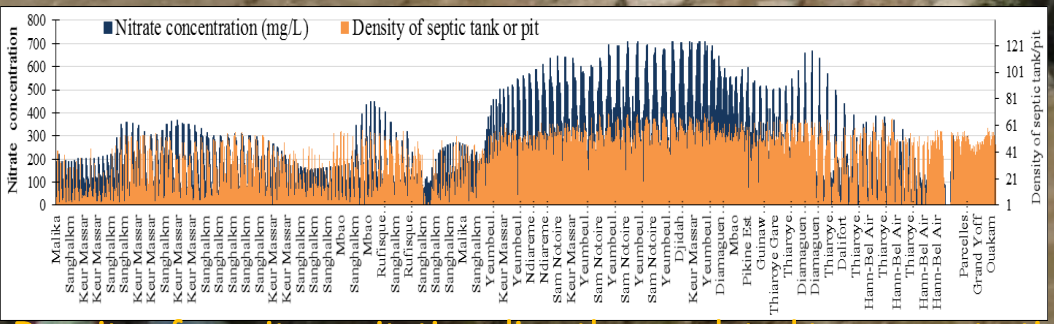
Untreated urban GW provides low - cost assess to safe water: Self-supply (Manual Pump)

In the Thiaroye aquifer of Dakar, evidence from piezometry, stable-isotope ratios of O and H, and tritium (^3H) shows that shallow groundwater derives from modern monsoonal rainfall

Risk of pollution from on-site and centralized sanitation systems as well as uncontained faecal waste remains key constrain urban groundwater use

Supplemented by diffuse flows from on-site sanitation facilities (*i.e.* 253 000 septic tanks, latrines mapped over 520 km2) draining to the Thiaroye aquifer

Mapped density of on-site sanitation facilities : to realise the UN SDG 6



leaky septic tank

Density of on-site sanitation directly correlated to concentration of faecal chemical pollutants (nitrate) Thiaroye aquifer

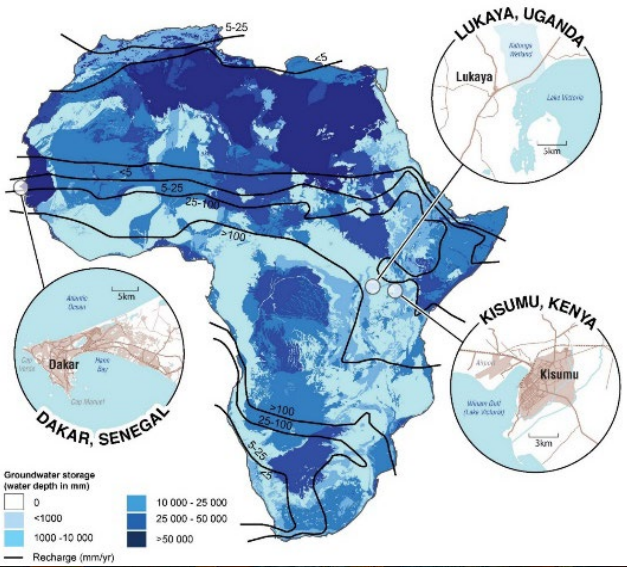
Dakar Research: pan-African study *AfriWatSan*

www.afriwatsan.org

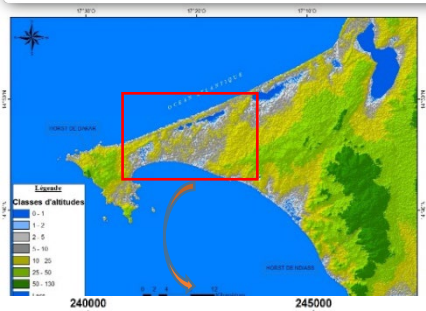
AfriWatSan

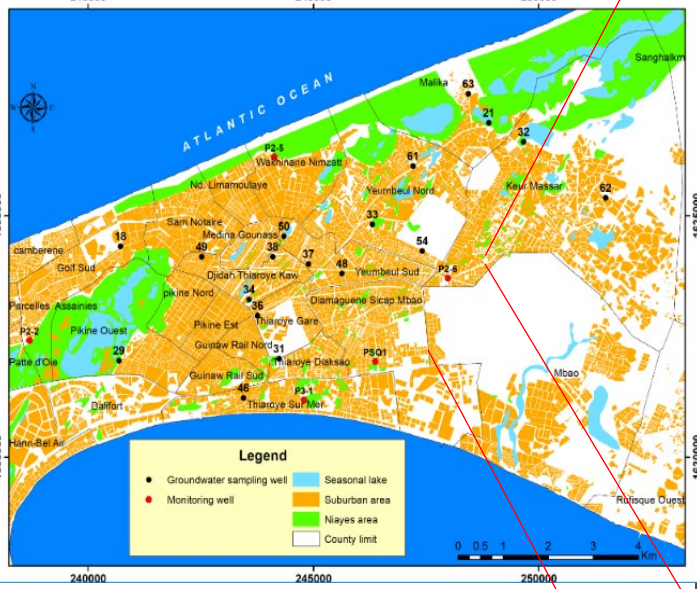
1. to develop scientific evidence required to inform policies and practices that sustain the quantity and quality of low-cost, urban water supply and sanitation systems exploiting the sub-surface in Sub-Saharan Africa; **aligned surveys & monitoring protocols across 3 urban observatories;** and

2. to strengthen the capacity of individuals and institutions to conduct this vital research.



Thiaroye aquifer : Urban groundwater observatory





shallow, unconfined quaternary sand aquifer occupying a low-lying area of ~300 km² that is prone to flooding

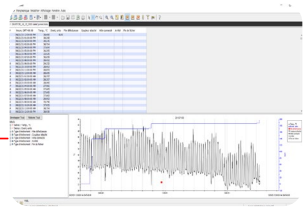
Dakar and its suburb represent 54% of the total urban population of Senegal **Keur Massar district : 203,000 inhabitants over 25 km²**

Probes: high-frequency monitoring of rainfall and effluent migration

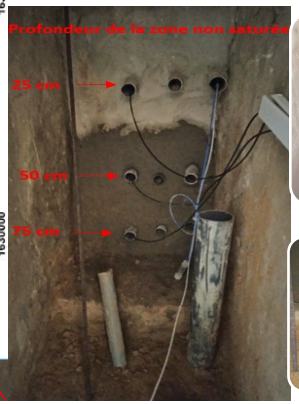
Data Collection

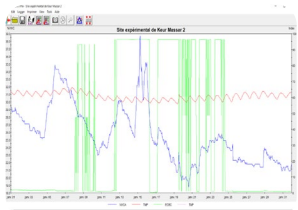
Data processing

Rain gauge

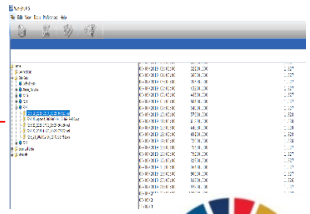


Monitoring USZ

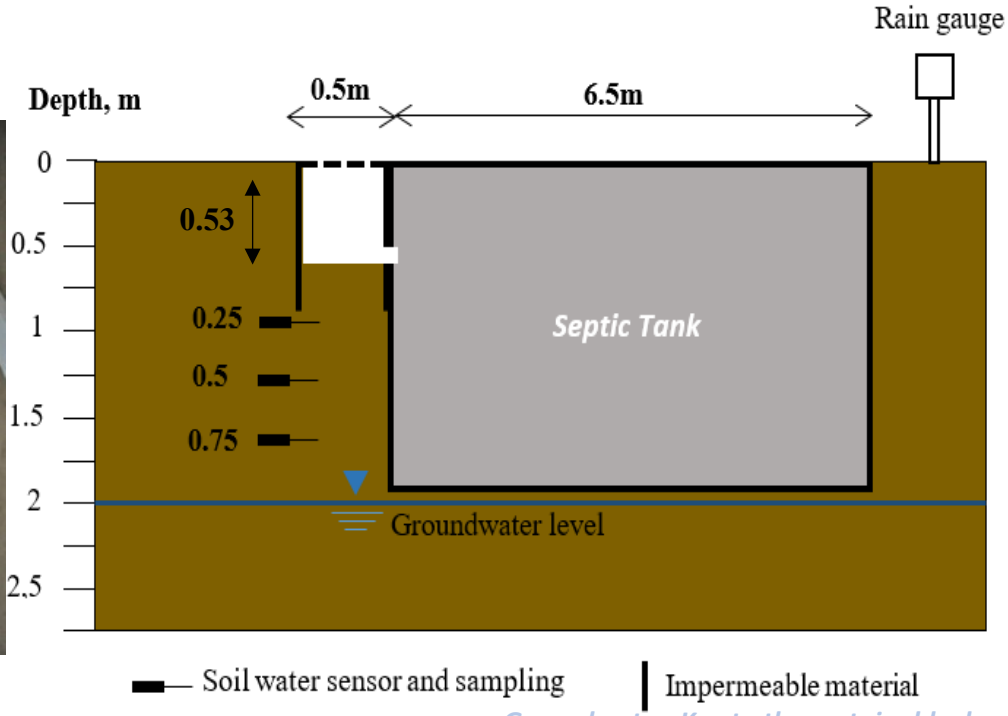




Piezometer



Experimental Site



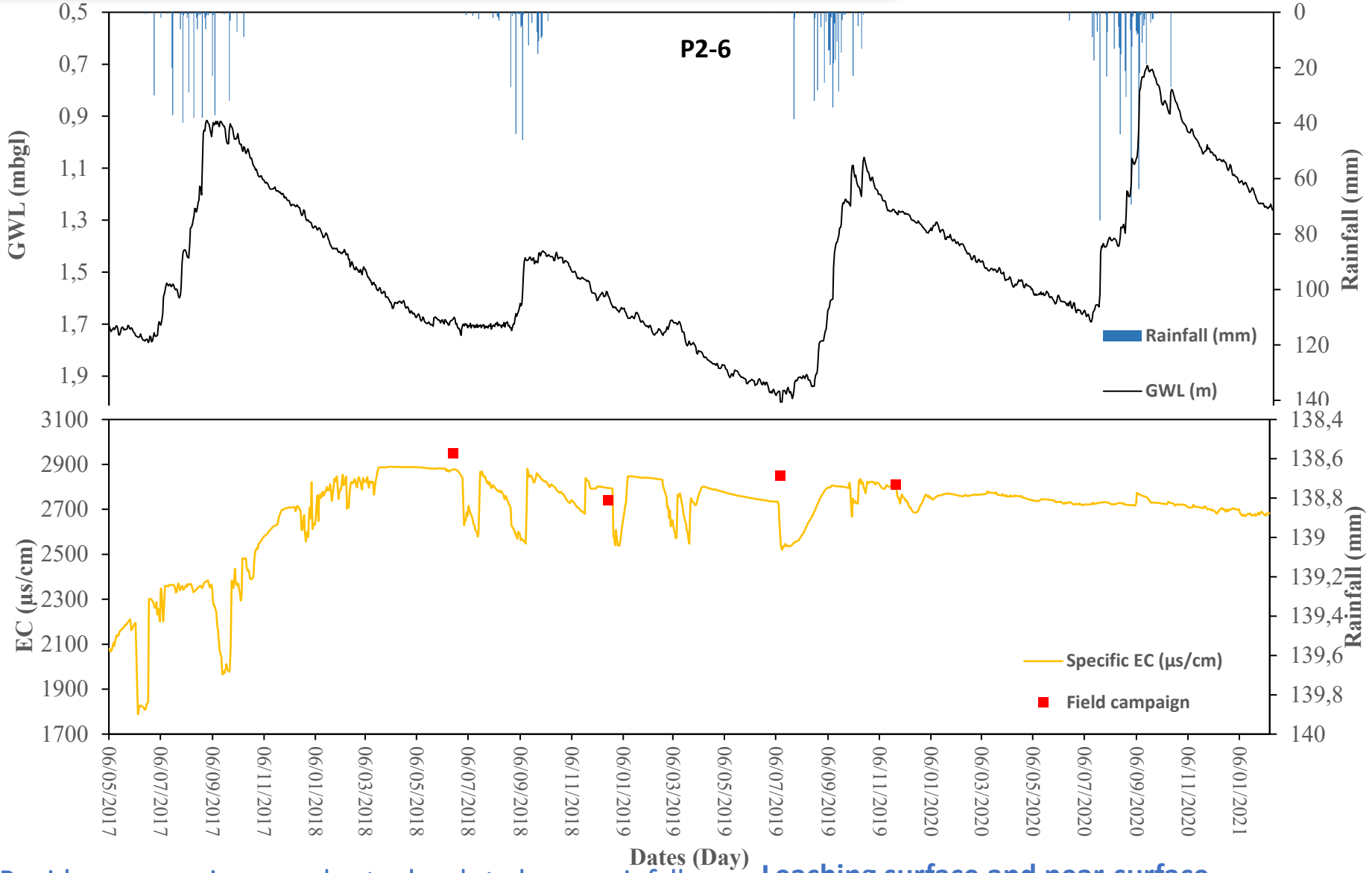
Urban groundwater observatory design :

- Primary school K. Massar PAEEU3 (523 pupils)
- large septic tank (6.5 x 2 x 2 m), installed 2 m into the ground, collects faecal effluent

Monitoring:

- High - frequency monitoring of rainfall, soil moisture and groundwater levels
- spot (event-based) sampling of nitrogen species concentrations in soil moisture and GW

hydrological responses to rainfall : USZ & GW

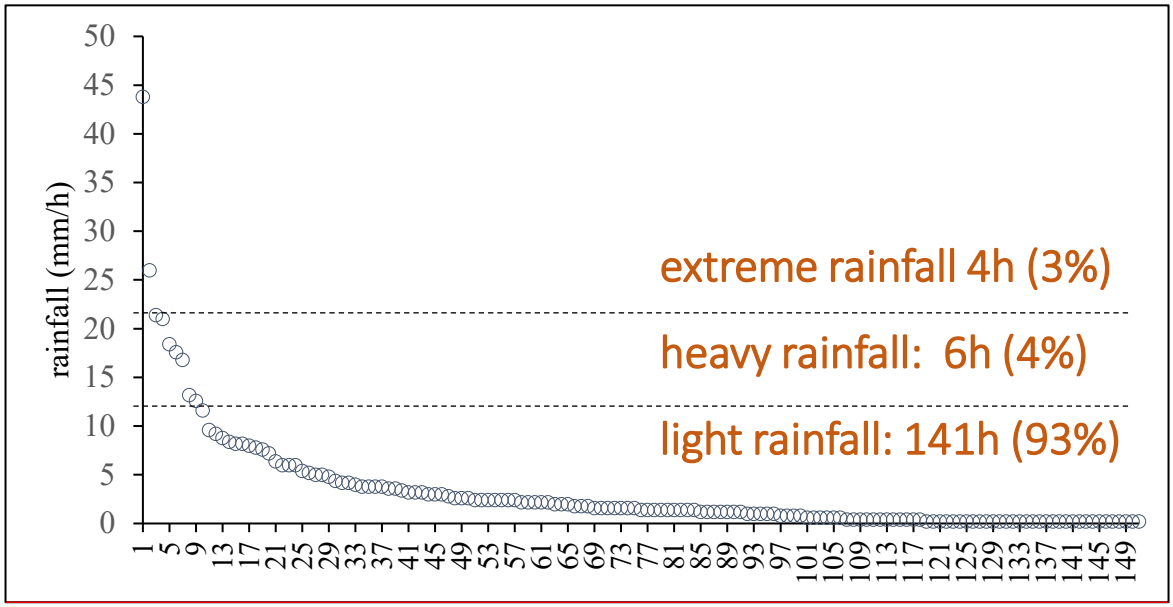


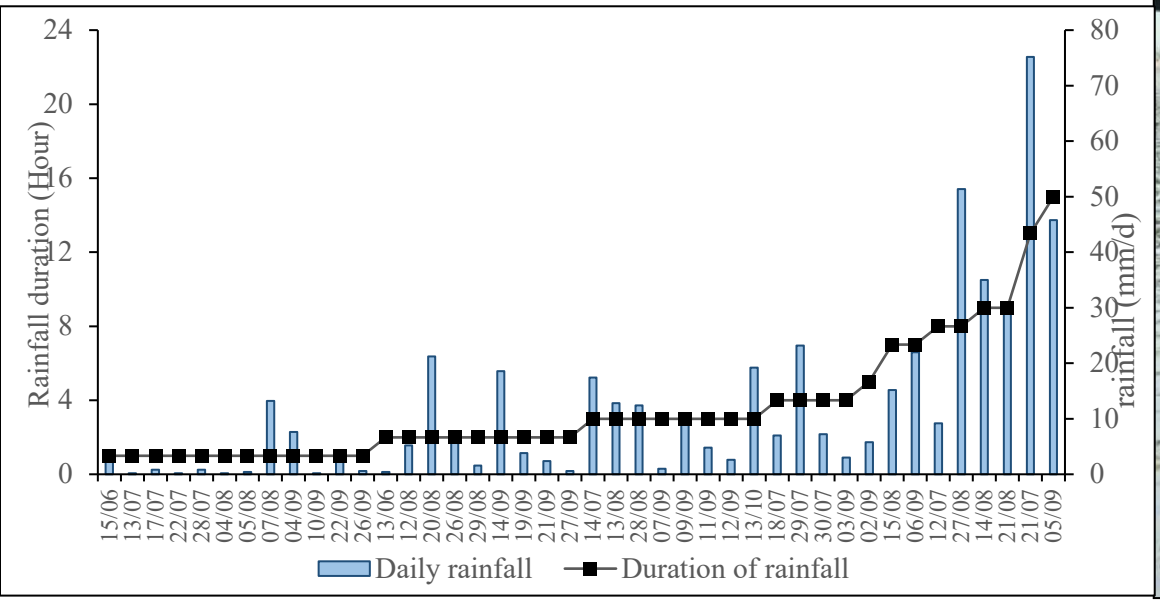
Rapid responses in groundwater levels to heavy rainfalls observed in piezometric records highlight the vulnerability of shallow groundwater to contamination

Leaching surface and near-surface contamination from uncontained and contained faecal waste (on-site sanitation)

Rainfall distribution (June - October 2020)

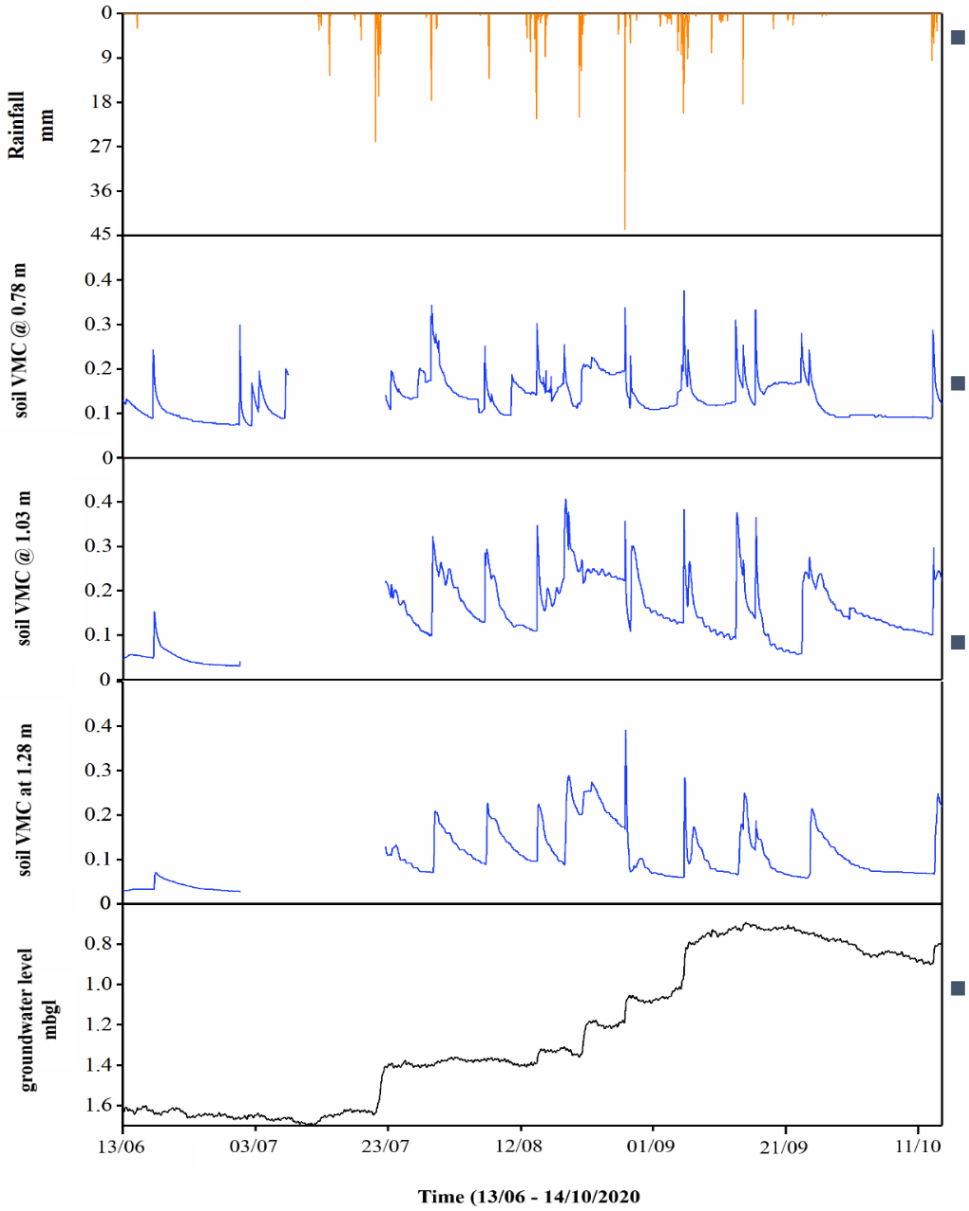
- Total rainfall amount: 502 mm wetter than normal rainy season (400 mm)
- Total hours of rainfall: 151
- rainfall duration: 1 – 15 hours





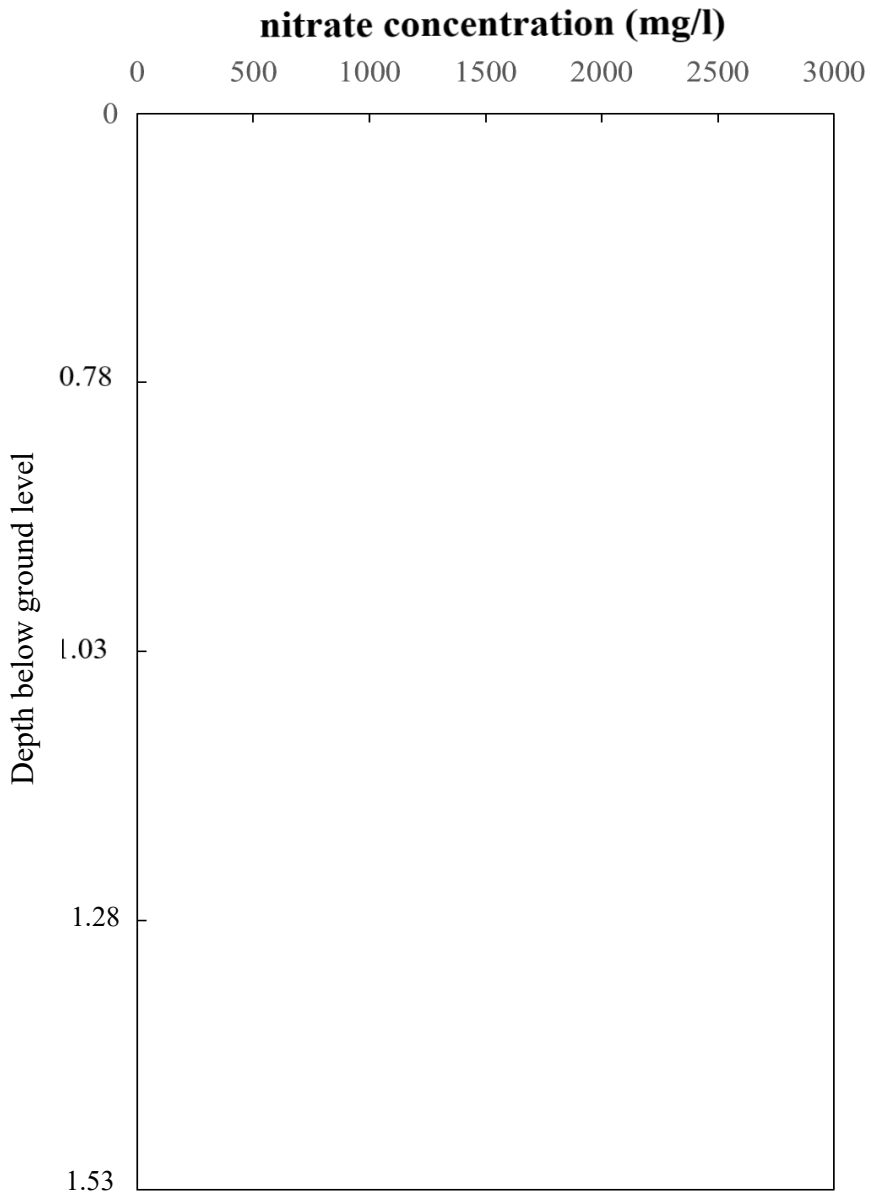

Urban flooding in Keur Massar 27th August 2020

hydrological responses to rainfall : USZ & GW



- distinct rises in soil moisture content (N=24) coincide with heavy and extreme rainfall events
- peaks outside of rain events reveal the influence of wastewater effluent from toilets.
- sharp recessions in soil-moisture occur during more rapid infiltration (e.g. 27th August 2020; 69 mm and RI = 43 mm/h)
- positive deflections in groundwater levels associate most strongly with periods of heavy and extreme rainfall

Chemical soil water dynamics



- 21st August: nitrate concentrations profile 340 - 400 mg/L at 1,28 m
- During extreme rainfall event on the 27th (69 mm - **RI = >20 mm/h**) and 28th of August, nitrate concentrations rose more than six-fold at depths of 1,03 and 1,28 m to 2380 mg/L and 2630 mg/L, respectively
- More modest increases, amounting to a doubling or tripling in nitrate concentrations at 0,78 m to 950 mg/L at 9am and 730 mg/L at 2pm on the 28th of August.
- 1st September: Nitrate concentrations in soil moisture receded to values close to 21st August and less than a quarter of that observed during intensive rainfall (510 mg/L and 730 mg/L);

Conclusions

- heavy (>10 mm/h) and extreme (>20 mm/h) rainfall intensities by global warming; consistently generate sharp rises in soil moisture content and subsequently shallow groundwater levels (recharge)

- seasonal rain-fed recharge and perennial anthropogenic recharge via septic tank effluent exacerbate frequency and duration of groundwater flooding in Dakar.

- nitrate concentrations in sampled soil moisture rose dramatically during extreme rainfall intensities on 27th August and subsequently receded in the absence of rainfall – providing evidence of how heavy and extreme rainfall intensities serve to flush faecal waste from a septic tank

- first observations to reveal the process by which Quaternary sand aquifer in Dakar has been contaminated by nitrate from faecal waste in on-site sanitation systems

THANK YOU FOR YOUR KIND ATTENTION

Acknowledgments to :

UKaid from the British people

THE ROYAL SOCIETY

Africa Capacity Building Initiative