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Rising groundwater levels and pollution in the Thiaroye aquifer of Dakar, Senegal: Historical background and current management initiatives

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1. Introduction

In many developing countries, achieving UN Sustainable Development Goal (SDG) 6 for water and sanitation presents a major challenge. The development and protection of groundwater have emerged as key pathways to the realisation of SDG 6 as groundwater is more resilient to pollution and drought than surface waters, and can be developed at low cost since the source can be sited close to demand and often requires minimal treatment. The risk of pollution from on-site and centralised sanitation systems as well as uncontained faecal waste remains, however, a key constraint to the sustainability of groundwater use. The city of Dakar (Senegal) is characterized by rapid population growth since the 1970s that coincided with the Sahelian multi-decadal drought. Dakar and its periphery represent 54% of the total urban population of Senegal and cover an area of 550 km², ~0.3% of the Senegal's land area. Water supply derives from multiple resources including the Thiaroye aquifer in suburban Dakar. From the 1920s, modern wells replaced traditional hand-dug wells. Geochemical and isotopic indicators have also been applied to trace the faecal origin of nitrate contaminating groundwater (Cissé Faye, 2012). Reductions in the abstraction of groundwater from the suburban Thiaroye aquifer due to the magnitude of nitrate contamination have contributed to rising groundwater levels which now contribute to recurrent flooding in many parts of the suburban zone. Recent efforts by local water supply operators to mitigate flooding include the abstraction of nitrate-contaminated shallow groundwater at rates of up to 16 000 m³ per day used to irrigate peri-urban agriculture. Here, we present on-going research and monitoring under the *AfriWatSan* project (www.afriwatsan.org) that seeks to provide the evidence base to inform policies and practices to sustain the quantity and quality of urban groundwater in Sub-Saharan Africa; this research is supported by allied research in urban observatories in Kisumu (Kenya) and Lukaya (Uganda). Research includes: 1) high-frequency monitoring of groundwater quality and groundwater levels; 2) inter-disciplinary evaluations of the characteristics of water users and on-site sanitation systems on human health.

2. Material and Methods

The unconfined Thiaroye aquifer within Quaternary sands lies beneath suburban Dakar and extends ~300 km from Dakar to Kayar (**Fig. 1**). A new monitoring network enabling high-frequency observations of groundwater levels and salinity has been established to assess the impact of urban groundwater pumpage and on-site sanitation systems on groundwater quality assessed using chemical (*i.e.* majors ions, bromide, DOC, N and P species), and bacteriological (*Escherichia Coli*) indicators as well as real-time fluorescence (tryptophan-like).

3. Results and Discussion

The new monitoring infrastructure reveals a pronounced seasonal response in shallow groundwater levels to rainfall (**Fig. 2**) and a temporary (seasonal) stabilisation of a trend toward increase salinity measured as EC (**Fig. 3**). These new observations suggest that the shallow groundwater system is dominated by direct (vertical) infiltration of monsoonal rainfall; the extent to which this infiltration is leaching surface and near-surface contaminants (e.g. septic tanks) is the subject of on-going research. An association between the density of on-site sanitation and groundwater quality in suburban Dakar has been observed and is reflected in the observed quality of shallow groundwater.

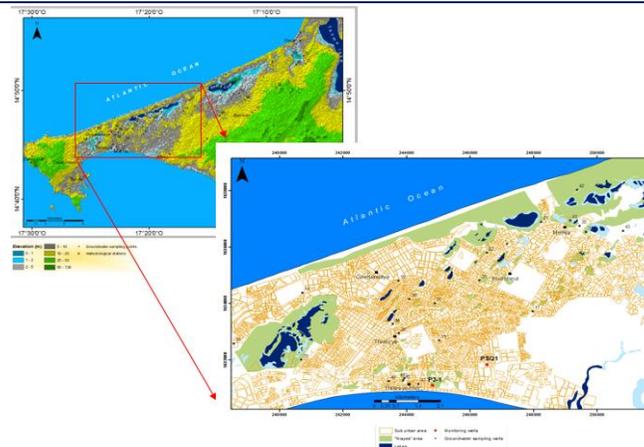


Figure 1. Location of the Dakar region and the Thiaroye suburban zone with new monitoring network.

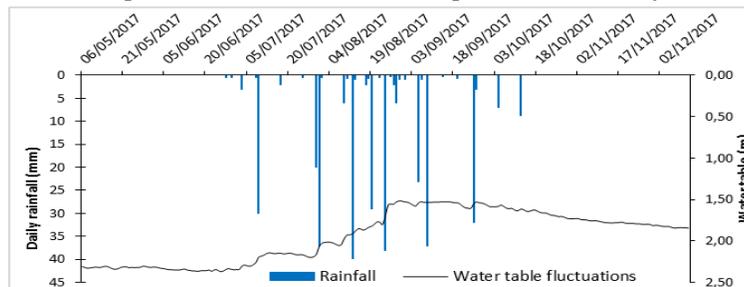


Figure 2. Daily water table fluctuation at piezometer P2.6 relative to rainfall from May to December 2017.

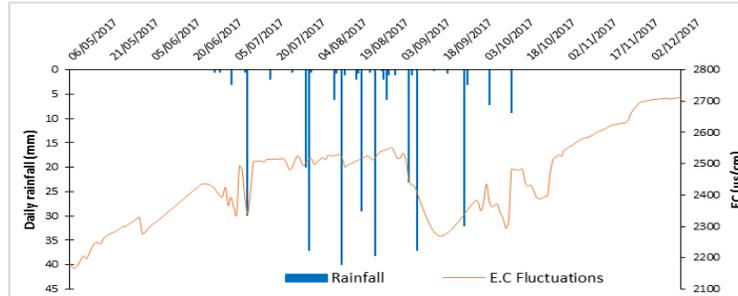


Figure 3. Groundwater EC & daily rainfall in the peri-urban Thiaroye aquifer from May to December 2017.

3. Conclusion and Recommendations

High-frequency (hourly) monitoring of groundwater levels and salinity provide new insight into the nature of recharge to the shallow Thiaroye aquifer underlying Dakar. Together with seasonal monitoring of groundwater quality, these observations suggest that recharge derives from rainfall and effluent from on-site sanitation systems. Further research is required to inform an evolving conceptual model of the Thiaroye aquifer as well as groundwater flow and transport modelling in order not only to quantify recharge but also to inform a groundwater management model that recognizes the attenuation capacity of the Thiaroye aquifer. Such models will be used to assess the viability of urban groundwater abstraction for peri-urban irrigated agriculture and risk posed by seawater intrusion

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