First step to understand the importance of new deep aquifer pumping regime in groundwater system in a developing country, Kwale, Kenya

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UPGro is funded by:

A. INTRODUCTION

Global population growth not only causes increased demand for fresh water, but also provokes a decrease in the quality and quantity of this resource. To avoid this deterioration it is essential to undertake careful management of surface water and groundwater (Pimentel et al., 2004). Groundwater management starts with an accurate hydrogeological characterization of the aquifer system. This is particularly important in aquifer systems with fast-changing abstraction regimes, as is the case for aquifers in many African countries. In this study of Kwale County, Kenya, we characterize the coastal groundwater system made up of an unconfined shallow aquifer and a confined deep aquifer underlying the shallow.

This groundwater system has long served urban water demands, local communities and an established tourism industry, but now faces unprecedented ground and surface water resource demands, especially from KISCOL's (5,500 hectares of irrigated sugarcane) and the country's largest mining operation (Base Titanium Ltd.) which commenced operations in 2013.

Figure 1. Location of the study area of the project

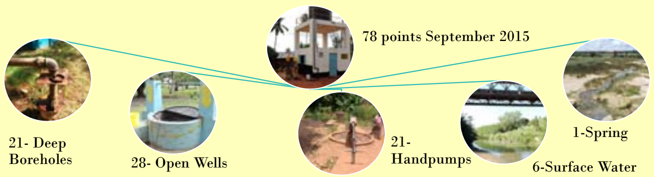
Despite both companies having drilled deep boreholes around the study area (416 km2) to extract groundwater from the deep aquifer, no major pumping activity has started yet, allowing baseline evaluation. Scattered around the study are 440 handpumps (Thomson et al., 2012) accessing the shallow aquifer to provide drinking water to over 90,000 people.

This work is part of the "Gro for Good: Groundwater Risk for Growth and Development" project, one of a number of consortium projects funded through the UPGro Progamme - Unlocking the Potential of Groundwater for the Poor (*http://upgro.org/consortium/gro-for-good/*).

B. OBJECTIVES

The main aim is to define the system and to understand the complex interactions between the aquifer units and water users before major pumping starts. In this presentation we show the results obtained from the first field sampling survey (Sept 2015).

C. METHODOLOGY



Field Parameters

Ph and Temperature
- Eutech pH 6+ pH/ORP

Electrical Conductivity EC_{25}
- HANNA conductivity meter

Alkalinity
- Digital tritator by HACH of the USA

Laboratory Analysis

Cations
- ICP-AES

Anions
- ionic chromatography

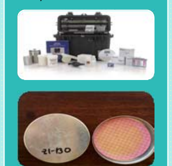
Trace Elements
- ICP-MS

Isotopes $\delta D/\delta^{18}O$
- ionic chromatography

Alkalinity
- Potentiometric titration

Faecal Bacteria Analysis

DelAgua Kit
- CFU/100ml



D. RESULTS and DISCUSSION

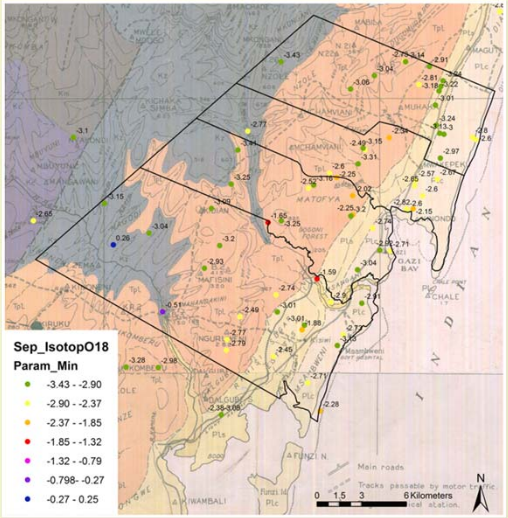


Figure 2. Water isotopes $\delta^{18}O$ in September 2015

The isotopic signal is lighter at higher altitudes such as Shimba Hills Range (west area).

Similar signals are found in the samples from the deep boreholes located on the coastal area.

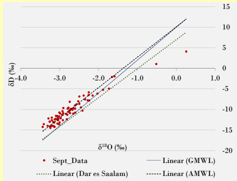


Figure 3. Oxygen and hydrogen isotopes ratios of all points sampled in September 2015. The solid line is the global meteoric water line, dotted line is Dar es Salaam and dashed line is Africa meteoric water line (Levin et al., 2009)

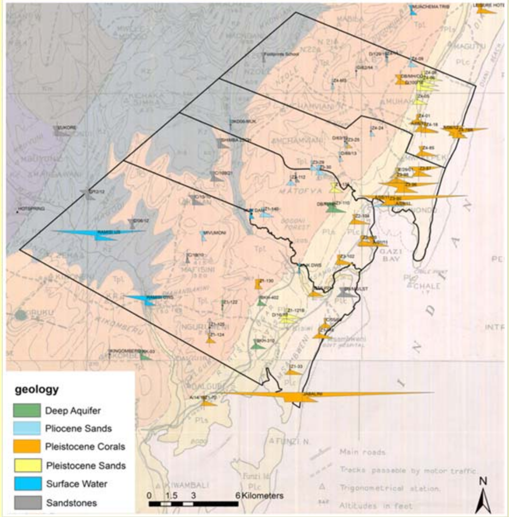


Figure 5. Stiff diagrams with geological map of the study area from September 2015.

Hydrochemical results:

Calcium bicarbonate facies are predominated.

Most of the wells which present saline intrusion are located on the coastal area, on Pleistocene coral geological materials.

There is a clear correlation between stiff diagrams and geological units.

The residence time is low.

Total Thermotolerant Faecal (TTF) Bacteria pollution:

21 of the 25 wells which are polluted by TTF supply drinking water to local communities.

Faecal contamination of river water samples is likely due to herds of livestock (sheep, goat and cattle).

Most points showing TTF contamination are open wells, without sanitary covers.

In this case, bacteria could come from the nearest pit latrine through the aquifer to the well or from outside to inside the bucket (i.e. from non-hygienic conditions of the bucket used for water collection).

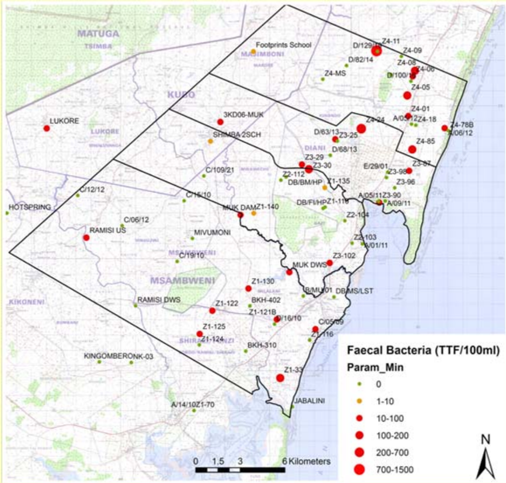


Figure 4. Total Thermotolerant Faecal Bacteria TTF/100 ml in September 2015

Nitrate pollution:

4 of the 5 most contaminated wells are used for drinking water supply.

At the moment, the source of the pollution is unknown. Possible sources include infiltration from pit latrines or animal defecation.

Water samples from wells around sugar cane fields showed a nitrate concentration of between 10 and 30 mg/L.

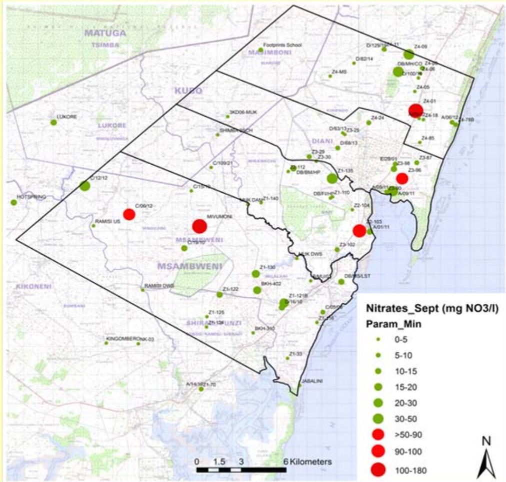


Figure 6. Nitrate concentration in mg/l in September 2015

E. CONCLUSIONS

-This initial field survey and analysis has provided a useful start towards understanding the recharge rate and area for the deep aquifer and characterizing the groundwater quality of both deep and shallow aquifer systems.

-Improved knowledge of the deep aquifer system will be very important for sustainable water management in the Kwale area as further demands are placed on this resource.

-Isotopic signals suggest that the recharge area of the deep aquifer is located on the west part of the study area, on the Shimba Hills Range, and that the recharge of the aquifer is quite fast.

-As so many people depend on the shallow aquifer for their drinking water, monitoring water quality in this aquifer is also important for management. TTF pollution is indicated in many open wells, although the source is not yet defined (see Future research). The wider project will be gathering more evidence relating to the impacts that improved water supplies can have on community health.

-The industrial sugar cane plantations do not appear to be a source of nitrate pollution.

F. FUTURE RESEARCH

- Study the hydrochemical evolution of the system comparing dry (March) and wet (June) seasons.
- Define the connection between aquifer units.
- Create a groundwater flow model of the system.
- Define the sources and mechanisms of chemical and biological contamination.

G. REFERENCES

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Acknowledgements:

The research is primarily supported under the NERC/ESRC/DFID Unlocking the Potential of Groundwater for the Poor (UPGro) as a Catalyst Grant (NE/L001950/1) with work extending until 2019 as a Consortium Grant (NE/M008894/1), see http://www.upgro.org. Data for the paper will be publicly posted on the National Geoscience Data Centre and the UK Data Archive under the terms of the UPGro data management agreement.