Mapping local groundwater flow systems in the regolith of Dodowa, Ghana

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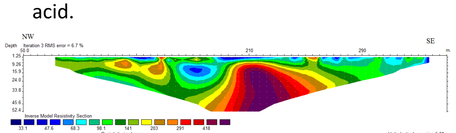
In the township of Dodowa, households use water from a variety of sources. For ~38% of the population, the main source is groundwater from private dug wells or boreholes, while 56 % accesses piped water from the public water supplier (Gronwall, 2016). For 73% of the population, the second source of water is groundwater from wells or boreholes. The objective of our research was to carry out a groundwater flow systems analysis (GFSA) in order to prepare a groundwater management plan.

2 Methods

- Dodowa is located close to Accra in Ghana.

- We carried out an Electrical Resistivity Tomography study of the area with 8 transects of 200-1000 m each.
- We drilled 12 holes at 8 locations with depths ranging from 15 to 50 m. In addition, we carried out multi-screen pumping test, recovery tests and slug tests using automated pressure transducers in order to obtain aquifer characteristics.
- We carried out an inventory of all wells in the Dodowa area, whereby groundwater levels and water use was recorded.
- We took some 40 groundwater samples and analysed them for all major cations, anions, selected trace metals, and TOC at the UNESCO-IHE laboratories in Delft.
- Finally, for a number of drill core samples reactive metal ion concentrations were determined by leaching in dilute (0.43 M) nitric acid.



Example of ERT section (upper left); Drilling rig used (right); At bh8, we drilled 4 separate wells of various depths (15, 25,35, and 50 m; lower left)

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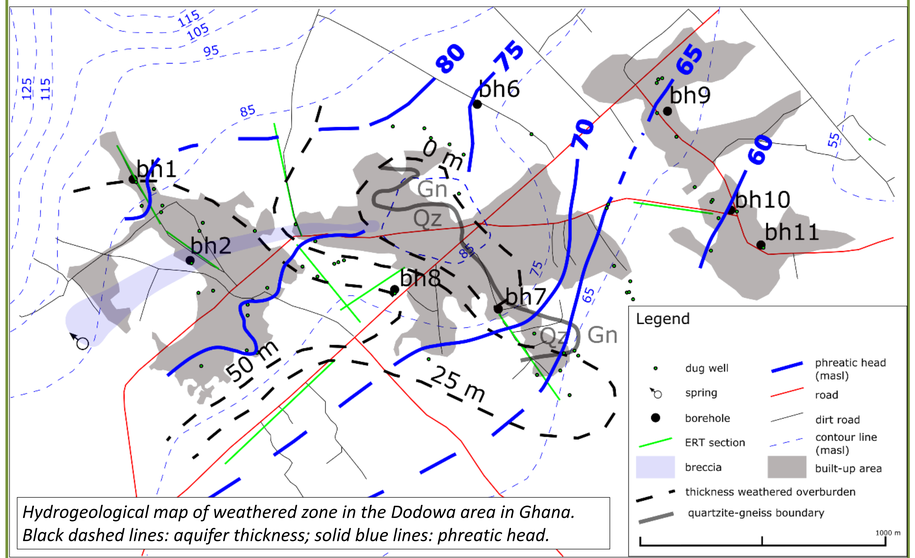
3 Results – Hydrogeological map

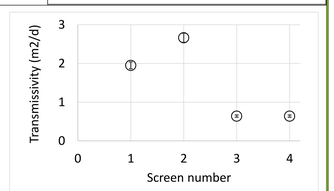
The geology of the area is mainly composed of weathered quartz-arenites and phyllites of the Togo Structural Unit on the western side of the study area and weathered hornblende gneiss of the Dahomeyan Structural Unit on the eastern side. The thickness of the weathered zone varied from a few meter to a few 10s of meter. Groundwater tables were within the weathered zone, roughly 1-5 m below the surface and the groundwater head gradient was from NW to SE.

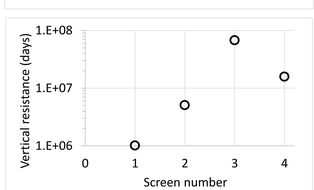


Hydrogeological map of weathered zone in the Dodowa area in Ghana. Black dashed lines: aquifer thickness; solid blue lines: phreatic head.

Results – Aquifer characteristics and hydraulics

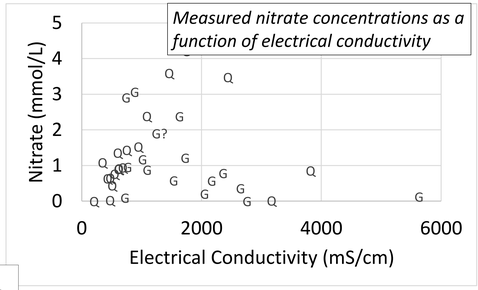
Transmissivity values of the weathered zone above the quartzites ranged between 0.5 and 3 m2/day (see figure right). Furthermore, at location bh8, pumping tests carried out with multiple observation wells in vertical direction revealed that resistance against vertical flow in the weathered zone ranged between 1E6 and 1E8 days (figure right). Such high values indicate that flow in vertical direction is likely to be limited.
Groundwater flow in the gneissic area is limited to interconnected fractures. The transmissivities of these fractures is generally in the order of 0.1-1 m2/d.

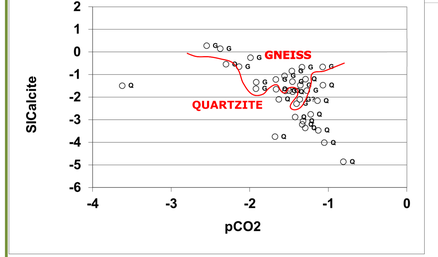




3 Results - Chemistry

Electrical conductivity values ranged from 200-5600 uS/cm, while nitrate concentrations ranged from 0-4 mmol/L (0-240 mg/L), which indicated infiltration and nitrification of on-site disposed waste water. Generally, TOC values were low (1-6 mg/L). Samples with high EC-values and no nitrate were found towards the south and south east. These samples indicated that evapotranspiration had occurred.





With PHREEQC determined calcite saturation index as a function of the partial CO2 pressure

Hydrochemically, samples from gneiss and quartzite type of groundwater could be best distinguished using the saturation index of calcite as a function of pCO2. Due to the higher reactive metal ion concentrations, as indicated by the dilute nitric acid leaching experiments (data not shown), groundwater in the gneissic Dahomeyan Structural Unit contained more calcium, sodium, and magnesium.

4 Conclusions

- Transmissivities of the weathered Togo and Dahomeyan Structural Units are low, but despite this, the layer stills act as an aquifer for local self-supply of groundwater.
- Most groundwater sampled contained high nitrate concentrations due to waste water infiltration combined with nitrification in the apparently aerobic weathered zone.
- Due to very thin weathered zone towards the south, we expect that groundwater system development is local and confined to the Dodowa area.
- Groundwater management strategies have to be aimed at non-potable limited usage.

5 Reference

Gronwall, J., 2016. Self-supply and accountability: to govern or not to govern groundwater for the (peri-) urban poor in Accra, Ghana. Environ Earth Sci (2016) 75:1163. DOI 10.1007/s12665-016-5978-6.