Environmental indicators of recharge to basement aquifers of Tanzania

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One of the main uncertainties surrounding the impact of climate change in Africa is its effect on water supplies. Adding to this uncertainty is a lack of information on recharge to the weathered basement aquifers and how these aquifers respond to rainfall and abstraction.

Residence time indicators (such as CFCs) which can indicate the amount of modern recharge in abstracted groundwater, can be a helpful first step in identifying whether active recharge is occurring. Simple chloride balance techniques are also useful to provide an indication of the proportion of recharge. We report the results of using these environmental indicators in the Singida area of Central Tanzania as part of a wider study of groundwater chemistry in the basement aquifers.

The study area: rural Tanzania

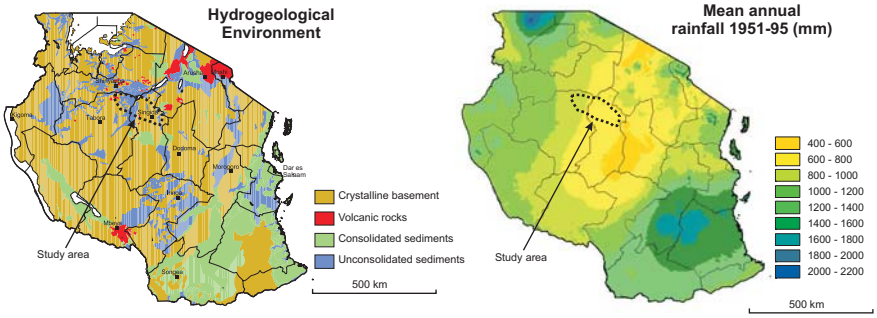
The Singida area of Central Tanzania is typical of many rural areas of sub-Saharan Africa. Population is dispersed and rely on groundwater from boreholes equipped with handpumps where available, or more frequently, unimproved wells, dugouts and ponds. Below is a summary of the main hydrogeological issues of the area:

1. Rainfall is low and seasonal: annual totals are between 600 and 800 mm with much of this rainfall occurring between November and April.

2. The area is mainly underlain by weathered granite and metasediments with generally sandy soil, although ferricrete is occasionally present on hill sides and mbuga clays in valleys.

3. Groundwater occurs in both the fractured and weathered zones of the basement aquifer. From the data available from drilling records, groundwater is often found at the base of the weathered zone often 20 40 m below ground surface.

4. Many sources (even boreholes) decline in yield through the dry season and some fail. A major concern for those working the in the area is that this may be an indication of low recharge, and that further climate change may lead to widespread failure.

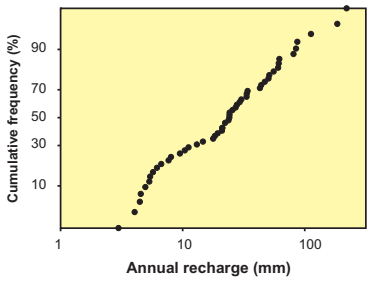


Chloride balance

The chloride balance method was used to estimate the average annual recharge. The method assumes that chloride is conservative in groundwater, and that all effective rainfall recharges to groundwater. Both assumptions are reasonable for the basement aquifers in the area. The method requires chloride concentrations in rainfall to be known: 3 sets of bulk rainfall samples were taken during one rainy season.

The chloride balance of the groundwaters indicates a median recharge rate of 24 mm/yr (n = 54), with a 25th percentile of 10 mm/yr and 75th percentile of 50 mm/yr.

Although the method has limitations,the estimates indicate that for much of the area the recharge required to sustain a handpump is readily available (3 -10 mm/yr)

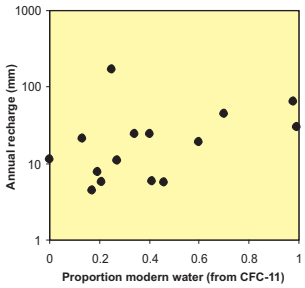


Residence time using CFC

The results of the residence-time survey indicate that there is a modern component (within the past 50 years) to much of the groundwater pumped from the weathered basement. This indicates that the recharge estimated from the chloride balance method is not from an earlier era, but that this recharge has occurred in the past few decades.

Most of the samples indicated a mix of modern and older water, suggesting that the aquifers are not highly vulnerable to short term climate variability, but have older waters to help buffer changes. There was no strong correlation of residence time with depth, suggesting the groundwater is well mixed.

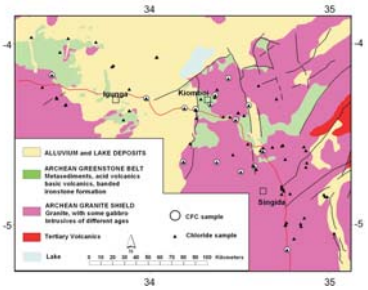
CFC-12 concentrations were less reliable than CFC-11, possible as a result of temperature effects.



Methods

Groundwater sampling was carried out during two campaigns, the first in March 2002 and the second in August 2002. In total, 85 water samples were taken. . The sample sources included 50 boreholes, 24 large-diameter wells and dugouts, 6 dams and lakes (including 'charco dams'), 1 spring and 4 samples of rainfall (see locations below).

On-site water sampling was carried out with dissolved oxygen, pH and redox potential (Eh) being measured where possible using a flow-through cell. Water samples were collected for subsequent laboratory analysis at the University of Dar Es Salaam and at BGS Wallingford, UK.



Samples for the dissolved gas chlorofluorocarbon (CFC) were taken at 16 of the sites. All these sites compromised boreholes equippled with handpumps. CFC samples were only collected where an airtight connection to the wellhead could be achieved.

Analysis was carried out at BGS Wallingford, UK. Measurements were made of CFC-11 and CFC-12 and results are given as percent modern recharge based on CFC-11 at 25ºC and with individual pressure corrections according to sampling altitude.

Conclusions

1. The study has shown that active groundwater recharge is occurring in the weathered basement aquifers of Central Tanzania, where annual rainfall is in the range 600 - 800 mm/a.

2. Estimated average mean recharge is 10 - 50 mm/a, which is comparable to other studies within Africa.

3. CFC samples indicate that modern recharge is occurring and that water abstracted from boreholes is a mixture of recent water and groundwater at least several decades old.

4. Recharge is therefore unlikely to be a limiting factor on water availability from rural handpumps in Central Tanzania.

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