Case Study Groundwater Quality Lusaka Zambia

From Earthwise
Jump to navigation Jump to search

Africa Groundwater Atlas >> Additional resources >> Case studies >> Case study: Groundwater Quality Lusaka Zambia

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See also the **Hydrogeology of Zambia** page.

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Contents

Groundwater Quality in Lusaka, Zambia

Introduction

Unregulated development of groundwater sources leads to concerns over water supply sustainability and water quality. This is particularly true in urban and peri-urban areas where inadequate provision of public water supply and waste disposal leads to inhabitants self-supplying – developing their own private water supplies (usually a shallow well or borehole) and installing their own waste disposal facilities (usually a pit latrine or septic tank). Pit latrines and septic tanks pose a potential threat to the underlying aquifer, which is a particular concern where wells or boreholes are located in close proximity.

This case study summarises the results of a project carried out by the University of Zambia and Natural Resources Development College, Lusaka, to look at the impact of septic tanks on borehole water quality in a low-density, high-income area of Lusaka, Zambia. It followed an earlier study that examined the impact of pit latrines on shallow wells in a high-density, low-income part of the city. Both studies found that poor sanitation practices were negatively impacting groundwater quality, with different concerns in the wet and dry seasons.

To read more about this case study see the 2015 report, which is available through IGRAC.

Study Area and Methods

The team of researchers examined the water quality of 20 boreholes in St. Bonaventure suburb, 10km south west of Lusaka city centre (Figure 1). Each borehole tested was located in a household that also had a septic tank.

The lack of groundwater legislation prior to the 2011 Water Resources Management Act, and subsequent lack of implementation of this act, means that households have been able to sink wells and boreholes regardless of what other activities are taking place around them. This has resulted in boreholes and septic tanks from neighbouring properties being located very close to each other (Figure 1).

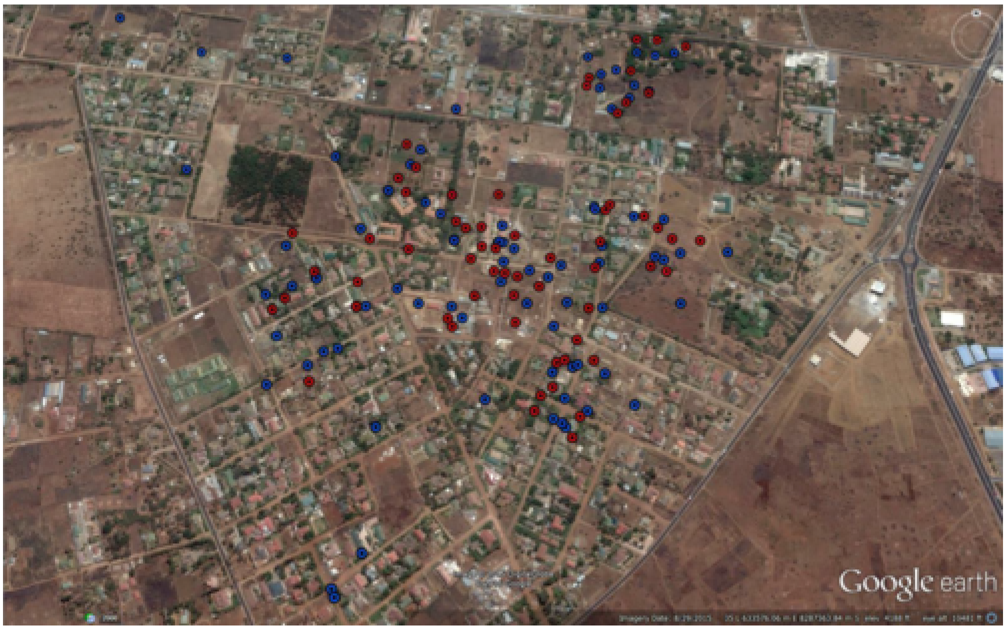

Figure 1: St. Bonaventure study site. Boreholes shown in blue, septic tanks in red (reproduced from Nkhuwa et al., 2015)

Prior to Zambia's 2011 Water Resources Management Act, there was also no requirement for individuals to record data about their personal boreholes, therefore little was known about the depth of the boreholes tested, or the depth of the pump extracting water from the boreholes. Water samples were taken from household taps because the boreholes were largely sealed.

Water samples were collected in the dry season of 2013 and the wet season of 2014. Samples were tested for 10 physico-chemical parameters and 2 microbiological parameters (Table 1).

Table 1: Groundwater Quality Sampling

Physico-chemical parameters	pH, specific electrical conductivity (SEC), total alkalinity, total hardness, nitrate, chloride, sulphate, calcium, magnesium, sodium, potassium
Microbiological parameters	Total coliforms, faecal coliforms

Hydrogeology

The area is underlain by carbonate rocks belonging to the Katanga supergroup, which are intensely karstified and laterally extensive. Groundwater flow occurs in a well-developed system of conduits and channels, making the aquifer highly transmissive, and typically providing high-yielding boreholes.

The bedrock aquifer is unconfined and overlain by permeable superficial deposits of varying thickness. The superficial deposits are hydraulically connected to the underlying bedrock aquifer and the water table is therefore often very shallow. Direct recharge from rainfall occurs over the entire extent of the aquifer.

The properties of the bedrock aquifer and superficial cover mean that contaminants can enter the aquifer and be transmitted through it quickly and easily. Pollutants from a septic tank, or other surface activities, could therefore easily reach a borehole or well unattenuated.

More information about the geology and hydrogeology can be found on the **Hydrogeology of Zambia** page.

Water Quality Results

Groundwater from all 20 boreholes sampled was very hard (above the World Health Organisation's recommended limit of 100 mg/l for drinking water) and alkaline due to the underlying carbonate geology.

Several parameters showed lower concentrations in the wet season than the dry season, although in some cases the differences were small. Parameters showing reductions in the wet season included SEC, pH, total dissolved solids, sulphate, chloride, nitrate, and calcium. The authors attribute this to dilution from increased rainfall and aquifer recharge. They also indicate that the nitrate:chloride ratio suggests the source of nitrate contamination was likely anthropogenic and derived from wastewater. It should be noted, however, that even in the dry season, nitrate concentrations remained below the World Health Organisation's recommended limit of 50 mg/l for drinking water.

Only 10% of boreholes showed bacterial contamination in the dry season, and 20% in the rainy season. The researchers had expected that rainwater would flush bacteria through the system into the aquifer, thus increasing contamination more significantly in the rainy season. This had been observed from groundwater sampling undertaken the previous year where 36% of 55 samples from the same study area had shown the presence of coliforms during the wet season. However, rather than concluding that the lower than expected levels of coliforms was indicative of on-site sanitation having no impact on groundwater quality, the authors attribute this to much lower than average rainfall in the month prior to sampling.

The research team also compared the St. Bonaventure results to data from a high-density low-income area, located around 5km from this study site. Pit latrines and shallow wells were used here, in contrast to boreholes and septic tanks. In this location, coliforms also increased and chemical parameters decreased in groundwater sources in the wet season. The team again attributed this to dilution of chemical parameters and simultaneous flushing of microbes into the aquifer system during increased rainfall. These effects were greater in the low income area than in St. Bonaventure. They attributed this not only to the fact that the low income area had unprotected latrines rather than septic tanks, but also that the wells in the low income area were shallower, providing less opportunity for attenuation of microbacterial contaminants.

Implications of on-site sanitation for groundwater quality in Lusaka, Zambia

Prior to this study there was a perception that unprotected pit latrines in poorer, high-density settlements were primarily responsible for groundwater pollution in Lusaka and resulting repeated outbreaks of cholera in the city. This study aimed to look at the potential risk of septic tanks to groundwater quality in high-income, low-density settlements.

The study concluded that contamination from waste water disposal points was a risk not only in low-income high-density areas without sewage infrastructure, but also in high-income low-density areas. Installation of septic tanks alone is insufficient to protect against contamination of groundwater – an adequate distance between septic tanks and boreholes, maintenance of boreholes, and regular emptying and management of septic tanks also has to be implemented. This is likely to become increasingly important as the city expands further into areas without provision of public water supply and centralised sewer networks.

Sources

Nkhuwa D.C.W., Namafe C.M., Chabwela H., Phiri L., Chompolola A., Mweemba C.E., 1Kabika J. 2015. Groundwater Resource Management in the St. Bonaventure Township, Lusaka. Delft: IGRAC

Return to Africa Groundwater Atlas >> Additional resources >> Case studies

Categories:

- Case study
- Additional resources
- Africa Groundwater Atlas

Navigation menu

Personal tools

- Not logged in
- Talk
- Contributions
- Log in
- Request account

Namespaces

- Page
- Discussion

☐

Variants

Views

- Read
- Edit
- View history
- PDF Export

☐

More

Search

Search Go

Navigation

- Main page
- Recent changes
- Random page
- Help about MediaWiki

Tools

- What links here
- Related changes
- Special pages
- Permanent link
- Page information
- Cite this page
- Browse properties

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