Livelihood challenges posed by water quality in the Mzingwane and Thuli river catchments, Zimbabwe

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Abstract

Most strategies to improve rural livelihoods, such as upgrading agriculture, improving water supply and sanitation or industrialisation require increased water supply. In semi-arid areas, water resource availability is an obvious constraint. Water chemistry, which is a major control on the quality of water resources, can also be a constraint. Human health requires water that is both safe to drink (especially low in metals and nitrates) and palatable. Water for livestock must meet similar requirements. Water for irrigation – a major livelihood intervention in low rainfall areas – must have low salinity levels in order to avoid clogging delivery systems and must also be safe for plants. On this basis, many livelihood interventions require a water quality assessment.

This study looked at the possible impact of ambient water quality on livelihood interventions in two river catchments in low rainfall areas of south-western Zimbabwe. 36 water samples were collected from rivers and alluvial aquifers in the Mzingwane and Thuli river catchments. The samples were analysed for alkalinity, cadmium, calcium, chloride, copper, fluoride, iron, magnesium, manganese, nickel, nitrate, nitrite, pH, phosphate, potassium, sodium, sulphate, total dissolved solids and zinc.

Results show that the ambient river water quality in the upstream tributaries is generally satisfactory, although some parameters such as arsenic and antimony were not analysed for. Water in some river reaches show high (although not toxic) metal levels. This is partly an ambient condition and partly due to pollution from mining. The latter can be better managed to reduce any risk to human and livestock health.

The principle challenge encountered is that many alluvial aquifers in the downstream catchments, especially smaller aquifers and those on river bank flood plains, are characterised by high levels of sodium and chloride. This is an ambient condition, related to the geology of the aquifers, and threatens irrigated agriculture with equipment or crop failure. It necessitates the characterisation of boreholes and other water points as suitable or unsuitable for irrigation, prior to interventions such as drip kit distribution. Some alluvial aquifers showed elevated nitrate levels, which is a serious risk if the water is used for human consumption. Awareness campaigns are required to inform residents of those river reaches and aquifers where water is unsuitable for human consumption.

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1. Introduction

1.1. Water quality requirements of rural livelihoods

Most strategies to improve rural livelihoods, such as upgrading agriculture, improving water supply and sanitation or industrialisation require increased water supply. In semi-arid areas, water resource availability is an obvious constraint. Water chemistry, which is a major control on the quality of water resources, can also be a constraint. Human health requires water that is both safe to drink. Safe drinking water, as defined by the WHO (2004), is water which does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Infants and the elderly are generally at greater risk. Drinking water must especially be low in metal, fluorides, nitrates and nitrites (Ncube and Schutte, 2005; WHO, 2004). It must also be palatable in terms of taste, odour and colour (DWAF, 2006a). Water for domestic purposes also includes water used for bathing and laundry, which requires low carbonate levels. In Zimbabwe, 90 % of rural households consume untreated water (Hoko, 2005). For this reason, the ambient water quality is of high importance.

Water for livestock must meet similar health requirements to drinking water. In addition to micro-organisms, livestock are sensitive to high levels of transition metals, sulphates, nitrates and fluoride (DWAF, 2006c). Providing water for irrigation is a major livelihood intervention in low rainfall areas, and it must have low levels of total dissolved solids in order to avoid clogging delivery systems and must also be safe for plants, especially in terms of low metal levels (DWAF, 2006b).

Because of these risks, many interventions in rural livelihoods have definite water quality requirements. They therefore require a water quality assessment. This study looked at the possible impact of ambient water quality on livelihood interventions in two river catchments in low rainfall areas of south-western Zimbabwe.

1.2. Study area: the Mzingwane and Thuli River Basins

The Mzingwane and Thuli Rivers are left-bank tributaries of the Limpopo River in Zimbabwe (Fig. 1). The basins show a strong division in agro-ecological and socio-economic structure:

1. The northern areas (north of a line from Kezi to Gwanda), have higher rainfall, better soils, more commercial agriculture, higher population density and higher household incomes. These areas lie within Natural Region IV, with low (under 650 mm) and unreliable rainfall, and poor soils.
2. The southern areas have lower rainfall, poor soils, more communal lands (smallholder farm land held under traditional land tenure) and ranchlands, lower population density and lower household incomes. These are mainly in Natural Region V, with poor soils, rainfall under 600 mm and in places under 450 mm.

The rainfall is erratic, with annual rainfall at Esigodini in ranging from 1200 to 200 mm over the last 70 years, and at Beitbridge from 500 to 50 mm for the same period. A drought year may easily record less than 250 mm, such as the 2004-2005 season in southern Zimbabwe and Mozambique (Love *et al.*, 2006a). Rainfall for a single site can vary by up to 1000 mm from year to year (Twomlow and Bruneau, 2000). Preliminary analyses suggest that daily rainfall within the rainy season is also highly variable in time and space. Rainfall appears to have

been declining across the catchment for the last 70 years, although the trends have low R2 values, probably due to sub-decadal cyclicity (Love *et al.*, 2006b).

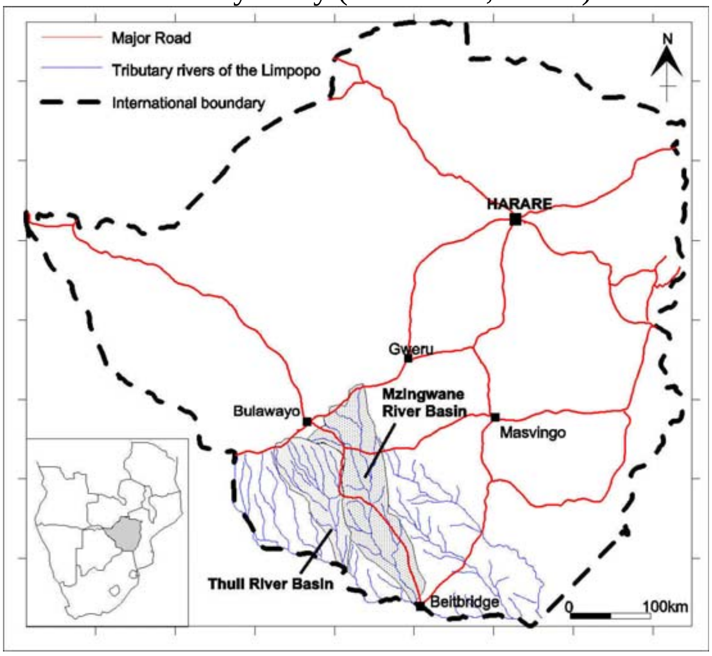


Fig. 1. Location of the Mzingwane and Thuli Basins within Zimbabwe.

The Mzingwane and Thuli Basins contribute to the Limpopo Basin around 7.9 mm/a and 15.7 mm/a mean annual unit runoff respectively (Chibi *et al.*, 2005). The main rivers are sub-perennial in their upper reaches and ephemeral in the lower reaches.

Groundwater resources are controlled by the geology of the basins (Fig. 2). The alluvial aquifers of the Mzingwane Catchments are the most extensive of any tributaries in the Limpopo Basin (Görgens and Boroto, 1997). They are extensive, forming ribbon shapes covering over 20 km in length and areal extents ranging from 100 ha to 255 ha in the channels and 85 ha to 430 ha on the flood plains (Moyce *et al.*, 2006). Smaller alluvial aquifers occur along many of the tributaries of the Mzingwane and Thuli Rivers. The granite and gneiss backbone of Zimbabwe is a secondary aquifer, with the main components being the weathered regolith and in fractures on the bedrock (Owen, 2000). In such rocks, fracture porosity contributes to higher permeability and transmissivity.

Many of the headwater tributaries are dammed to supply water to Bulawayo, Zimbabwe's second largest city. Sheet and Blanket Dams supply water to the City of Gwanda and Blanket and Vubachikwe Mines. Silalabuhwa, Thuli-Makwe and Zhove dams supply irrigation water. Smaller users in the rural areas make extensive use of groundwater for domestic and livestock water supply, supplemented by small dams and rivers (Nare *et al.*, 2006).

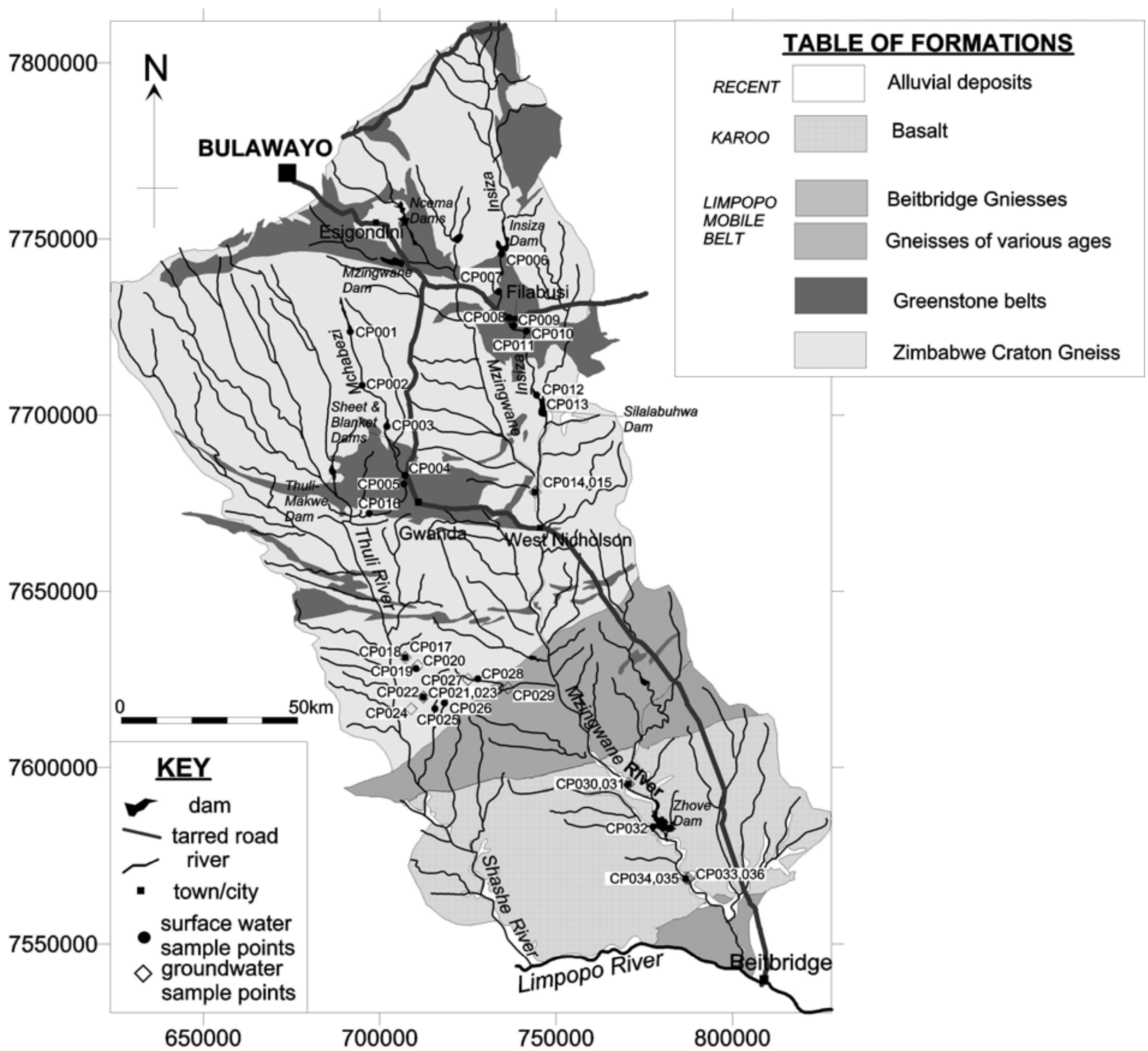


Fig. 2. Geology and location of water sampling points in the study area.

2. Materials and Methods

36 water samples were collected from rivers and alluvial aquifers in the Mzingwane and Thuli river catchments (fig. 2).

The samples were analysed at the National Water Quality Laboratory, Harare. Arsenic, cadmium, calcium, copper, magnesium, manganese, nickel, potassium, sodium and zinc were analysed by atomic absorption spectrophotometry. Iron, nitrate, nitrite and phosphate were determined by Ultra-violet spectrophotmetry. Chloride, alkalinity and total hardness were determined by titration and total dissolved solids by gravimetry. Sulphate was determined by the turbidimetric method.

3. Results

These can be divided into three groups: (i) upper catchment tributary rivers and large dams, (ii) small dams and alluvial aquifers in lower catchment tributaries and (iii) lower Mzingwane River and associated alluvial aquifers.

3.1. Upper catchment tributaries and large dams

Two upper catchment tributaries were studied: the Mchabezi (fig. 3) and the Insiza (fig. 4). The Mchabezi River has high quality water, with small but noticeable rises in most parameters once the river leaves the highlands of its source into communal lands. This area also has a serious siltation problem. Most measured parameters also rise slightly in the mining area but are not noticeably affected by the Gwanda urban area.

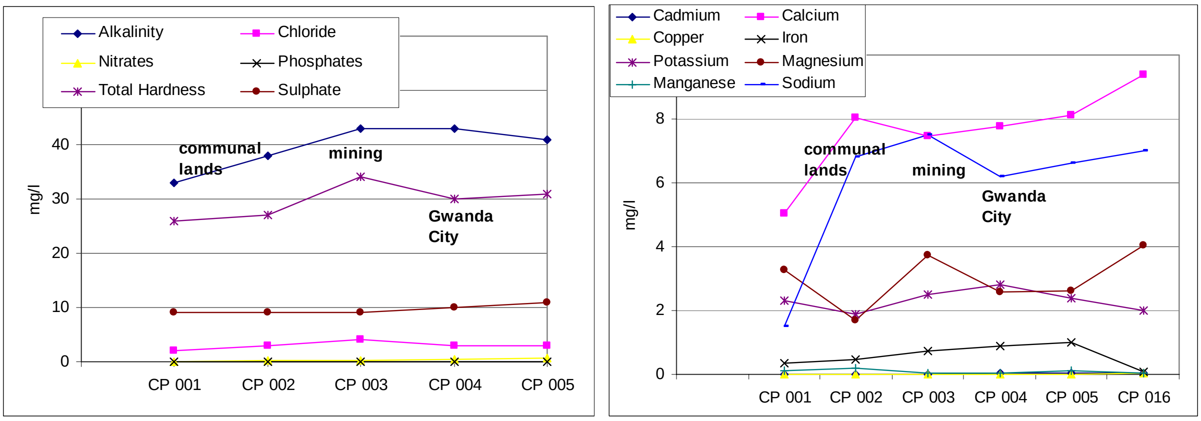


Fig. 3. Water quality variations along the Mchabezi River. See Fig. 2 for sampling point locations.

The Insiza River has lower quality water than the Mchabezi, but parameters remain within water quality standards for domestic use (WHO, 2004) and agricultural use (DWAF, 1996b, 1996c). Most metals, sulphate and hardness rise in the upstream area where there are gold panners, and downstream of Filabusi town, where there are old mines and gold panners.

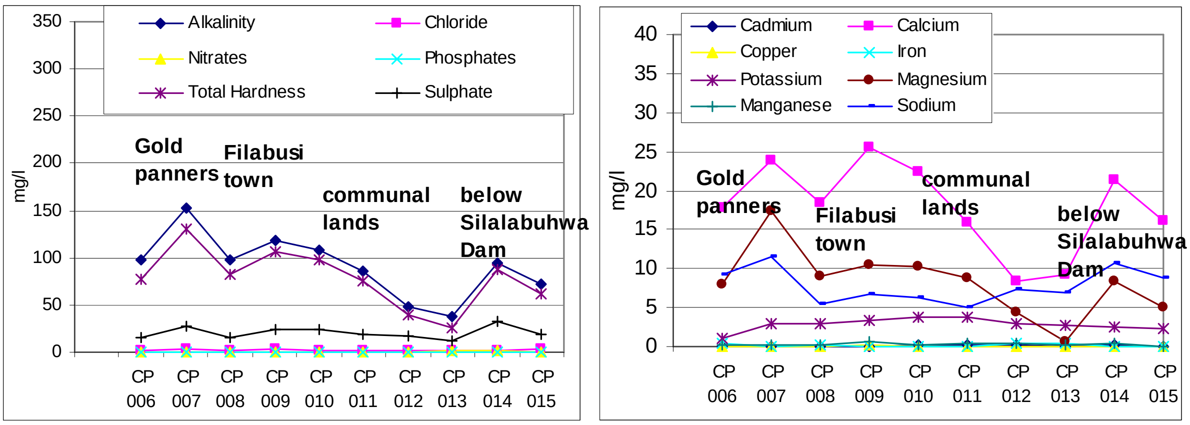


Fig. 4. Water quality variations along the Insiza River. See Fig. 2 for sampling point locations.

3.2. Small dams and alluvial aquifers in lower catchment tributaries

The small dams and associated aquifers (see fig. 5) should widespread high calcium levels. Several of the alluvial aquifers sampled show sodium levels which are too high for crops (CP024, CP026, CP029) and almost all are above the 100 mg/l chloride recommended for irrigation (DWAF, 1996b). Three aquifers also have nitrate levels that are too high for drinking (CP022, CP024, CP026).

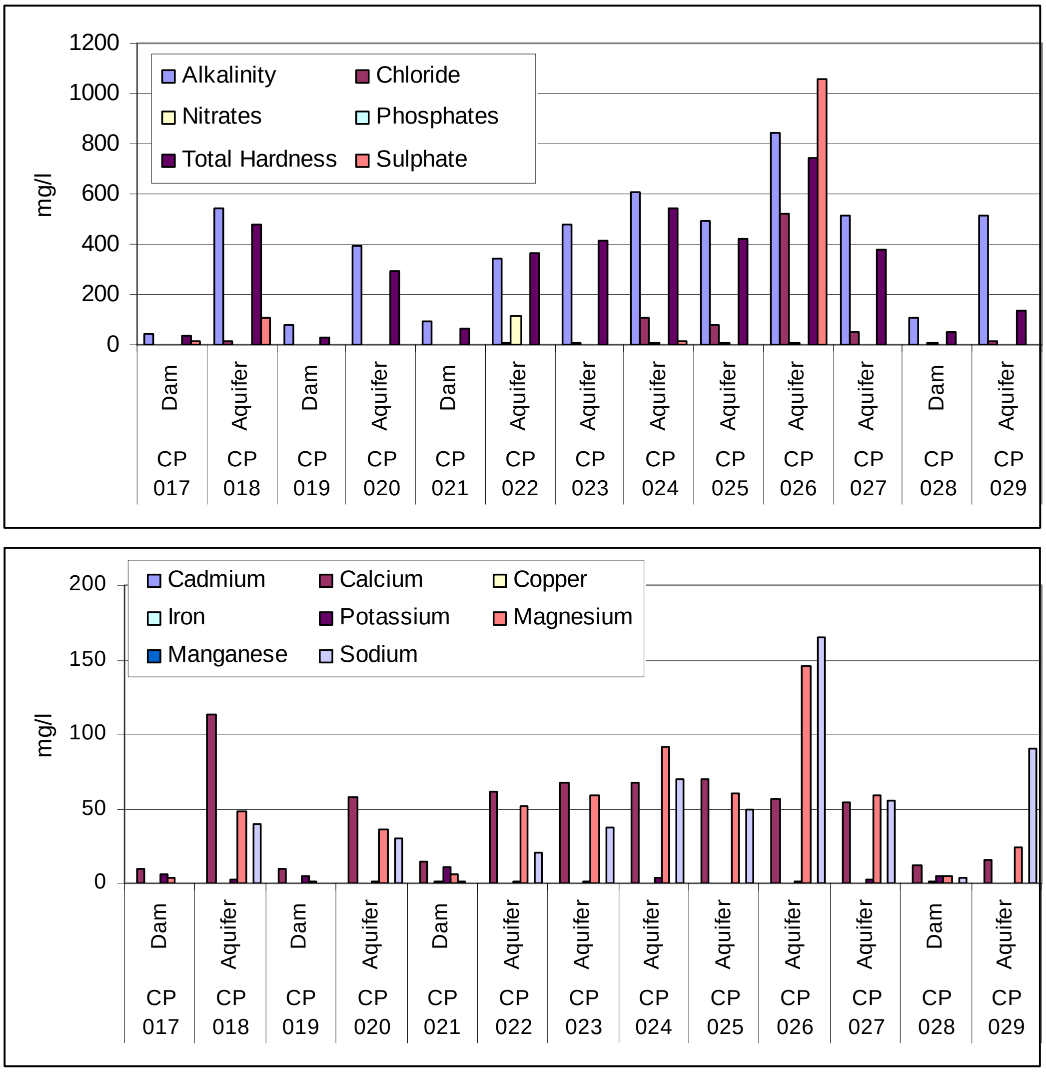
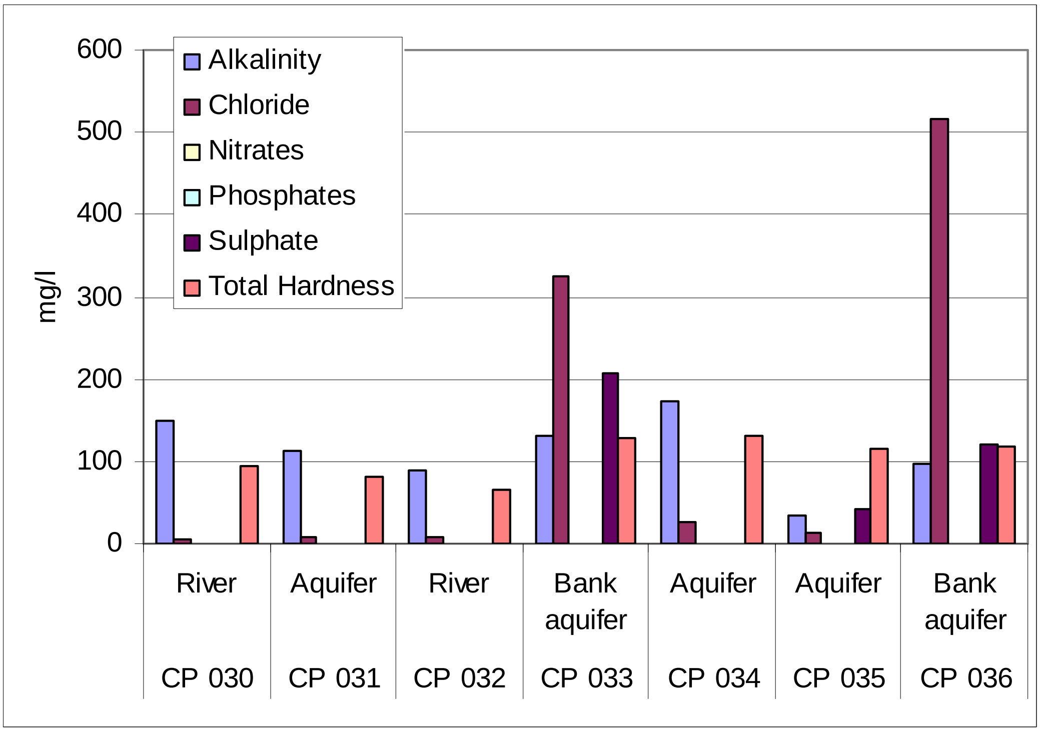


Fig. 5. Water quality from small dams and alluvial aquifers in lower catchment tributaries of the Thuli and Mzingwane Rivers. See Fig. 2 for sampling point locations.

3.3. Lower Mzingwane River and associated alluvial aquifer

The difference in chemistry between the river bank aquifers on the one hand and the rivers and bed aquifers on the other is clear (fig. 6). The bank aquifers (CP033, CP036) show very high levels of sodium and chloride, well above recommended levels for irrigation, livestock watering or domestic use. The riverbed aquifers have similar chemical signatures to the river surface water and are of acceptable quality for most uses.



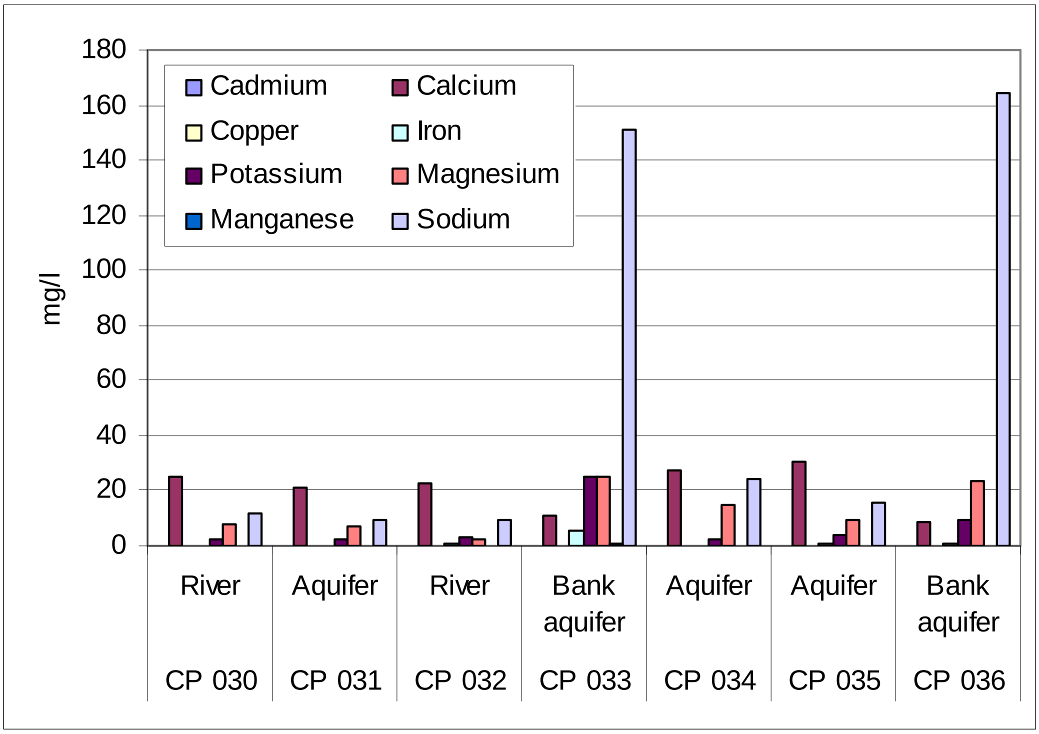


Fig. 6. Water quality variations from the Lower Mzingwane River and associated alluvial aquifer. See Fig. 2 for sampling point locations.

4. Discussion

The ambient river water quality in the upstream tributaries is generally satisfactory, although some parameters such as arsenic and antimony were not analysed for. Nitrate levels need monitoring near the towns, but currently are unproblematic.

In the lower catchments, in contrast to the generally held opinion that groundwater has a higher quality than surface water, the rivers and dams have generally safe water, while some of the aquifers are unsafe due to high nitrate levels. High sodium and chloride levels are likely to affect palatability of water, but are not toxic. They do, however, render some of the groundwater unsuitable for irrigation, especially when drip kits are used. The trend is most extreme for the bank aquifers as compared to the riverbed aquifers.

The problems observed with alluvial aquifers have important implications for water supply development. Since these aquifers provide the principle water sources for rural communities in the south of the study area (Nare *et al.*, 2006), awareness campaigns are required to inform residents of those boreholes where water is unsuitable for consumption. Boreholes where water is too saline for irrigation need identifying and users will need to make arrangements with neighbouring communities for irrigation water. This has important institutional implications, and should be considered prior to interventions such as drip kit distribution. Boreholes with high nitrate levels must be identified as unfit for human consumption, to avoid health risk, especially to infants.

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