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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Water quality

Determining the quality of water in the North West province

The Water Research Commission (WRC) has funded a large-scale study into the quality of selected groundwaters and surface waters in the North West Province.

Background

Water from the North West province catchment areas supports prosperous gold and platinum mining, manufacturing industries, agricultural sector as well as a growing urban and rural population. However, water allocation for the province has almost reached the quota available, based on surface water estimates.

Furthermore, there are reports that source water within the catchment may be exposed to pollution from various sources, but particularly from economic activities. These reports have demonstrated that several surface waters and groundwaters are faecally contaminated and some with opportunistic pathogenic bacteria.

Rainfall in the eastern and central parts of the province is higher than the western part. The latter borders on and is part of the Kalahari Desert. Further social and economic developments as well as climate change will impact on the anticipated water availability, requirements and quality of water.

Baseline data in these categories will be important for long-term planning. Water requirements are national priorities and processes such as the National Water Resource Strategy are in place.

However, detailed large water quality studies have not been conducted all over the country. This WRC-funded study, undertaken by North West University, was an effort to address this gap.

Methodology

Water samples were collected at specific time periods from selected groundwater and surface water sources in the North West province using standard procedures. Standard methodologies were used to collect and analyse the water samples.

A sequential exploratory mixed-methods design was used for the social water management study. A mixed-methods approach includes the use of both qualitative and quantitative research methods to collect, analyse and interpret the research data.

Results and discussion

Quality of surface water sources

Selected river systems covering the upper middle and lower Vaal river management areas were targeted. Average physic-chemical and microbial levels measured at some sites during the 2010 and 2011 seasons were elevated. Some exceeded the target water quality range (TWQR) for full and intermediate recreational contact, livestock watering and irrigation.

Elevated electrical conductivity (EC) when compared to TWQR for drinking water was not at levels likely to cause health impacts. However, this elevated EC could be indicative of increasing salinization occurring. This may have long-term effects on agricultural activities but also on drinking water production.

Enterococcus spp. as well as *Escherichia coli* were isolated from various surface water sources. Isolation of enterococci from surface waters illustrates that any full contact activity in the water is risky, and could result in infectious disease.

Bacteriophage data supported the general findings of the bacterial analysis, namely that many of the water sources in

the North West province have some form of faecal pollution.

Baseline culture-independent molecular profiling data of the dominant bacterial communities in the Vaal River are also provided. Although this profiling has some limitations it allowed for the identification of the bacterial community composition and dynamics in the planktonic component in this river system.

Next generation sequencing or high through-put sequencing analysis presented a better resolution of the bacterial diversity and dynamics in the Vaal River. This technology was not suitable for detecting faecal indicator bacterial in surface water samples that contained known high levels of ***E.coli*** and ***enterococci***.

Results demonstrated that some of the wastewater treatment plants were decanting huge concentrations of enterovirus particles into surface water sources. This was probably due to the operational challenges at the plants.

Some other plants in the province were operating in such a manner that up to 99.99% of enteroviruses were removed. Impacts of municipal wastewater treatment plants as well as other forms of faecal pollution on virus diversity and dynamics in water sources should be further investigated.

Such a study should focus on the percentage of viable viruses that are reaching the water bodies and the epidemiology thereof. In such a virology study the presence of other relevant viruses should also be targeted. Furthermore, detection of bacteriophages in the surface water that are associated with faecal pollution supports the finding that some of the targeted surface water sources in the North West are faecally polluted.

Quality of groundwater

In the North West Province more than 80% of the rural community depend on groundwater for all their water needs. The approach was to mainly target boreholes that provided water for domestic use. This included urban, peri-urban and rural areas.

A total of 114 boreholes were sampled. Physic-chemical analyses demonstrated that the pH and EC levels were at acceptable ranges for domestic use. However, it was found that only 28% (<6 mg/ℓ)of the boreholes tested complied with the South African TWQR for nitrate and 43% of the boreholes had nitrate levels greater than 20 mg/ℓ. this study also demonstrated that groundwater from the North West Province is vulnerable to nitrate contamination.

In 2009, 49% of the 76 boreholes tested were positive for faecal coliforms and 67% for faecal streptococci. A further 47% of these boreholes were also positive for presumptive ***P. aeruginosa*** and 7% for ***S. aureus***. A percentage of 33% nof the boreholes had heterotrophic plate bacteria exceeding 1 000 cfu/ml.

In 2010, 38 boreholes were sampled. Of these 55% were positive for faecal coliforms and 63% for faecal streptococci. During this sampling period, 55% of the boreholes were positive for ***P. aeruginosa***. Detection of faecal indicators was higher in the warm wet seasons than the cold dry season. This was observed in both the number of positive results as well as levels detected.

Next generation sequencing results provided data on the microbial diversity in borehole water of the North West Province. This method is rapid and provided information about the bacterial community structure in these water samples.

It was demonstrated that the winter and summer bacterial compositions were different. In the summer samples there were Gamma and Beta proteobacteria as well as Actinobacteria present. Sequences from ***E.coli*** as well as ***Pseudomonas sp***. and ***S. aureus*** were also detected in the summer samples.

The results indicate that microbiological quality of groundwater in the North West Province may be of concern as more than 75% of boreholes were positive for faecal pollution. This indicates that groundwater should be tested and treated before being supplied to communities.

It was, however, demonstrated that 23% of the boreholes tested negative for both faecal coliforms and faecal streptococci. This result indicates that there are boreholes where no faecal pollution has occurred. This could be due to protection of the borehole and thus the aquifer. Management practices should be put in place to prevent pollution of aquifers.

Potential human health effects

The main human health concern is the high level of nitrates in some of the groundwater sources, some exceeding the 20 mg/ℓ level that could cause methaemaglobinemia. This was not the case with surface water sources in associated areas.

Signs of salinisation were observed for some of the surface water samples. However, at the moment this cannot be linked to human health concerns.

Faecal indicator and opportunistic bacteria were regularly detected in surface and groundwater sources of the North West Province. It was shown that pathogenic ***E.coli*** may also be present among the environmental ***E.coli*** population. Various known opportunistic pathogenic enterococci were regularly detected in surface waters.

Among the yeasts isolated several opportunistic pathogenic species were also regularly detected. These studies were conducted over two separate sampling periods, about one year apart.

The results suggest that these bacteria (and in the case of surface waters also yeast) could be ubiquitous. This is cause for concern and regular monitoring of such sites is proposed.

It could indicate that pathogenic microorganisms such as viruses and bacteria may also be present in these water sources. This study has also detected bacteriophages associated with faecal pollution. The phages are surrogates for human viruses.

What the study has further demonstrated is that enteroviruses are being discharged into receiving surface waters. This study did not determine whether the viruses were viable. However, if one considers that faecal bacteria detected in the water sources were all viable there is a chence that the viruses may also be viable.

The detection of virus genetic material in a water source is thus a cause for concern. all these findings demonstrate that people in the North West Province that directly use untreated water for household purposes or recreation may be exposed to several pathogenic or opportunistic pathogens. Such exposures imply that the health of these individuals may be compromised.

Several of the faecal coliform isolates from surface water tested resistant to multiple antibiotics. These results are of concern, particularly if one considers the potential of the isolates to cause invasive infections in sensitive individuals. In such cases antibiotics may not be effective. The cause of the resistance is unknown.

A social and water management study

Five different themes emerged during the qualitative phase of the study of the interactions of communities of water: perceptions about water, beliefs or attitudes towards water, sources of water, uses of water, and water management.

The study indicates that there are no meaningful differences between the two districts (Dr Kenneth Kaunda and Bophirima) regarding their perceptions about the quality of their water or its availability. The majority of the participants perceive the quality of their water to be average (72%), while 25% though that their water is good, 1% that their water is very good/excellent and only 3% that it is of poor quality.

In addition, the majority of the participants in each of the two districts perceives their water to be a limited resource but different in their opinion regarding how their water is managed. In Bophirima, almost half of the participants (47%) said that they think their water is not managed correctly, while the minority of participants in Dr Kenneth Kaunda district (28%) thought the same.

Around 90% of participants felt that they should not have to pay for water. They also felt that water must be used sparsely and be conserved.

With regard to their beliefs and attitudes towards water, almost half of the participants said that they have a spiritual connection with water (45%) and that they use water, for example to cleanse themselves or others after a funeral ceremony or to make contact with their ancestors.

The study also confirmed that the majority of households make use of municipal water (77%). Sources of water did not differ greatly between the two districts, except in regard to the harvesting of rainwater. In the Bophirima district, communities make more use of rainwater harvesting (32%).

A number of uses different statistically and practically between the two districts. In the Bophirima district, traditional uses such as using water to drive out evil spirits differed from the Dr Kenneth Kaunda district.

Other popular uses of water that scored above 88% include the use of water for house building or other physical structures (for example, in combination with soil), to cook their food, to drink and flush their toilet. More than 90% of respondents indicated that water helps them when they are fasting. A total of 97% indicated that water is used during religious ceremonies.

The majority of households still appear to make use of a tap in their yard. Fewer had access to piped water in their houses. A section of the community was still using a communal tap for which they have to travel less than 50 m or to a lesser extent more than 50 m. Finally, most households appear to store water inside their homes (65%) where it is cooled down in most cases.

Conclusions

Results of the study have shown various trends. Firstly, nitrates in groundwater and salts in surface water are the main physic-chemical hazards. A number of groundwater and surface water sources in the North West Province are polluted with faecal matter.

Furthermore, bacteriophage and enterovirus data indicated that the sources may also contain viruses that could be human pathogens. Large numbers of faecal coliforms and enterocci isolated in this study were resistant to several antibiotic groups. This is cause for concern as it may eventually have human and animal health as well as plant pathology implications.

A cytoxicity test to determine the impacts of microorganisms on human cell cultures was also developed as part of this study. It may be useful in future studies where water quality and suitability of human consumption is determined. The adaptation proposed in the study make it more rapid and precise but also, at the moment, more costly to conduct.

Baseline data on social aspects of source and drinking water management was also provided for six communities from 2 of the 4 districts of the North West Province. The study presented some data on how members of these communities interact with and manage water.

It also demonstrated that certain perceptions, beliefs and behaviour are associated with these interactions. The results demonstrated that water has important social and cultural meaning and that, importantly, future education programmes could build on knowledge existing with these communities.

Further reading:
To order the report, ***A large-scale study of microbial and physic-chemical quality of selected groundwaters and surface waters in the North West province, South Africa*** (**Report No. 1966/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.