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Microbial water quality in the upper Olifants River catchment: implications for health

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INTRODUCTION

The Olifants River is presently one of the most threatened river systems in South Africa, with microbial pollutants being one of the stressors (Van Vuuren, 2009; Ballance *et al*., 2001). Micro-organisms may adversely affect water quality, as microbial pathogens present in water can cause serious human disease. According to the World Health Organization diarrhoeal disease linked to unsafe water supplies remains a major contributor to mortalities in developing countries (WHO, 2004).

In this study faecal indicator levels and selected water-borne pathogens were monitored in the upper Olifants River catchment. The data was used to perform a quantitative microbial risk assessment (QMRA), and was also used to identify possible sources of microbial contaminants. Insights gained can be used to shape and guide mitigation strategies for the remediation of microbial water quality problems within this catchment.

METHODS

Study area

The Olifants River catchment is located in Mpumalanga, South Africa, and covers 54 570 km².

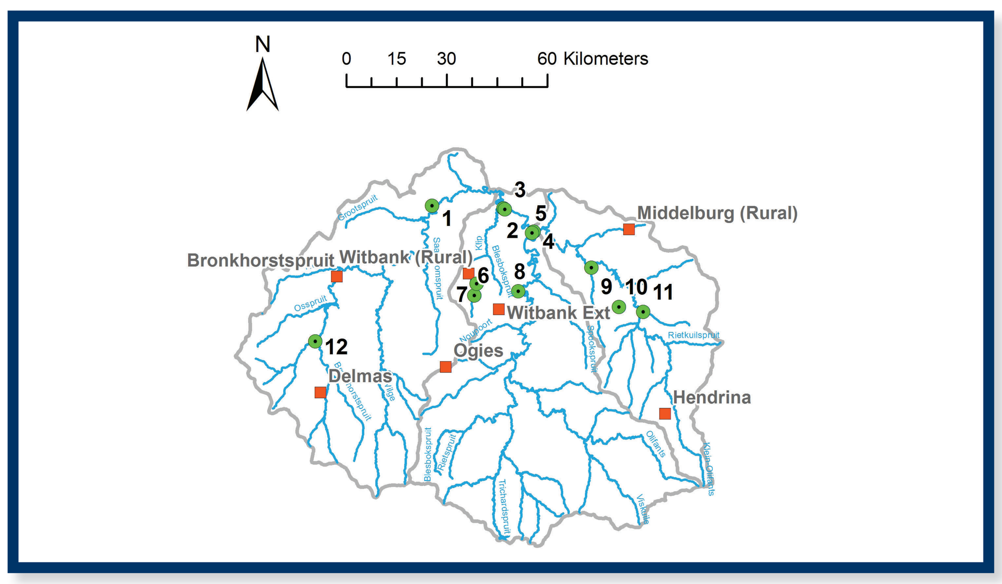


Figure 1: The upper Olifants River catchment study area. Routine sampling sites, numbered from 1 to 12, are indicated

Microbial monitoring

Microbial water quality was monitored over a two year period. In addition to faecal indicator counts (*E. coli*) several pathogens were also monitored for (**Table 1**).

Table 1: Microbial pathogens monitored and the detection method used

Determinant	Method
E. coli	Colilert ™
Salmonella sp.	Real-Time polymerase chain reaction
Shigella sp.	Real-Time polymerase chain reaction
Vibrio cholerae	Real-Time polymerase chain reaction
Giardia sp.	Immuno-Fluorescence Microscopy
Cryptosporidium sp.	Immuno-Fluorescence Microscopy
Norovirus	Real-Time polymerase chain reaction
Enterovirus	Real-Time polymerase chain reaction

- **Year 1:** E. coli levels were monitored bi-monthly at 11 sampling sites (**Figure 1**). Pathogens were tested for bimonthly at the sites that exhibited high faecal indicator counts (FIO) counts. Twelve additional sites were monitored for FIO to determine pollution sources
- **Year 2:** 86 sampling sites were monitored for *E. coli* during low flow conditions using a once-off sampling approach.

Quantitative microbial risk assessment

The average counts and/or detection data for indicator organisms, pathogenic bacteria, viruses and parasites were used to perform a quantitative microbial risk assessment. Doses were calculated based on the conservative assumption that 100ml of untreated river water was consumed (Formulae in Le Roux *et al*. 2012).

RESULTS AND DISCUSSION

High levels of *E. coli* were recorded at three sites (Sites 6, 8, 9), and these sampling points were all located in urban areas and were directly downstream of wastewater treatment works (**Figure 2**). The sites with the highest levels of *E. coli* also harboured the most water-borne pathogens. Bacterial pathogens were present at many of the tested sites. *Salmonella* sp. and *Vibrio cholerae* (non-enterotoxigenic) were highly prevalent, with *Shigella* sp. detected at fewer sites. Protozoan parasites (*Giardia* and *Cryptosporidium*) were more prevalent at sites 10 and 11; these sites are located directly down-stream of cattle feed-lots (**Table 2**).

Table 2: Pathogens detected at sampling sites in the upper Olifants River catchment area

	Salmonella	*Vibrio cholerae*	*Shigella*	*Giardia*	*Cryptosporidium*	Norovirus	Enterovirus
Site 1	••	not detected	not detected	••	not detected	not detected	not detected
Site 6	••••	•	•••	•	not detected	••	•••••
Site 8	••••	••	•••	not detected	not detected	•	•
Site 9	••••	•••••	••••	•	•	••••	••••
Site 10	••	•••	not detected	•••	••	•	•
Site 11	••	•••	not detected	••	•	•	•

• *Each dot corresponds to a detection event, with a maximum of 5 dots possible for each pathogen*

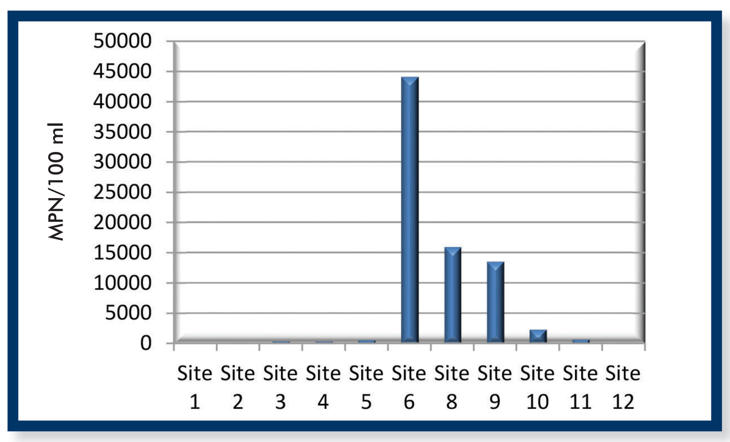
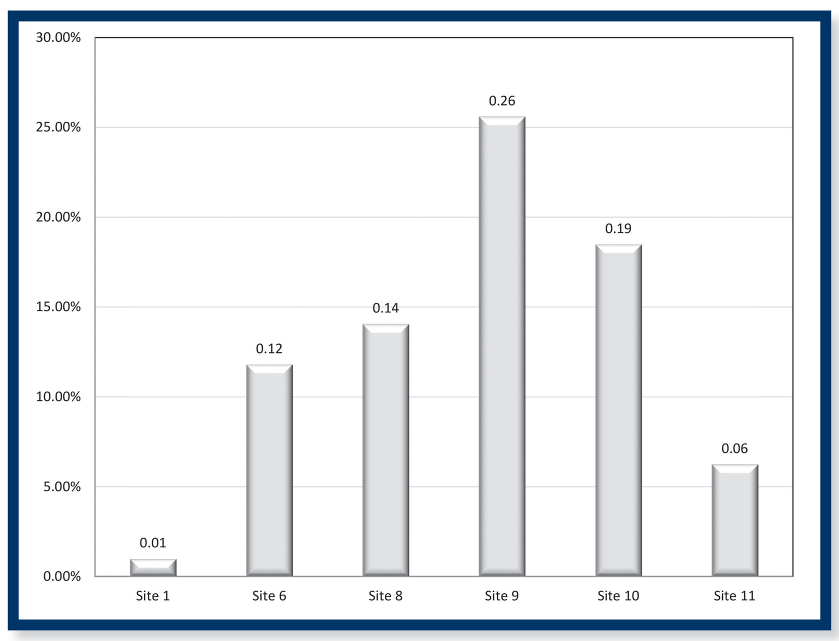


Figure 2: Average *E. coli* counts at sampling sites in the Olifants River catchment

The data obtained was used to perform a QMRA. **Figure 3** indicates the combined probability of infection (risk of infection of all pathogens summed) for the seven pathogens that were monitored for during the study. Water from site 9 (a tributary of the Klein-Olifants River) resulted in the highest risk of infection (Pi = 26%), followed by site 10 (a tributary of the Klein-Olifants), site 8 (Olifants River) and site 6 (Brugspruit/Klip River), ranging from 26% to 12% probability.

Figure 3: Combined probability of infection (Pi) for the seven water-borne pathogens monitored in this study



The seven pathogens represented in **Figure 3** are only a fraction of the total pool of water-borne pathogens that may be present in contaminated waters. In order to provide a representative risk, *E. coli* was used as a surrogate for pathogens in calculating the probability of infection (**Figure 4**). The sites with the highest levels of *E. coli* (sites 6, 8, 9 and 10) had the highest probability of infection, ranging between 70 and 82%.

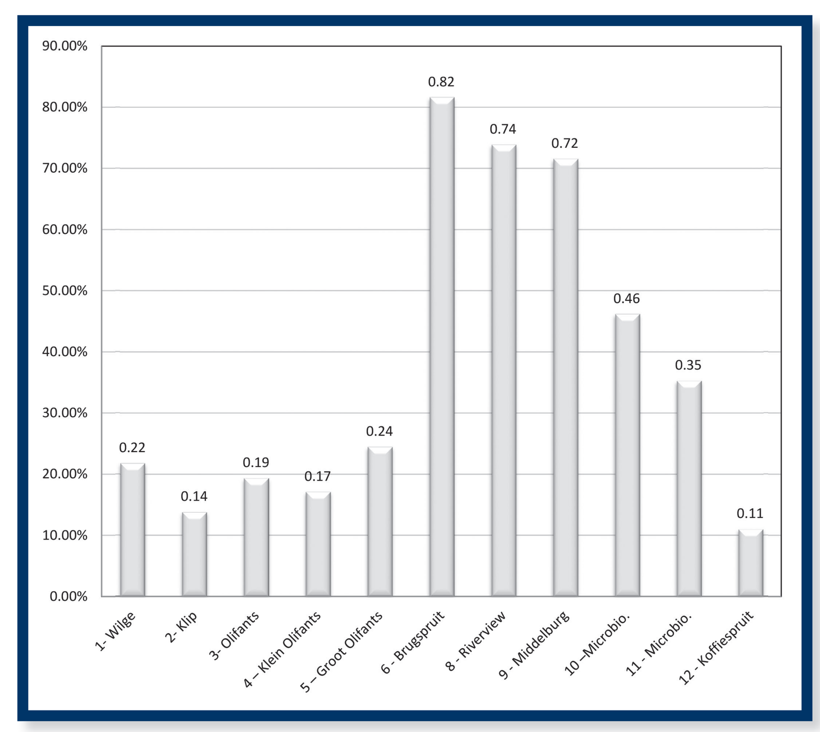


Figure 4: Risk of infection calculated using *E. coli* as a surrogate for water-borne pathogens

Sources of microbial pathogens

In order to gain insight on the sources of microbial pathogens 86 additional sample sites, including all major tributaries of the Wilge, Klein Olifants and Olifants rivers, were sampled in the upper catchment for faecal indicator levels. Of the 86 sites sampled, 12 sites had *E. coli* levels in excess of 1000 MPN/100 ml. Of the twelve sites, seven were located directly downstream of WWTWs, two sites were directly downstream of urban areas, one was located in an area characterised by intensive mining activities, and another two sites were located in agriculture regions. On average the *E. coli* levels were an order of a magnitude higher for sites linked to WWTWs compared to non-point sources like agriculture and other intensive land uses (average *E. coli* counts were 40,000 MPN/100 ml and 2700 MPN/100 ml respectively).

A quantitative microbial risk assessment of water in the upper Olifants River catchment showed that sections of the catchment are highly contaminated with faecal indicator bacteria and pathogenic micro-organisms and that the polluted waters pose an unacceptably high risk to water users within this catchment.

CONCLUSION

It was shown that sections of the upper Olifants River catchment are highly contaminated with faecal indicator bacteria and pathogenic micro-organisms. Data from the quantitative microbial risk assessment also showed that the polluted waters pose an unacceptably high risk to water users within this catchment. Extreme levels of faecal pollution could in most instances be traced back to inadequate wastewater treatment. In order to mitigate water-borne risks in the upper Olifants River, wastewater treatment works need to be maintained and operated in such a way that sewage effluent meets effluent discharge criteria at all times. Until the current short comings are addressed, water users at certain locations within this catchment will continue to be at risk from water-borne infections.

REFERENCES

Balance A, Hill L, Roux D, Silberbauer, M, Strydom W (2001). State of the Rivers Report: Crocodile, Sabie-Sand and Olifants River Systems. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Le Roux W.J, Schaefer L.M, Genthe B (2012).Microbial water quality in the upper Olifants River catchment; implications for health. African Journal of Microbiology Research 6: 6580-6588.

Van Vuuren L (2009). Experts unite to save abused river from extinction. South African Water Research Commission, ISSN: 18167969, Water Wheel 8 : 14-17.

World Health Organisation USA (WHO) (2004). Available (online) at: http://www.who.int/water_sanitation_health/diseases/burden/en/index.html. Date Accessed: 2010-05-03.

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