Analysis of physico-chemical and bacteriological quality of drinking water in Mafikeng, South Africa

Suma George Mulamattathil, Carlos Bezuidenhout and Moses Mbewe

ABSTRACT

Mafikeng, the capital of the North West Province, receives water from two sources, namely the Molopo eye and the Modimola dam. Once treated, the potable water is mixed and supplied to the city via distribution systems. This study was designed to assess the quality of drinking water in Mafikeng and also to determine whether the water from the two sources has an impact on the mixed water quality. Physico-chemical parameters and bacteriological quality (faecal coliforms (FCs), total coliforms (TCs), heterotrophic bacteria and *Peudomonas* spp.) was monitored at three drinking water sites weekly for 4 months. The results revealed that the physico-chemical quality of the water was generally acceptable. The pH ranged from 5.7 ± 0.18 to 8.6 ± 0.14, the temperature ranged from 18.3 ± 0.69 to 25.1 ± 0.69 °C and the total dissolved solids (TDS) ranged from 159.9 ± 22.44 to 364.4 ± 12.44 mg/l. These values are within the target water quality range for drinking water as prescribed by WHO, Department of Water Affairs and SANS 241. What is of concern was the microbial quality of the water. FCs, TCs, heterotrophic bacteria and *Pseudomonas* spp. were present in some of the treated water samples. The most significant finding of this study is that all drinking water samples were positive for *Pseudomonas* spp. (>100/100 ml).

Key words | drinking water, faecal coliforms, heterotrophic plate count, physico-chemical, *Pseudomonas* spp., total coliforms

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INTRODUCTION

Water is generally a scarce resource in the North West province of South Africa. With the increasing demand on water for drinking, irrigation and industrial purposes this scarce resource should be well protected and managed (Brettar & Höfle 2008). Successful management depends on the regular monitoring of the physico-chemical and bacteriological quality of water. Potable water should be clear, not saline and free from compounds that can cause colour, taste and odour (Pritchard *et al.* 2007). Bacteria, inorganic, organic and water soluble radioactive substances are considered as the major water pollutants contributing to the deterioration of water quality and responsible for various public health problems (Azizullah *et al.* 2011; Butiuc-Keul *et al.* 2012). To protect consumers from waterborne diseases, drinking water utilities should ensure that the distributed water is completely free of pathogenic or potentially pathogenic microorganisms as well as harmful chemicals (Pereira *et al.* 2009). Potable water of poor quality can cause social and economic problems through water-related epidemics (Pritchard *et al.* 2007).

The analysis of microbiological quality of water aims to ensure that the consumer is protected from pathogenic organisms such as bacteria, viruses and protozoa (Figueras & Borrego 2010). Sampling and analysis of microbiological parameters must be done more frequently than physico-chemical parameters, because microbial contamination can have acute health effects on consumers (DWA 2005). Bacteria can be used either as indicators of faecal pollution or to indicate the effectiveness of a water treatment system (Wingender & Flemming 2011). Indicator organisms are generally used for the surveillance of the potential presence of pathogens in water.

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Coliform bacteria are present in the environment and faeces of all warm-blooded animals and humans (Connecticut Department of Public Health 2010). Coliform bacteria are unlikely to cause illness. However, their presence in drinking water indicates that disease-causing organisms (pathogens) that may be associated with intestinal infections, dysentery, hepatitis, typhoid fever, cholera and other illnesses could be present in the water system (Emmanuel *et al.* 2009). Their presence in drinking water can thus be seen as an indication of faecal pollution and possible deteriorating water quality (Rompré *et al.* 2002). There are three groups of coliform bacteria and each is an indicator of drinking water quality with great variations in the level of risks that they pose on consumers (USEPA 2013). Total coliforms (TCs) are a large collection of different kinds of bacteria while faecal coliforms (FCs) are those that exist in faeces. *Escherichia coli* is a subgroup of FC (USEPA 2013).

TCs are a group of closely related bacteria that are (with few exceptions) not harmful to humans (USEPA 2013). Because TCs are common inhabitants of ambient water and may be injured by environmental stresses (e.g., lack of nutrients) and water treatment (e.g., chlorine disinfection) in a manner similar to many pathogens, the Environmental Protection Agency (EPA) considers them a useful indicator of other water associated pathogens. Health problems associated with these pathogens include diarrhoea, cramps, nausea and vomiting. Together these symptoms comprise a general category of complication known as gastroenteritis. Gastroenteritis is not usually serious for a healthy person, but it can lead to more serious problems for people with weakened immune systems, such as the very young, elderly or immuno-compromised individuals (USEPA 2011). TCs do not necessarily indicate recent water contamination by faecal waste. However, the presence or absence of these bacteria in treated water is often used to determine whether water disinfection process is working properly and it also serves as a parameter to provide basic information on surface water quality (WHO 2006).

In drinking water quality management, FCs are used as indicators of faecal contamination and heterotrophic plate count (HPC) levels as a measure to indicate the effectiveness of the water purification processes (Hurst *et al.* 1997). The presence of FCs in drinking water may be due to sewage discharge, insufficient treatment and/or an ineffective distribution system (Pathak & Gopal 2008). A high density of heterotrophic bacteria found in treated drinking water may indicate the presence of opportunistic pathogens such as *Pseudomonas aeruginosa* that are known to cause health complications in humans (Lye & Dufour 1991; WHO 2011; Chowdhury 2012).

Pseudomonas aeruginosa is a waterborne opportunistic pathogen which may have impacts on human health, especially in immunocompromised populations (Wang *et al.* 2012). There is no South African National Standards (SANS 241) (2011) standard for *Pseudomonas* in drinking water. High levels of this bacterium in water may cause taste, odour and turbidity problems (WHO 2011). *Pseudomonas* spp. can survive extreme physical conditions (Völker *et al.* 2010) and is an opportunistic pathogen implicated to cystic fibrosis infections, septicaemia, pneumonia, endocarditis, otitis and keratitis (Lavenir *et al.* 2007) infections in high-risk populations (da Silva *et al.* 2008).

Worldwide water borne diseases are the cause of death and suffering of millions of people, especially children in developing countries (Schäfer *et al.* 2009). Many countries in Africa including South Africa (SA) are faced with serious shortages of drinking water. Therefore, in some areas of the country reused water is released in to the source water which may affect the quality of the receiving water. Source water associated microorganisms sporadically cause infections especially in immunocompromised patients.

Mafikeng is the capital of the North West province and has a population of about 260,000 people (Statistics South Africa Census 2011). The potable water in this city is obtained from two sources. The Molopo eye is a natural spring that is situated 30 km from town. Its water is clear and the total dissolved solids (TDS) is generally very low. For this reason no sedimentation and filtration is required. The water from this source is only chlorinated and supplied to the Mafikeng community. The other source is the Modimola dam. The water works is downstream from the wastewater treatment plant. This water source is thus impacted on by the sewage works, human settlements, farming and other anthropogenic activities that are prevalent in this area. However, the water samples are treated at the Mmabatho water works where chemical dosing, sedimentation, sand filtration and chlorine sanitation are the processes followed (Personal communication, van der Heiden, Director Operations, Botshelo Water, Mafikeng). This water is then

stored in reservoirs before being mixed with treated water from Molopo eye and supplied to the Mmabatho community.

Recent studies in Mafikeng provided evidence of bacterial contamination in both ground water and surface water (Wose Kinge & Mbewe 2010; Ateba & Maribeng 2011; Siri *et al.* 2011). *Escherichia coli* O157, a virulent strain, implicated in waterborne infections has also been reportedly isolated from South African water sources intended for direct and indirect human consumption (Müller *et al.* 2001; Ateba & Mbewe 2011). According to the Blue Drop Report of 2010, a certification programme that was introduced by the South African Department of Water Affairs to assess the quality of drinking water provided by municipalities, a score of only 30% was achieved by the Mmabatho water works. The Blue Drop score for Mafikeng in 2011 was reduced to a dismal 8.85% (DWA 2012). The Blue Drop certification process does not only evaluate drinking water quality, but also several management aspects including water safety plans. The scores for both Mmabatho water works and Mafikeng indicate inadequate monitoring and treatment of drinking water as well as several management aspects that are being neglected. The drinking water standard did not comply with the drinking water quality proposed by SANS 241 (2011), DWA (2012) and WHO (2008). Non-compliance to national legislation (SANS 241 2011), Department of Water Affairs (DWA) and World Health Organization (WHO) standards pose a significant risk of infection. According to the Blue Drop Report of 2011, there is no information about the microbiological and chemical compliance of drinking water in Mmabatho/Mafikeng drinking water. For this reason, a study on the chemical and microbiological quality of drinking water in this area is necessary.

This study was conducted with the aim of assessing the physico-chemical and microbial quality of drinking water that were obtained from Modimola dam and the Molopo eye. A secondary aim was to determine whether the water produced from these sources had a negative impact on the quality of the mixed water.

MATERIALS AND METHODS

Description of the study area

SA has a mostly temperate climate. It is surrounded by the Atlantic and Indian Oceans on three sides, and is located in the climatically milder southern hemisphere. Average elevation is higher towards the north (towards the equator) and further inland. A result of this varied topography and oceanic influence is that different parts of SA have different climates. North West is the country's fourth-smallest province, with a total area of 106,512 km^2, taking up 8.7% of SA's land area and with a population of 3.5 million people. The landscape is largely flat regions of scattered trees and grassland. Temperatures range from 17 to 31 °C (62–88 °F) in summer and from 3 to 21 °C (37–70 °F) during winter. Annual rainfall totals about 360 mm, with almost all of it falling during the summer months, between October and April. Mafeking is the capital of the North West province.

Molopo River is one of the main rivers in Southern Africa. It has a length of approximately 960 km and a catchment area of 367,201 km^2 with Botswana, Namibia and SA sharing roughly about a third of the basin each. It rises east of Mafikeng in North West province, SA, and flows generally west to join the Orange River near the southeastern border of Namibia. Its source is between Groot Marico and Lichtenburg and the river generally flows first to the west, and then to the southwest from its source. In its middle course the Molopo River forms a significant section of the border between Botswana and SA. River flow is intermittent and when it flows, its water flows very slowly owing to a gradient of only 0.76 m/km. Floods are rare because the vast sandveld areas of the Kalahari Desert on the Namibian side of its basin absorb all water from the seasonal rains. The upper Molopo is part of the *Crocodile (West) and Marico Water Management Area* and the lower are included in the Lower Vaal Water Management Area. Major dams in the river are the Modimola dam and the Disaneng dam, both located near the city of Mafikeng, which lies on the banks of the river.

Sampling sites

Several sampling points were selected and are located along the distribution system. Source water is obtained from two different sites. One of them is Molopo eye which is a natural spring where human settlements and other anthropogenic activities are prevalent. Modimola dam is the other catchment area which receives effluent from Mmabatho sewage

treatment plant. Treated water from both sources are mixed in Signal hill reservoir and distributed to some areas in the city.

Physico-chemical parameters

The physico-chemical parameters of the water were analysed three times a week for 4 months on water samples collected from three sites along the distribution system which received treated water from Modimola dam, Molopo eye (Mafikeng) and mixed water (Mmabatho) from these two sites. Temperature was measured at the sites and water samples for other parameters were collected in sterile Schott bottles, immediately stored on ice in a cooler box and transported to the laboratory. Physico-chemical parameters analysed were pH, TDS and temperature using Crison pH 25 multimeter.

Sample collection and isolation of bacterial consortia

For the bacteriological analysis, water samples were collected from the Modimola dam and the Molopo eye before and after treatment as well as the mixed water (Figure 1). Treated water was collected from household taps in the city. At each of the three different sites two taps were used as sampling points. One tap had a point of use carbon filter connected. Each of the sample points was supplied either by water from one of the sources or mixed water.

Collection of samples was from August to November 2010. Water samples were collected in sterile Schott bottles, immediately stored on ice in a cooler box, transported to the laboratory and analysed within 3–6 hours. For all the samples, 100 ml were filtered through 0.45 μm pore sized

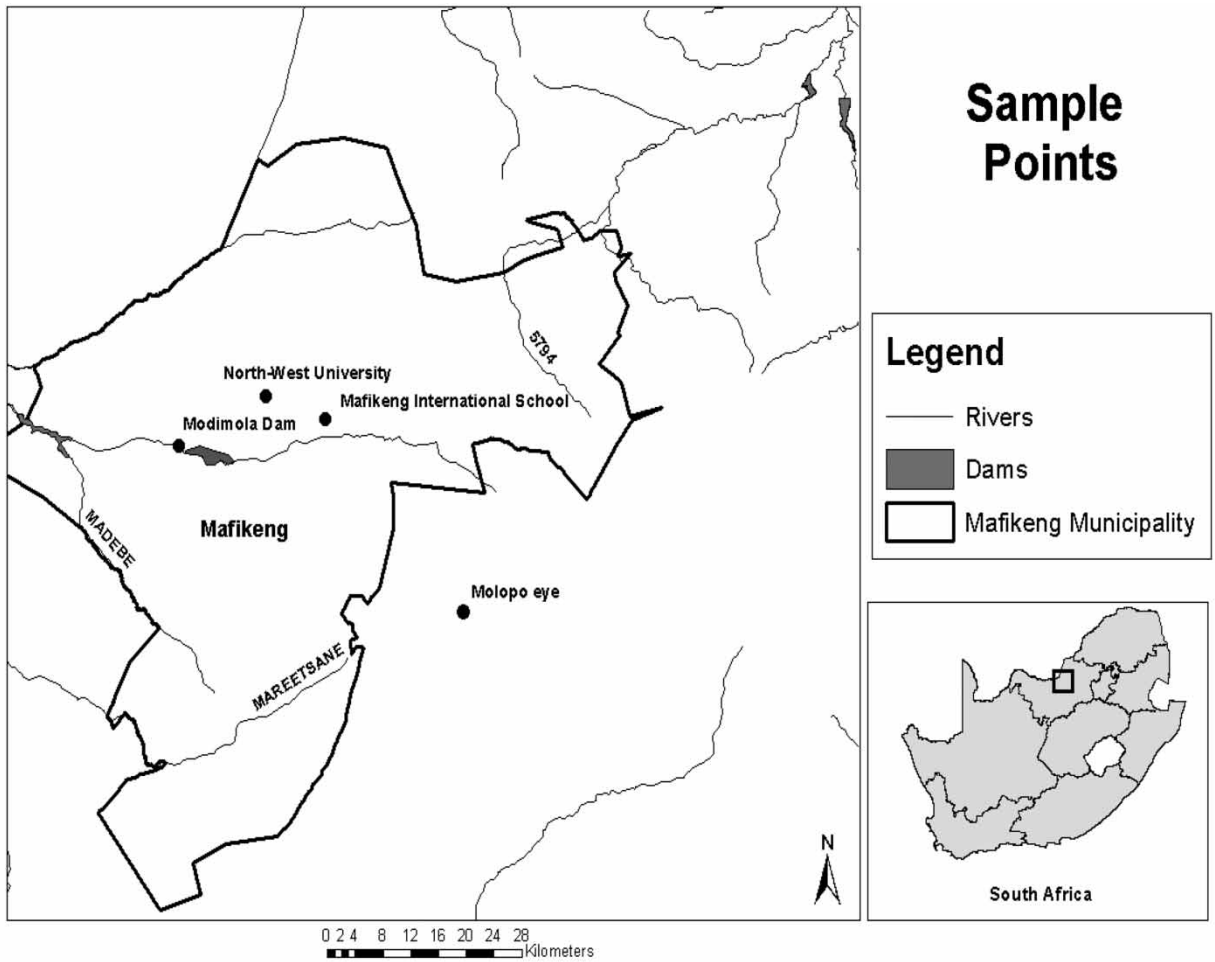

Figure 1 | A map of the sample points.

filters (cellulose nitrate membranes, 45 μm diameter, Whatman Laboratory Division, Maidstone, UK) using a membrane filtration unit and vacuum pump (model Sartorius 16824). These membranes were aseptically placed on petri dishes containing appropriate selective media, such as mFC agar, mEndo agar and Aeromonas selective agar to selectively isolate FCs, TCs and *Aeromonas* and *Pseudomonas*, respectively. All the media was prepared according to the manufacturer's instruction (Biolab, Merck, South Africa). The membranes were placed on the agars ensuring that no air bubbles were trapped. To isolate HPC bacteria, 100 μl of the treated water samples were spread on to the nutrient agar plates. Water samples from the dam and Molopo eye were serially diluted and 100 μl of the 5-fold serial dilutions was spread on to the nutrient agar plates.

The plates were incubated at 35 °C except for mFC agar which were incubated at 45 °C for 24 hours. Blue colonies from mFc agar (presumptive coliforms), metallic-sheen colonies from mEndo agar (presumptive TCs) and yellow (presumptive *Aeromonas*) and green colonies (presumptive *Pseudomonas*) from Aeromonas selective media were enumerated. The results for FCs, TCs and *Pseudomonas* were expressed as number of colony forming units per 100 ml of water and the results for HPC were expressed in number of colony forming units per 1 ml of water.

Statistical analysis

The data obtained were subjected to statistical analysis using Excel 2007 (Microsoft) and SPSS (version 14.0) programmes. Pearson's correlation product of the moment was used to determine the correlation between EC, TDS, pH and temperature. The two-tailed test of significance ($p < 0.05$) was used to determine the significance of the result.

RESULTS AND DISCUSSION

The physico-chemical and microbiological quality of drinking water in Mafikeng were analysed over a period of 4 months. Results were compared with WHO (2008) SANS 241 (2011) and DWA (2012) drinking water quality guidelines (Table 2) to ascertain if the quality of the drinking water was in accordance with the appropriate drinking water standards. In SA, the quality of the domestic supply that is considered safe for human consumption is assured by monitoring for compliance with the South African National Standard (SANS 241 2011).

Physico-chemical parameters

Table 1 represents the minimum, maximum and standard deviation of pH, TDS and temperature of the water samples tested. The chlorine level ranged from 0.2 to 0.7 mg/l (obtained from the water works).

All the values were within the accepted range for no health risk as proposed by WHO and DWA and SANS 241 (Table 2). Water temperatures ranged from 18.3 to 25.3 °C which would pose no adverse effects on living organisms. Temperature is the main factor which affects almost all physico-chemical equilibriums and biological reactions (Delpla *et al.* 2009). It can influence the pH, dissolved oxygen, redox potentials and microbial activity (Park *et al.* 2010). Temperatures in this range and higher enhance microbial activity and other chemical reactions (Pritchard *et al.* 2007). This would encourage biofilm formation and regrowth potential in the distribution system which could serve as an environmental reservoir for pathogenic microorganisms (Wingender & Flemming 2011).

Table 1 | Maximum, minimum and standard deviation of physico-chemical parameters of treated water in each site tested over the study period between August and November 2010

	pH			Temperature (°C)			TDS (mg/l)		
Site	**Max**	**Min**	**SD**	**Max**	**Min**	**SD**	**Max**	**Min**	**SD**
Molopo eye derived water	8.1	5.7	0.18	25.1	18.3	0.69	238.6	159.9	22.44
Modimola dam derived water	8.7	8.	0.15	25.3	20.4	0.19	364.4	226.3	12.44
Mixed water	8.6	5.6	0. 14	25	19.8	0.55	222.5	173.3	15.56

SD, standard deviation; Min, minimum; Max; maximum.

Table 2 | Recommended limits for no risk

Parameters	pH	TDS (mg/l)	Total coliforms (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	HPC (cfu/ml)
WHO (2008)	6.5–8.5	1000	0	0	≤1000
DWA (2012)	6.0–9.0	0–450	0–5	0	0–100
SANS 241 (2011)	6.0–9.0	≤1200	0	≤10	≤1000

It was observed that the pH and TDS concentration was higher in water obtained from Modimola dam (pH: 8.0–8.7; TDS: 226.3–364.4 mg/l) than in the Molopo eye derived water (pH: 5.7–8.1; TDS: 159.9–238.6 mg/l). Biological and anthropogenic activities can give rise to pH and TDS fluctuations. The elevated pH and TDS in the Modimola derived water could be attributed to the wastewater effluent released into the dam from the sewage treatment plant where lime is used for treatment. The lower pH and TDS values of water derived from the Molopo eye impacted positively on the quality of mixed water.

The pH of water is a reflection of the degree of acidity (pH lower than 7) or alkalinity (pH greater than 7). The fact that the pH of most unpolluted water lies between 6.5 and 8.5 pH is an important operational water quality parameter (WHO 2011). The taste of water, its corrosiveness and solubility and speciation of metal ions are all influenced by pH. At low pH, water may taste sour while at high pH water taste bitter or soapy (DWA 2006). Water with a low pH level may cause corrosion in galvanized or copper pipes (DWA 1998). Total heavy metal content in water could increase at low pH which is a matter of public concern (Virkutyte & Sillanpää 2006).

There are no health consequences attributed to pH of water, except at extreme values. The direct health effects of low and high pH levels include acid and alkali burns, respectively. These extreme pH levels may also cause irritation of the mucous membranes (DWA 1998). The main significance of pH in domestic water supplies relates to its effects on water treatment process. To ensure effective disinfection, the pH levels must be controlled when disinfection products are added (WHO 2011).

Parameter variations were not always statistically significant as a result of occasional peaks that occurred. Pearson's correlation analysis showed a significant ($p < 0.05$) positive correlation ($r = 0.99$) between TDS and temperature in water from the Molopo eye and the mixed water ($r = 0.928$, $p = 0.000$). The same was not true for the water derived from the Modimola dam. Furthermore, TDS values for the mixed water were lower than the Modimola derived water but higher than the Molopo eye derived water (Table 1). It thus appears as if the Molopo eye derived water diluted the Modimola dam derived water. A strong positive correlation ($r = 0.931$, $p = 0.000$) between pH from Molopo eye water and mixed water was observed, but a weak negative correlation ($r = 0.360$, $p = 0.170$) was observed between TDS from both sites. Modimola dam pH and TDS showed a weak negative correlation to pH and TDS of mixed water. For pH and temperature, significant ($p < 0.05$) positive correlations ($r = 0.78$–0.99) for treated water from all three water types were calculated. There was also a general significant (<0.05) correlation between pH and TDS measurements for water from the various samples.

Bacteriological quality

TC, FC and HPC bacteria are indicator organisms and are generally recommended for assessment of the microbiological safety and the potential occurrence of pathogens in potable water (Yáñez *et al.* 2006; Okeke *et al.* 2011). If contaminated water is consumed these organisms may cause diseases such as gastroenteritis, dysentery, cholera and typhoid fever (Azizullah *et al.* 2011). Results of the microbiological tests conducted during the study period are given in Table 3.

TC bacteria and HPC are primarily used to determine the general hygienic quality of water and to evaluate the efficiency of treatment procedures. FC bacteria are used to detect faecal pollution and the presence of pathogens that are associated with faecal pollution (Lin *et al.* 2004; Rousselon *et al.* 2004). *Pseudomonas* spp. are common inhabitants of aquatic environments, including drinking water (Vaz-Moreira *et al.* 2012). This ubiquitous genus includes species considered to be opportunistic pathogens that can colonize animals and humans (Mena & Gerba 2009). Periodical enumeration of *Pseudomonas* is vital to assess the drinking water quality (da Silva *et al.* 2008).

The WHO (2008) standard for drinking water quality limit is 0 cfu/100 ml for TC and FC. Raw water from both

Table 3 | Maximum, minimum and standard deviation of microorganisms enumerated in different sampling sites for a period of 4 months

	HPC cfu/ml			TC			FC			PS		
							cfu/100 ml					
Site	Max	Min	Ave ± SD	Max	Min	Ave ± SD	Max	Min	Ave ± SD	Max	Min	Ave ± SD
Molopo eye raw water	>100	0	>73 ± 44.7	>100	0	>73.3 ± 41.7	>100	0	>49 ± 49.5	>100	0	>93.3 ± 25.8
Molopo eye unfiltered water	>100	0	>12 ± 30.3	0	0	0	0	0	0	>100	0	>49.8 ± 49.3
Filtered water	50	0	3.4 ± 12.9	0	0	0	0	0	0	>100	0	54.7 ± 50.3
Modimola dam raw water	>100	1	85 ± 34.4	100	40	96 ± 15.5	>100	1	33.5 ± 37.5	>100	>100	100–0
Modimola dam unfiltered water	>100	0	33.3 ± 46.8	>100	0	31.3 ± 47.9	10	0	1.1 ± 2.7	>100	0	57.7 ± 49.6
Filtered water	>100	0	33.4 ± 48.8	>100	0	33.3 ± 48.8	1	0	0.1 ± 0.4	>100	0	42.3 ± 48.9
Mixed water unfiltered water	60	0	4.13 ± 15.5	0	0	0	0	0	0	>100	0	44.5 ± 47.3
Filtered water	9	0	0.6 ± 2.3	0	0	0	0	0	0	>100	0	44.4 ± 46.3

HPC, heterotrophic plate count; TC, total coliform; FC, faecal coliform; Ps, *Pseudomonas* spp.

sites was heavily contaminated with all the organisms tested for. Similar results were observed by Schraft & Watterworth (2005), Moulin *et al.* (2010) and Chidya *et al.* (2011). The results obtained in this study imply that TC and FC bacteria are present in water subjected to faecal pollution. Pollution may have been caused by sewage effluent released in to the dam and herds of cattle and sheep grazing around the dam and also pollutants being washed to the dam by rain water. Input of untreated or partly treated waste water cause fresh water pollution (Thevenon *et al.* 2011). Occurrence of nutrients enhances bacterial growth in the distribution system (Lehtola *et al.* 2004).

In this study we have observed that both unfiltered and filtered treated water samples from all sites possessed high *Pseudomonas* and HPC counts (>100 cfu/ml). This observation was in accordance with the findings of Ghizellaoui (2008), da Silva *et al.* (2008) and Völker *et al.* (2010). There were no significant changes in the number of *Pseudomonas* in filtered and unfiltered water samples and during the sampling period. The observation demonstrated that carbon filters did not effectively remove *Pseudomonas.* This result is comparable with the ineffectiveness of filters used for water purification in the removal of bacteria demonstrated by Fengyi *et al.* (2009). In Modimola dam water, we have observed elevated levels of HPC, TC and *Pseudomonas*, but significantly low levels of FC. There was no reduction in the number of any of these organisms when the levels in the filtered and unfiltered water were considered. However, TC and FC were not observed in the treated water from the Molopo eye and mixed water.

Lower levels of HPC bacteria were observed in mixed treated water compared with the Modimola dam treated water. The low levels of these organisms in the mixed water could potentially be attributed to the impact of Molopo eye derived water. However, elevated levels of HPC and *Pseudomonas* were observed in treated water samples from all sites. In a similar study conducted by Ferretti *et al.* (2007) drinking water samples contaminated with HPC could be attributed to the presence of nutrients in the water. However, tests for nutrients were not conducted in the present study but in future studies this must be included.

The trends of *Pseudomonas* from all sites were similar during all sampling periods and the exceptionally high level of *Pseudomonas* is a cause for concern. *Pseudomonas* spp. can survive extreme physical conditions (Völker *et al.* 2010) and is an opportunistic pathogen implicated to cystic fibrosis infections, septicemia, pneumonia, endocarditis, otitis and keratitis infections in high risk populations (Lavenir *et al.* 2007; da Silva *et al.* 2008). The number of *Pseudomonas* in the filtered water was also very high. This could be attributed to the ability of *Pseudomonas* to form biofilm (Moritz *et al.* 2010; Waszczuk *et al.* 2010). Periodical

enumeration of *Pseudomonas* is vital to assess the drinking water quality (da Silva *et al.* 2008).

The results suggest that the counts of FCs, TCs and HPC of Modimola dam and Molopo eye during this study period were significantly lower than those reported by Germs *et al.* (2004). The level of contamination can however, be compared with those reported by Lin *et al.* (2004).

High levels of HPC were observed in raw water and treated water from Modimola dam which received sewage effluent. Occurrence of high levels of HPC means that the treatment process at the sewage treatment plant failed to reduce HPC bacteria to acceptable levels before discharge. High densities of heterotrophic bacteria found in both potable source waters and treated drinking waters have raised concerns as this harbours opportunistic pathogens (Lye & Dufour 1991). Opportunistic pathogens express activities which by themselves are not sufficient to cause disease, unless interacting with a host that is debilitated or whose body defence system has been compromised in some way (Lye & Dufour 1991). Pereira *et al.* (2009) and Iqbal *et al.* (1995) detected high levels of TCs and *E. coli* in spring water and in all surface water. Occurrence of *E. coli* O157:H7 was reported in South African waters (Müller *et al.* 2001; Ateba & Mbewe 2011). This bacterial strain is responsible for bloody and non-bloody diarrhoea, haemorrhagic colitis and haemolytic uremic syndrome (Olsen *et al.* 2002; Tozzi *et al.* 2003). Drinking water that failed to meet the standard set by WHO (2008), DWA (2012) and SANS 241 (2011) guidelines and failure to comply with bacteriological standards demonstrate that this water is not safe for human consumption. The supply of clean drinking water is a major public health milestone (Berry *et al.* 2006). One of the most important requirements for domestic water is that the water should be safe to drink (Schutte 2006; Momba *et al.* 2009). Studies have shown that water purification plants in SA may not always produce the quality and quantity of drinking water they are designed for (Momba *et al.* 2006). To determine if the water provided to communities is safe to drink, the physico-chemical and microbiological analysis of water must be performed.

CONCLUSION

Increased microbial numbers can cause drinking water quality deterioration and it is a major problem faced within the water distribution systems in Mafikeng. The quality of drinking water distributed to the consumers must be of prescribed standards for physico-chemical and microbial quality. Results presented in this study are not unique as similar results were demonstrated by other researchers. These results revealed that the physico-chemical parameters of drinking water were constant over time and within the limits set by WHO and DWA and this would pose no significant threat to domestic use. However, bacteriological quality of the water in the Mafikeng distribution systems was unacceptable as the study demonstrated the widespread occurrence of *Pseudomonas* and HPC. A comparison of the levels of organisms in the drinking water from each site demonstrated an increased level in the treated water from the Modimola dam and low in mixed water. This could probably be attributed to a dilution effect of Molopo eye water on the mixed water. Moreover, *Pseudomonas* and HPC counts were high in all the drinking water samples tested. These organisms can harbour opportunistic pathogenic features. Therefore, it is recommended to evaluate the levels of *Pseudomonas* periodically in addition to the routine faecal indicator and *E. coli* tests.

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