

Microbiological and physico-chemical assessment of the quality of domestic water sources in selected rural communities of the Eastern Cape Province, South Africa

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Abstract

The domestic raw water sources in Nkonkobe and Gogogo were characterised by using both microbiological and standard physical methods to investigate the quality of the water at the sampling sites. For microbiological analysis, indicator bacteria namely, heterotrophic bacteria, total and faecal coliforms and for physical parameters, pH, turbidity and temperature were assessed to check whether the distributed water as well as the water from dams, and rivers was safe for drinking and other domestic uses. The water quality parameters of concern were microbial contamination and turbidity. Almost all the indicator bacteria counts and turbidity values were above the South African recommended limits. Both Nkonkobe and Gogogo raw water sources had a poor water quality. The water was unfit for human consumption without prior treatment. The quality of the water source depended on local conditions. This indicated that poor sanitation and hygiene conditions and lack of, or little environmental awareness among the people in rural areas, could be considered as the major causes of source water contamination.

Keywords: water quality, coliform bacteria, heterotrophic plate count, rural communities, pH, turbidity, and temperature.

Introduction

The lack of safe drinking water and adequate sanitation measures lead to a number of diseases such as cholera, dysentery, salmonellosis and typhoid, and every year millions of lives are claimed in developing countries. Diarrhoea is the major cause for the death of more than 2 million people per year world-wide, mostly children under the age of five. It is a symptom of infection or the result of a combination of a variety of enteric pathogens (ANON, 2000).

Water-borne pathogens infect around 250 million people each year resulting in 10 to 20 million deaths world-wide. In South Africa alone more than 7 million people (approximately 17% of the population) do not have access to potable water supply and nearly 21 million (about 54% of the population) lack basic sanitation (DWAF, 1996). This highlights the potential of infection due to water-borne pathogens.

The evaluation of potable water supplies for coliform bacteria is important in determining the sanitary quality of drinking water. High levels of coliform counts indicate a contaminated source, inadequate treatment or post-treatment deficiencies (Mathew et al., 1984). Many developing regions suffer from either chronic shortages of freshwater or the readily accessible water resources are heavily polluted (Lehloesa and Muyima, 2000). Microbiological health risks remain associated with many aspects of water use, including drinking water in developing countries (Craun, 1986), irrigation reuse of treated wastewater and recreational water contact (Grabow, 1991). It has been reported that drinking water supplies have a long history of association with a wide spectrum of microbial infections (Grabow et al., 2000). Therefore, the primary

goal of water quality management from a health perspective is to ensure that consumers are not exposed to doses of pathogens that are likely to cause disease. Protection of water sources and treatment of water supplies have greatly reduced the incidence of these diseases in developed countries (Craun, 1986; Grabow et al., 2000).

One of the difficulties in evaluating the impact of drinking water supply on health is the lack of local demographic statistics, particularly in rural communities. Therefore, it is important to know the incidences of diseases occurring in rural areas due to polluted water. This will provide an opportunity to compare the incidence of water-borne diseases between communities that have drinking water and those that do not.

Detection of bacteria, potentially toxic substances and other contaminants in water usually requires laboratory-conducted tests. There are various methods for the detection of the degree of water contamination (*Standard Methods*, 1998). Detection and enumeration of indicator organisms, is the basic microbiological technique, used in water quality monitoring (*Standard Methods*, 1998). The coliform group of bacteria can be defined as the principal indicators of purity of water for domestic, industrial and other uses.

Major factors affecting the microbiological quality of surface water are discharges from sewage works and runoff from informal settlements. High total and faecal coliform counts in water are usually manifested in the form of diarrhoea, fever and other secondary complications (Fatoki et al., 2001).

In South Africa nearly 80% of the population rely on surface water as the main source of water (Venter, 2001). This relatively high percentage of the population that is without proper water supply services indicates that many of the people still utilize untreated surface water for domestic purposes. Most of these people are poor and rely on State intervention for improved water supply. Pegram and collaborators (Pegram et al., 1998) showed

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that a substantial number (about 43 000) of South Africans die every year from diarrhoeal diseases.

The incidence and prevalence of water-borne pathogens are subject to geographical factors. Most of the pathogens are distributed world-wide, but outbreaks of some diseases, for instance, cholera, shigellosis, and typhoid tend to be regional (Grabow et al., 1994).

In less industrialised areas like Gogogo and Nkonkobe, pollution from human settlements lacking appropriate sanitary infrastructure, partially treated or untreated wastewater, leachates from refuse dumps and from land-use activities such as agriculture are the major pollution sources of the surface water. Microbiological and physical water quality indicators are therefore the major parameters to be monitored in the rivers, dams or boreholes of catchments (Fatoki et al., 2001).

Meteorological events and pollution are a few of the external factors, which affect physico-chemical parameters such as temperature, pH, and turbidity of the water. They have a major influence on biochemical reactions that occur within the water. Sudden changes of these parameters may be indicative of changing conditions in the water. Internal factors, on the other hand, include events, which occur between and within bacterial and plankton populations in the water body (Nübel et al., 1999; Byamukama et al., 2000; Goni-Urriza et al., 2000; Nishiguchi, 2000).

The purpose of this study was to determine the present microbiological and physico-chemical qualities of domestic water sources used by Gaga, Gqumashe, and Gogogo rural communities in the Eastern Cape province of South Africa.

Materials and methods

Description of the study area and sampling points

The study covered Gaga, and Gqumashe village in the Nkonkobe Municipality, a semi-rural area and Gogogo Village, a true rural area situated about 60 km from Port St Johns in the Eastern Cape Province of South Africa. Lower Gqumashe sampling points were the dam, a broken standpipe with untreated water from Binfield Dam and three sites on the Tyume River. The dam and a valley in Upper Gqumashe were also sampled. In Gaga Village, the dam and windmill storage tank were sampled. Gogogo sampling sites were Tank, Rwyatini A, Rwyatini B, Enkolweni, Emthonjeni, Fatyini, Ntaba A and Ntaba B.

Both upper and lower Gqumashe Villages use untreated surface water for drinking. Upper Gqumashe Village makes use of the water from the small stream that joins the Tyume River and the water from a nearby dam. Lower Gqumashe Village draws water from the Tyume River, a dam and a broken pipe that brings water from Binfield Dam to the Alice water treatment plant. This shows that the Gqumashe community uses untreated water for domestic purposes. Water from Lower Gqumashe Dam is used mainly for laundry purposes and car washing, and construction works. Young people also use this dam for swimming.

Gaga Village uses underground water provided by a borehole and stored in a tank. This storage tank is located in the centre of the village. The second water source used in this village is the dam located on the outskirts of the village situated next to the main road from Alice. With the exception of Gaga Windmill storage tank and Gqumashe pipe, none of these sampling sites were protected. Domestic animals such as cattle, pigs, goats, sheep and donkeys used the same water sources.

Tank in Gogogo is so named because the source supplies water to the storage tank, which was built to supply the Gogogo commu-

nity with water. This site is narrow and covered by trees so its temperatures are always low. This source produces about 2 000 ℓ of water per day which is not enough to support and meet the needs of the community.

Rwyatini A is located at about 500 m from the river. This site is used only for doing the laundry. Domestic animals such as donkeys and pigs also use this water source. The water at this site was muddy in appearance in such a way that even the clothes washed in this water also become dirty. Since both human and animals shared the water it was often visibly contaminated with both human and animal faeces.

Rwyatini B is situated close to Rwyatini A. The source has clear water. However, the quality of the water has deteriorated since the source is shared with domestic animals. This site is under a tree and as a result it remains cool for most of the day.

Enkolweni is an underground water source and the main site used by the Gogogo community. During rainy days the water becomes contaminated due to the influx of water from the surroundings.

Emthonjeni (which means underground water) is mostly used for laundry purposes and occasionally for drinking especially during the winter months when water is very scarce. The site had eutrophication problems.

Fatyini was so named because this sampling point is shaped like a barrel. The site was wide compared to other sites in Gogogo and was divided into two parts. The upper part is used for collecting drinking water while the lower part is used by domestic animals. Faecal contamination is therefore expected to be high at this site. The water from Ntaba A is used for both drinking and laundry purposes. This well joins Ntaba B. A cement wall protects Ntaba A; however, animals with long necks like horses have access to it. Ntaba B is used only for laundry purposes. The water from this site is brackish as it is shared with pigs. Ntaba B is about 500m from the rise of the river. In the upper hilly part of this catchment, there are settlements without proper sanitation facilities. During rainy days faeces run down the valley thereby contaminating the water.

The key to the sampling site numbers is given in Table 1.

Site No	Site location	Site name
1	Gogogo	Tank
2	Gogogo	Rwyatini A
3	Gogogo	Rwyatini B
4	Gogogo	Enkolweni
5	Gogogo	Emthonjeni
6	Gogogo	Fatyani
7	Gogogo	Ntaba A
8	Gogogo	Ntaba B
9	Nkonkobe	Gqumashe Tyume River 1
10	Nkonkobe	Gqumashe Tyume River 2
11	Nkonkobe	Gqumashe Tyume River 3
12	Nkonkobe	Gqumashe pipe
13	Nkonkobe	Lower Gqumashe Dam
14	Nkonkobe	Upper Gqumashe Dam
15	Nkonkobe	Upper Gqumashe Valley
16	Nkonkobe	Gaga Dam
17	Nkonkobe	Gaga Windmill

Water sample collection

Water samples were collected in 1 ℓ containers and transported to the laboratory on ice in cooler boxes. The samples were collected every three weeks over a period of approximately one year starting from 3 July 2001 to 16 July 2002 inclusively.

Sampling of surface water

The cap of the bottle was carefully removed to prevent contamination of the inner surface. The sample was taken by holding the bottle at the bottom and plunging it below the water surface. The mouth of the bottle was placed opposite the water current. If there was no current, it was created artificially by pushing the bottle forward. The bottle was filled leaving about 25 mm of empty space to allow mixing during laboratory analysis. It was then immediately closed and kept in a cooler box.

Sampling of groundwater from windmill storage tank

The water was left to run from the tap for about 4 min. The bottles were then filled and immediately closed. The samples were kept on ice as stated above.

All the water samples were analysed within 12 to 24 h after collection.

Physico-chemical analysis of water samples

The temperature of the water samples was determined *in situ* using a mercury thermometer while the pH and turbidity measurements were performed using a Crison micro pH 2000 (Crison Instruments, South Africa) and a portable 2100P turbidimeter from Hach (Hach Co., Germany), respectively.

Microbiological analysis of water samples

The water samples were analysed for heterotrophic bacteria, total and faecal coliforms.

Heterotrophic plate counts were performed on R2A agar plates and incubated at 28°C for 3 to 7 d (Reasoner and Geldreich, 1985). Total coliform counts were determined using the membrane filtration method. A sample aliquot of 5 to 10 mL of the untreated water was filtered using 0.45 µm pore size, 47 mm diameter filter membranes. The membranes were incubated on m-Endo-Les agar at 37°C for 24 h (Grabow, et al., 1991). Faecal coliform counts were performed with m-FC agar plates also using the membrane filtration method. The microbiological tests were done in triplicate.

Statistical analysis

Statistica software was used both in the analysis of the data and in drawing the graphs. Factor levels were constructed for the sites (*ca.* 17 sites) and time (*ca.* 19 time periods). Box plots for these

Figure 1 (top right)

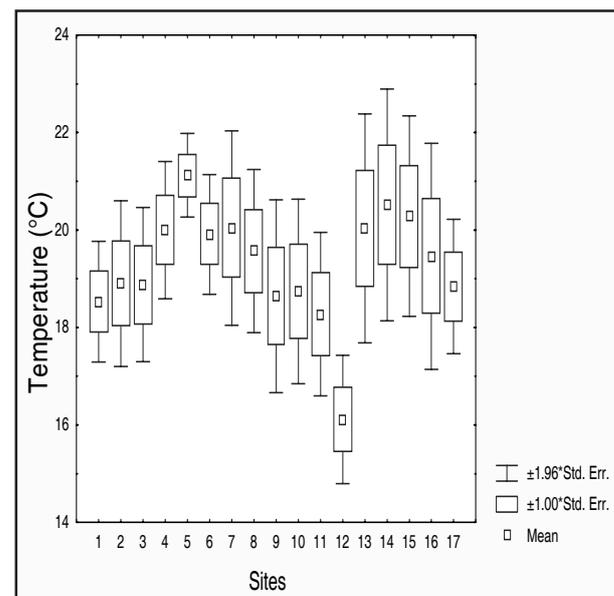
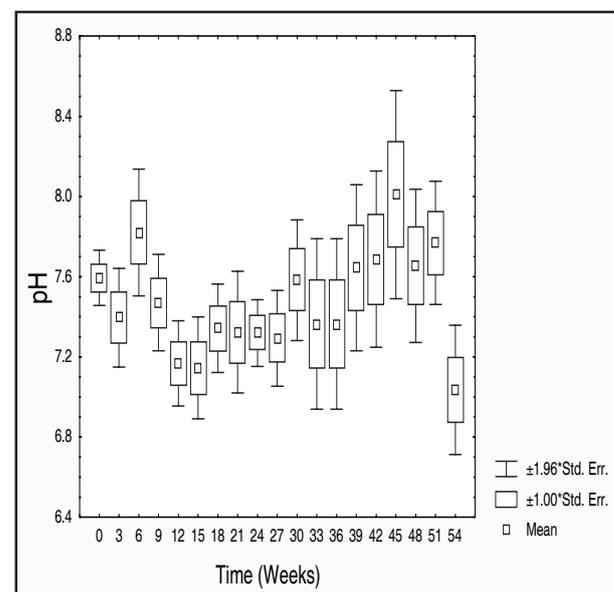
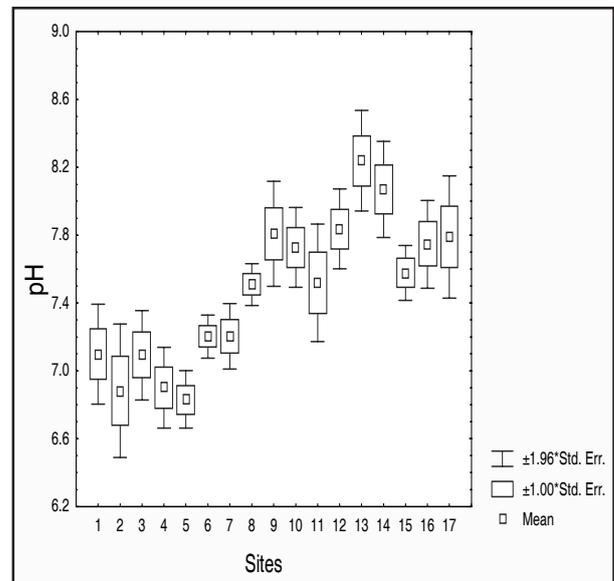
Box plots of 17 selected sites in Gogogo and Nkonkobe against pH of water for the period starting from 3 July 2001 to 16 July 2002

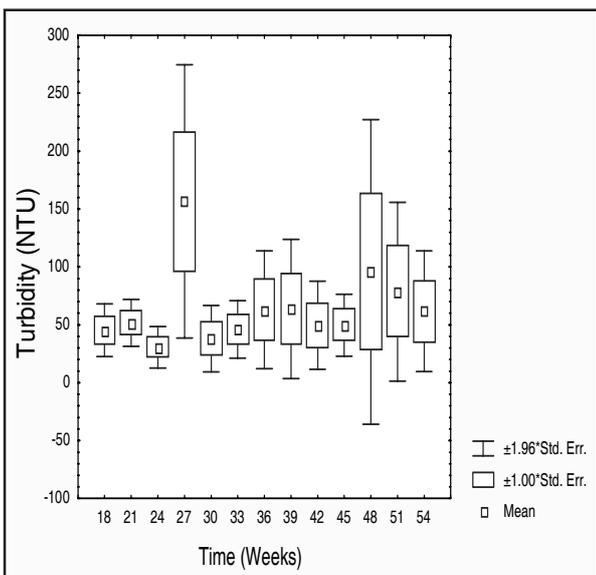
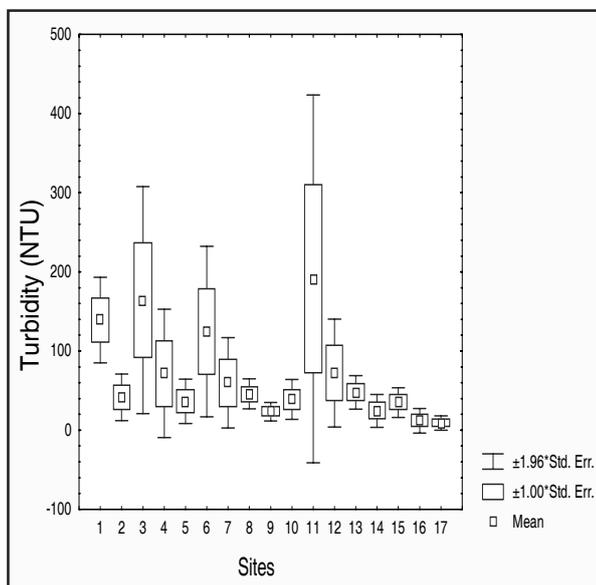
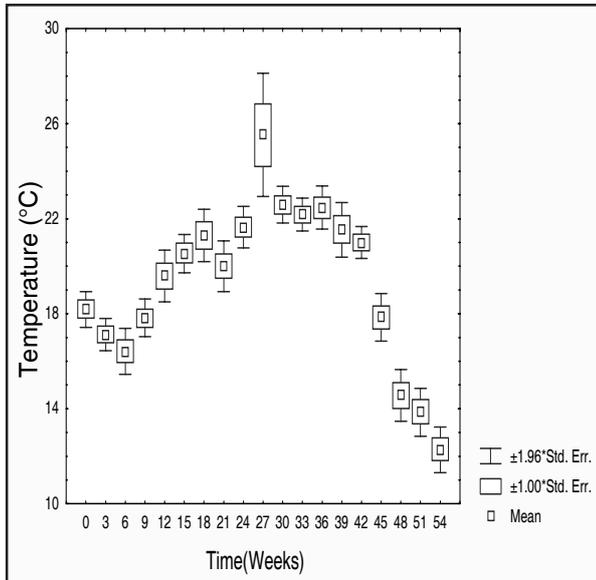
Figure 2 (middle right)

Box plots of time (weeks) against pH of water at 17 selected sites in Gogogo and Nkonkobe for the period starting from 3 July 2001 to 16 July 2002

Figure 3 (bottom right)

Box plots of 17 selected sites in Gogogo and Nkonkobe against temperature (°C) of water for the period starting from 3 July 2001 to 16 July 2002





levels (sites and time) were plotted against the dependent variables namely pH, temperature, turbidity, heterotrophic plate counts, total coliform and faecal coliform counts. In slots where zero counts were recorded, 0.001 was used to allow for logarithm transformation. This justifies the negative values shown in the figures.

Results and discussion

The results recorded during the monitoring of physico-chemical and microbiological parameters namely pH, temperature, turbidity, heterotrophic plate counts, total and faecal coliform counts of water sources used by the rural communities of Gogogo, Lower and Upper Gqumashe, and Gaga are summarised in Figs.1 to 12. The physico-chemical parameter box plots are displayed in Figs. 1 to 6 while Figs. 7 to 12 give the box plots for microbiological parameters.

The pH of the water at all the sites fluctuated greatly. Gogogo sites (Sites 1 to 8) had relatively lower pH values compared to the sites in Nkonkobe (Sites 9 to 17) (Fig. 1). According to Kunte and collaborators (1998) pH values ranging from 3 to 10.5 could favour both indicator and pathogenic micro-organism growth. The overall pH pattern showed that the pH values were relatively high in winter (i.e. weeks 0 to 9) compared to summer (i.e. weeks 12 to 36) (Fig. 2). Despite all the fluctuations, the pH of water in both Nkonkobe and Gogogo remained within the South African recommended standard limits (pH 6.0 to 9.0) (DWAF, 1993; Muyima and Ngcakani, 1998). Physical parameters, such as pH, temperature and turbidity have a major influence on bacterial population growth (Nübel et al., 1999; Byamukama et al., 2000; Goni-Urriza et al., 2000; Nishiguchi, 2000).

The temperature of the water varied between 16°C and 21°C during the sampling time (Fig. 3). The first three samplings (weeks 0 to 6) that displayed relatively low temperatures corresponded to the winter season. The temperature thereafter increased gradually during spring until summer when high temperatures were observed (Fig. 4). The highest temperature was reached in January (i.e. week 27). High temperatures were often accompanied with heavy rainfalls. The combined effect of elevated temperatures and heavy rains could explain the high coliform counts observed in this period (Figs. 8, 10, and 12).

Micro-organisms have been found growing virtually everywhere where there is water, regardless of its temperature. There were remarkable differences in temperature values between the different sites. The water temperature in Sites 1 to 3 (i.e. Tank, Rwatyi A and B) varied between 18.5°C to 19°C, while for Sites 13 to 17 (i.e. Lower Gqumashe – Dam, Upper Gqumashe – Dam, Upper Gqumashe – Valley, Gaga Dam and Gaga Windmill), it varied between 19°C and 20.5 °C. Both the microbiological and physico-chemical conditions at Sites 9 to 11 were almost similar

Figure 4 (top left)

Box plots of time (weeks) against temperature (°C) of water at 17 selected sites in Gogogo and Nkonkobe for the period starting from 3 July 2001 to 16 July 2002

Figure 5 (middle left)

Box plots of 17 selected sites in Gogogo and Nkonkobe against turbidity (NTU) of water for the period starting from 3 July 2001 to 16 July 2002

Figure 6 (bottom left)

Box plots of time (weeks) against turbidity (NTU) of water at 17 selected sites in Gogogo and Nkonkobe for the period starting from 3 July 2001 to 16 July 2002

with few variations. The relatively low temperature conditions observed at these sites could constitute an advantage for the maintenance of the quality of water due to lower microbial activity. In almost all the dams, relatively high temperatures were observed with a maximum of 20.8°C compared to other sites like wells and rivers. These relatively high temperatures in dams could be attributed to the fact that the water in these reservoirs was stagnant. As dams are constantly exposed to sunlight and there is no water flow, the water temperature remained high, especially in summer. Gaga Windmill provided water with relatively low temperatures compared to Sites 12 to 16 from the same area. Gaga Windmill water is from underground and it is stored in a cemented and sealed storage tank, thus the water is not directly exposed to sunlight. As mentioned above relatively low temperatures can retard the growth of micro-organisms, especially that of coliforms. This may explain the low heterotrophic plate counts, total and faecal coliform counts observed here (Figs. 7, 9 and 11).

At the onset of spring, starting from September, an increase in temperature was observed, which continued throughout the summer season. The peak temperature was reached in January (Week 27). Since high temperatures were accompanied with heavy rainfalls which drained animal and human wastes and other wastes in the water bodies, this explained the high coliform counts observed during this period (Figs. 8, 10, and 12).

The turbidity values recorded for all the samples from Gogogo and Nkonkobe were above the South African acceptable limits for drinking water (1 to 5 NTU) (DWAF, 1993;1998). The water samples from Gogogo sites had higher turbidity values compared to the ones from Nkonkobe (Fig. 5). In general, higher turbidity corresponded with sampling done after heavy rains. There was a remarkable difference in turbidity of the water sources with regard to time (Fig. 6). Despite some exceptions, the turbidity values during this study varied with seasonal changes. The highest turbidity was observed in Week 27 of the experimental period that corresponded with the start of the summer season. Turbidity was typically high during a storm as a consequence of rapid erosion of surface soils into rivers. According to a report published by the Department of Water Affairs and Forestry (DWAF), water turbidity varies from < 1 NTU in clear springs or deep groundwater, to 160 ± 60 NTU in mud-laden surface waters (DWAF, 1998). On average, there was no remarkable difference between the turbidity observed in Gogogo and Gaga, Lower and Upper Gqumashe sampling sites. The turbidity measured in these sites was far above the standard limits according to both the WHO and South African standards (1 to 5 NTU) (WHO, 1993; DWAF, 1998).

There were substantial differences in the quality of water in terms of heterotrophic plate counts (HPC). Sites 3 to 8 and Sites 13 to 16 were the most contaminated in this regard (Fig. 7).

Figure 7 (top right)

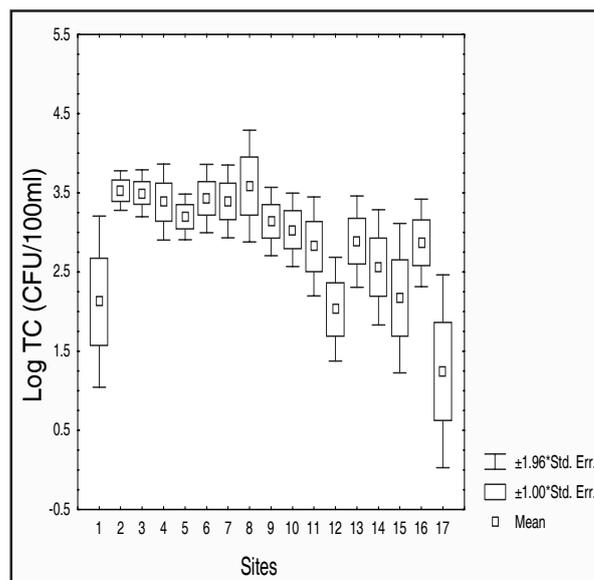
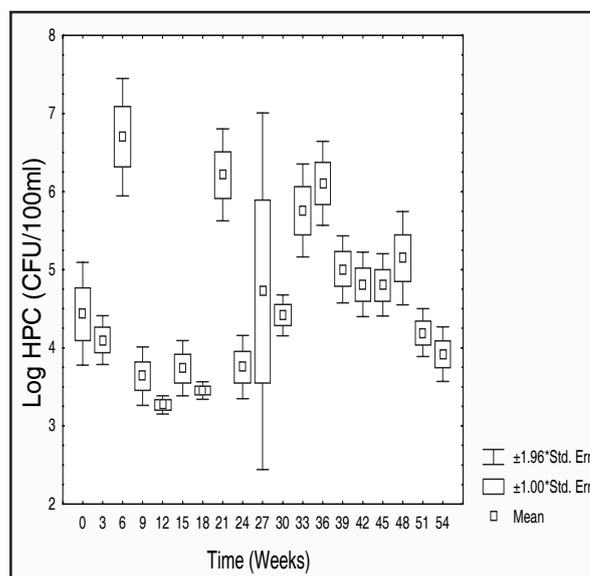
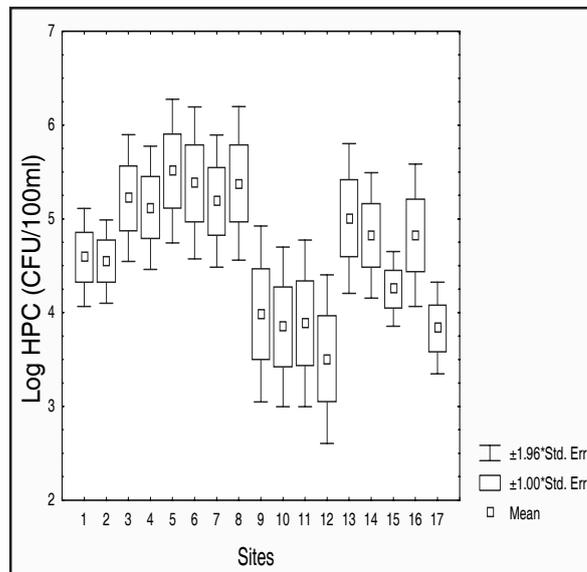
Box plots of 17 selected sites in Gogogo and Nkonkobe against heterotrophic plate counts (CFU/100 ml) of water for the period starting from 3 July 2001 to 16 July 2002

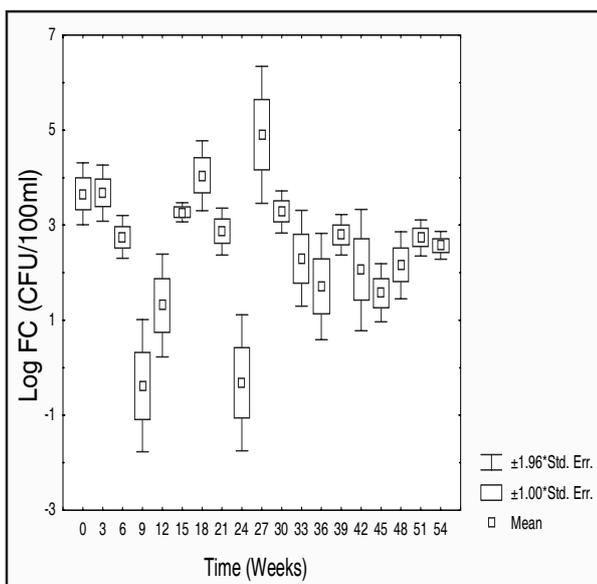
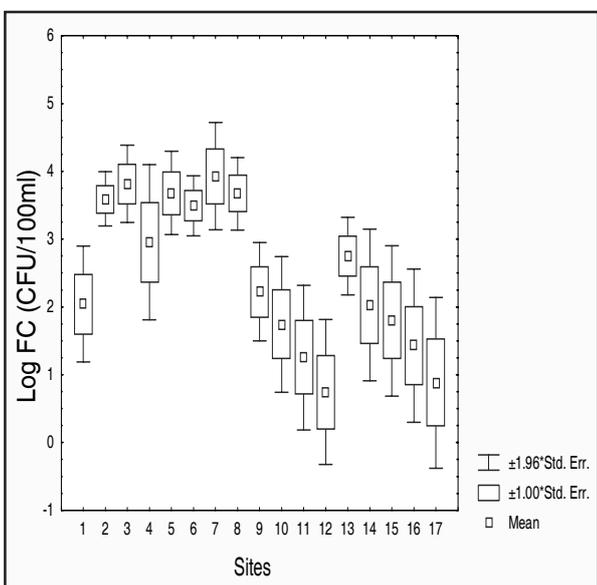
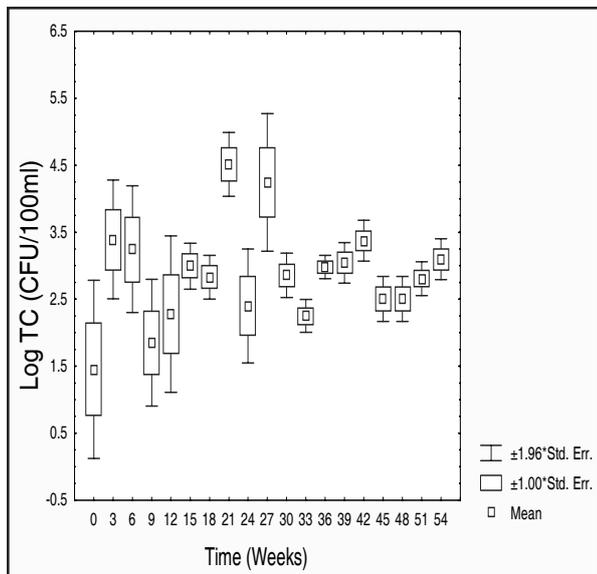
Figure 8 (middle right)

Box plots of time (weeks) against heterotrophic plate counts (CFU/100 ml) of water at 17 selected sites in Gogogo and Nkonkobe for the period starting from 3 July 2001 to 16 July 2002

Figure 9 (bottom right)

Box plots of 17 selected sites in Gogogo and Nkonkobe against total coliform counts (CFU/100 ml) of water for the period starting from 3 July 2001 to 16 July 2002





Microbiological water quality of the Gogogo sites

Water from the sites in Gogogo had the highest level of microbial contamination. It is important to recall that Tank, Rwtayi B and Emthonjeni were sometimes used as sources of drinking water. Fatyi, Ntaba A and Enkolweni were also used as sources of drinking water, while Emthonjeni, Rwtayi B and Ntaba B were used mainly for laundry purposes. Tank and Rwtayi A (i.e. Sites 1 and 2 in Fig. 7) were relatively less contaminated than the rest of the sites screened in this area. Tank was isolated from the community and the site was protected from animals. This could explain the relatively low microbial counts observed in the water from this source. Rwtayi B, Emthonjeni, Fatyi Ntaba B were expected to have high HPC counts because of pig farming activities in the surrounding that increased the risk of source water contamination. Enkolweni, the main drinking water source for people in Gogogo was highly contaminated (5.5 log HPC). This highlights the public health concerns for people living in this rural community.

The study showed that human and animal activities at water collection sites affected the quality of the water. Anthropological and animal activities in the vicinity of water collection sites as well as settlements lacking proper sanitation facilities, contributed to the poor water quality of the different water sources, especially Enkolweni, Ntaba A and Fatyi sites used by people in the Gogogo rural area.

Microbiological water quality of the sites in Nkonkobe

The heterotrophic plate counts in Gaga, Lower and Upper Gqumashe were lower compared to those obtained from Gogogo. Except for Binfield Dam, river water (Tyume River) seemed to be relatively less contaminated than stagnant water from unprotected dams. Binfield Dam was the only dam that was well protected by fences that prevented animal access to the water (Fig. 7). The difference between rivers and dams could also be due to the process of self-purification and the dilution effect since the river had relatively abundant water. The concentration of HPC bacteria varied with time (Fig. 8). Overall, low counts of heterotrophic bacteria were observed between July and December (Weeks 0 to 24).

Total coliform counts varied from site to site. However, the sites in Gogogo seemed to be more contaminated compared to sites in Nkonkobe with regard to total coliform counts. Water in the Gogogo sites was less protected from animal activities compared to the one in Nkonkobe. Moreover, Gogogo is a true rural area with most people lacking environmental awareness while Nkonkobe is a semi-rural area. The University of Fort Hare is located in the Nkonkobe area and interacts with the surrounding communities on some issues related to environmental awareness. The poor sanitation and hygiene conditions in Gogogo and lack of environmental

Figure 10 (top left)

Box plots of time (weeks) against total coliform counts (CFU/100 ml) of water at 17 selected sites in Gogogo and Nkonkobe for the period starting from 3 July 2001 to 16 July 2002

Figure 11 (middle left)

Box plots of 17 selected sites in Gogogo and Nkonkobe against faecal coliform counts (CFU/100 ml) of water for the period starting from 3 July 2001 to 16 July 2002

Figure 12 (bottom left)

Box plot of time (weeks) against faecal coliform counts (CFU/100 ml) of water at 17 selected sites in Gogogo and Nkonkobe for the period starting from 3 July 2001 to 16 July 2002

awareness could be considered as the major causes of water contamination. This could also explain the high incidence of the outbreak of water-borne and sanitation-related diseases such as cholera and typhoid reported in the former Transkei where Gogogo is located, compared to the rest of the province. Storage tank water sources seemed to be relatively good compared to all the other sources in Gogogo. Underground waters in this study seemed also to be less contaminated. This confirms the earlier report that groundwater has relatively good microbiological quality compared to surface water (Lehloesa and Muyima, 2000).

Water from the sites in Gogogo seemed also to be the most contaminated with regard to faecal coliforms (Fig. 11). The highest coliform count, i.e. 5 logs, was observed on the 27th week of the experimental period. During weeks 0, 3, 15, 21, 30, 39, 51 and 54 the bacterial counts remained approximately in the range of 3 logs. The lowest coliform count was observed during Weeks 9 and 24, i.e. 0.5 logs. The high level of faecal coliform counts observed during July could be explained by the fact that water was more scarce during this middle of winter period and the small dams had less and less water, therefore concentrating the microbial populations (Fig. 12). In winter, most of the water sources dry up and as a result, animals tend to flock towards any available water source including the one used by the community for drinking. Counts were also high in summer, i.e. Weeks 9 to 12, 15 and 18. A sudden rise in almost all the parameters examined, i.e. temperature, turbidity, HPC, TC and FC except the pH was observed from Week 24. This rise was associated with high rainfall. The results in this study also indicated that whenever there was a seasonal transition period (passage from one season to another) coliform counts were affected and often dropped to lower levels.

In general both the total and faecal coliform counts in all the sites under consideration were above the South African recommended limits for drinking water. According to South African Guidelines the number of total coliforms in drinking water should be less than 10 colonies per 100mL, while the number of faecal coliforms should be zero per 100 mL (DWAF, 1998). The high total and faecal coliforms counts, i.e. in the order of 4 logs per 100 mL, indicated a relatively high level of contamination especially in dams where the water was used by domestic animals, for laundry purposes and was exposed to heavy rainfall. Other possible sources of contamination of water sources in the study area could be the presence of pit latrines close to the water sources, lack or little environmental protection, and poor catchment management. The quality of the drinking water therefore depended on local conditions. Runoff from human settlements lacking proper sanitation facilities, animal and human activities in the proximity of the water source could be considered the major pollution sources for water in the rural communities. Microbial growth and physical water quality are considered to be priority parameters and have to be monitored in the river, dam or borehole catchments (Fatoki et al., 2001). Gaga Windmill water was stored in the storage tank before its distribution to the consumers. Groundwater is known to have low microbial contamination (Morgan, 1990; Lehloesa and Muyima, 2000) and this could explain the relatively low bacterial counts observed at this site compared to all the other sites (Figs. 7, 9 and 11).

The presence of faecal coliform bacteria indicates that the water is contaminated with faecal human or animal waste, while the total coliform counts indicate that the water is contaminated with both faecal waste and other bacteria from the soil. According to *Quality of Domestic Water Supplies - Assessment Guide*, the water from all sites under consideration could be classified as Class III (red), which means poor water quality. The water is therefore not

recommended for use without prior treatment (DWAF, 1998; ANON, 2000).

When comparing the microbiological water quality at sites in Gogogo and Gaga, Upper and Lower Gqumashe sites, Gogogo Sites were the most contaminated (Figs. 7, 9 and 11). Although Gaga, and Upper and Lower Gqumashe water was relatively less contaminated than the water in Gogogo, it still did not meet the South African standards for domestic water (DWAF, 1998).

Conclusion

Overall the water in all the sites in Gogogo and Nkonkobe is not fit for human consumption without prior treatment. The water quality parameters of concern were microbial contamination and turbidity. The high number of indicator micro-organisms' counts observed reflected the poor quality of water used by these communities. The people in these rural communities therefore live in constant risk of contracting water-borne and/or sanitation-related diseases as highlighted by the microbiological quality of the water they use for drinking and other domestic uses. Although water from the sites in Gogogo was the most contaminated, the one from the sites in Nkonkobe also failed to meet the South African Standards for Domestic Water Quality (DWAF, 1996). Summertime displayed higher indicator micro-organism counts and turbidity than the other seasons. There is therefore a need for protection of the domestic water sources in the rural communities under consideration. This should be supported by a strong environmental awareness campaign to help the people in these rural communities to participate positively in efforts to protect and manage the quality of their water resources.

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