ASSESSMENT OF LINKS BETWEEN MICROBIOLOGICAL QUALITY OF DOMESTICALLY STORED WATER AND DIARRHOEA

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ABSTRACT

Water has to be collected from public standpipes and stored in containers in the homes of the target urban community. This leads to health-related microbiological contamination of water in containers. Possible links between the water quality and health of the consumers in the target community was investigated. The investigation tested for differences in microbiological water quality of households affected by diarrhoea in the preceding twelve months (cases) and households not affected by diarrhoea (controls) under similar environmental conditions. Heterotrophic bacteria, total coliforms, *Escherichia coli* and *Clostridium perfringens* were used as indicator organisms to determine the microbiological water quality. Distance was also investigated to determine if it has an influence on microbiological water quality during collection. Results indicated that the microbiological quality of container-stored water from the plastic and metal containers for both the case and control groups generally did not comply with infection limits for domestic water proposed by Water Quality Guidelines of the Department of Water Affairs and Forestry. The waters used by both groups were similar in microbiological quality, with no statistically significant differences between the two groups. This indicates that both the study groups were equally at risk of microbial infection from their domestically stored water. The deterioration in water quality is probably due to storage containers that are not kept hygienically clean. Improvement of similar situations in urban communities would require education on container hygiene and anti-contamination measures for water handling and usage during fetching and storage.

INTRODUCTION

Water intended for human consumption should be safe for health and aesthetically pleasing (Nevondo and Cloete, 1999). Water that is contaminated with microbiological constituents is considered unsafe and can cause a variety of diseases, with diarrhoea as their main symptom (Water Research Commission (WRC), 1993). Notwithstanding the fact that people in SA have a right to safe drinking water (Republic of South Africa, 1997) the microbiological quality of the water they consume, often poses a risk of infection because of various circumstances such as accessibility (e.g. distance), domestic water storage and handling (Jagals et al., 1997). People can therefore not always be sure if the water they drink is safe for them (Coulson, 2000).

Most people in developing urban communities rely on access to a communal water supply for their daily water needs (Jagals et al., 1999). Problems, associated with the communal supplies, include substantial distances between homes and the standpipes (access) and long waiting times when filling domestic storage containers (MRC, 1999). These problems give rise to various water storage and handling practices in households, which lead to deterioration of the microbiological water quality between collection points and storage (Jagals et al., 1999), which could affect the health of consumers (Medical Research Council (MRC), 1999).

In an effort to investigate links between health-related microbiological water quality and health of the consumers in an urban community, this study was a follow-up of information obtained from two related studies done earlier in the same area. These were studies that measured ① the particular community's environmental health status, using diarrhoea as an indicator (Theron, 2000) and, ② the microbiological quality of water stored in containers for domestic consumption by the same community (Bokako, 2000). Study ① was an observational, cross-sectional, study aimed at establishing whether peoples' water-use patterns that developed around fetching, storing and handling of domestic container water, had any detrimental effect on their health. Diarrhoea was used as the health indicator. Study ② simultaneously assessed the microbiological quality of water in these containers.

The aim of this study was to determine whether the health-related microbiological quality of container-stored water, used in households affected by diarrhoea (cases), differed significantly from that in households not affected by diarrhoea (controls), in similar environmental circumstances. The potential link between environment and health was investigated by observing and defining the health status, indicated by diarrhoea, of the case and control households and, at the same time, establishing associations between the health status and the microbiological quality of the water stored at home.

METHODOLOGY

Study area

The study was conducted in a large, high-density, low socio-economic urban development in the south - eastern Free State. Water is supplied through a communal system, of which the standpipes are at varying distances from the premises. Sanitation consisted of pit latrines.

The epidemiological study component

Sampling frame: A sample population of 120 households with similar circumstances and socio-economic status were selected from the target population of 3000 households (Theron, 2000). Fifty-three of these households were identified as cases on the basis of at least one member of the household having contracted diarrhoea in the immediate past twelve months. Sixty-seven households were selected as controls on the basis of <u>not</u> having any incidents of diarrhoea for the same period.

Study design: An observational analytical case-control study design was used to enable comparison between case and control groups (Katzenellenbogen et al., 1997). For this study, two groups (cases and controls) were compared to determine whether they differed in exposure to microbiologically contaminated domestic water. Data sheets were designed that included structured questions to respondents, as well as observations of the household environment, by environmental health officers and their field assistants. Data were captured on factors such as water accessibility, handling and storage practices in the same households during the same day and time when container water samples were collected for microbiological analyses.

Respondents: The respondents were mothers, grandmothers or female family members at least

17 years old. It is generally accepted that adult respondents are more suitable to interview when data regarding household activities are needed. Furthermore it is considered best to interview the mother or caretaker of the children for health data (Pickering, 1985; Ahmed et al., 1994).

Data capturing and analyses: After data capturing, the data sheets were coded and the data converted to information using the programme Epi-Info 2000.

Microbiological analyses

Water samples were collected from container used in both the case and control households for microbiological analyses.

Heterotrophic bacteria (HPC) were used to indicate general microbiological water quality (Standard Methods, 1998). The organisms were enumerated inside a laminar flow cabinet using a spread plate method with glucose yeast agar. The prepared plates were incubated aerobically at 37^0C for 48hr. All the visible colonies were counted as heterotrophic bacterial colonies.

Total coliforms (TC) and *E. coli* (EC) were used to indicate organic and faecal pollution of water respectively (Grabow, 1996; Standard Methods, 1998). Enumeration was done on Chromocult® Coliform Agar (Merck, 1996), using the membrane filtration technique, and incubated aerobically at 35^0C-37^0C for 24 hours. Salmon to red colonies were counted as TC and dark blue-to-violet colonies as EC (Merck, 1996). Colonies were verified for TC and EC using API® 20E analytical profile indices.

Clostridium perfringens (CP) were used to indicate remote faecal pollution as well as possible presence of cyst and oocyst-forming protozoan parasites such as *Giardia* and *Cryptosporidium* (Payment and Franco, 1993). Enumeration was done on supplemented Perfringens Agar (Oxoid, 1990), using the membrane filtration technique, and incubated an-aerobically at 37^0C for 48 hours. Fully discoloured dark brown to black colonies were counted as CP.

Microsoft Excel® 97 was used to do descriptive statistical analyses such as the sample size, range, geometric mean, median, and the 95% confidence intervals. The statistical programme SigmaStat Version 2.0 (1997) was used to calculate the sample size as well as to test for statistically significant differences in the microbiological quality of water used by the case and the control groups.

RESULTS AND DISCUSSION

Microbiological Water Quality

The microbiological quality of water from the municipal supply was also assessed in the previous studies (Jagals et al., 1997; 1999) as well as this study. The supplies did not pose a general risk of microbiological infection to consumers in terms of the South African Water Quality Guidelines (Department of Water Affairs and Forestry (DWAF), 1996). The results presented here were therefore focused only on the microbiological water quality of the water used from containers in the households.

Figure1 shows a comparison of organism numbers in container-stored water used by the case and control groups. No statistical significant differences could be found in the microbiological quality of water used by the case and control groups with P=0.789 (HPC), P=0.363 (TC) P=0.749 (*E coli*) and P=0.534 (CP).

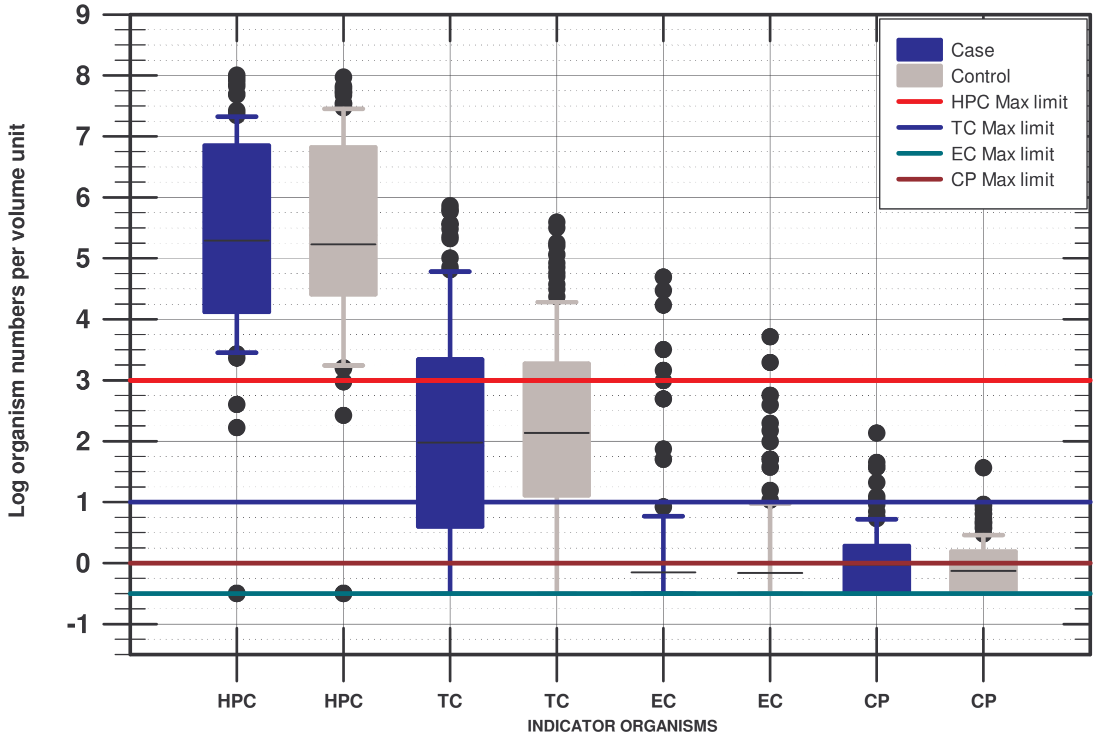

FIGURE 1: Microbiological indicator numbers in container-stored domestic water supplies.

The numbers of heterotrophic bacteria, in stored water used by both the case and control groups, exceeded the limits for an *increased risk* of microbiological infection to consumers (1000 organisms / 1mL) proposed by the South African Water Quality Guidelines (DWAF, 1996). The high heterotrophic bacteria numbers can be attributed to poor hygienic handling of water from containers within households as reported by Bokako (2000).

Total coliform bacteria indicate the possible presence of microorganisms in water that can cause gastro-intestinal diseases typically characterized by diarrhoea. Total coliform numbers in the water stored in containers generally exceeded the limits (5-100 organisms / 100mL), for a risk of infectious disease transmission of microbiological infection (DWAF, 1996), for both groups although the higher risk level was for the case group (Figure 1).

The mean *Escherichia coli* numbers in stored water of both groups were found to be 0 organisms / 100mL. This indicated that incidences of faecal pollution of the stored water were limited in the water used by case and control groups (DWAF, 1993). Although *E coli* did occur intermittently (Figure 1), the risk of infection was negligible. *Clostridium perfringens* in container-stored water used by the case and control groups was also compared in (Figure 1). There were no statistically significant differences in the occurrence of *Clostridium perfringens* in stored water used by both groups, regardless of the tap used. The median values also indicated that the water of both the case and the control group posed an *insignificant risk* (1organism/100ml) of infection proposed by the Water Quality Criteria in South Africa (Aucamp and Vivier, 1990).

Figure2 shows numbers of indicator organisms found in plastic metal container stored water used by the case and control groups.

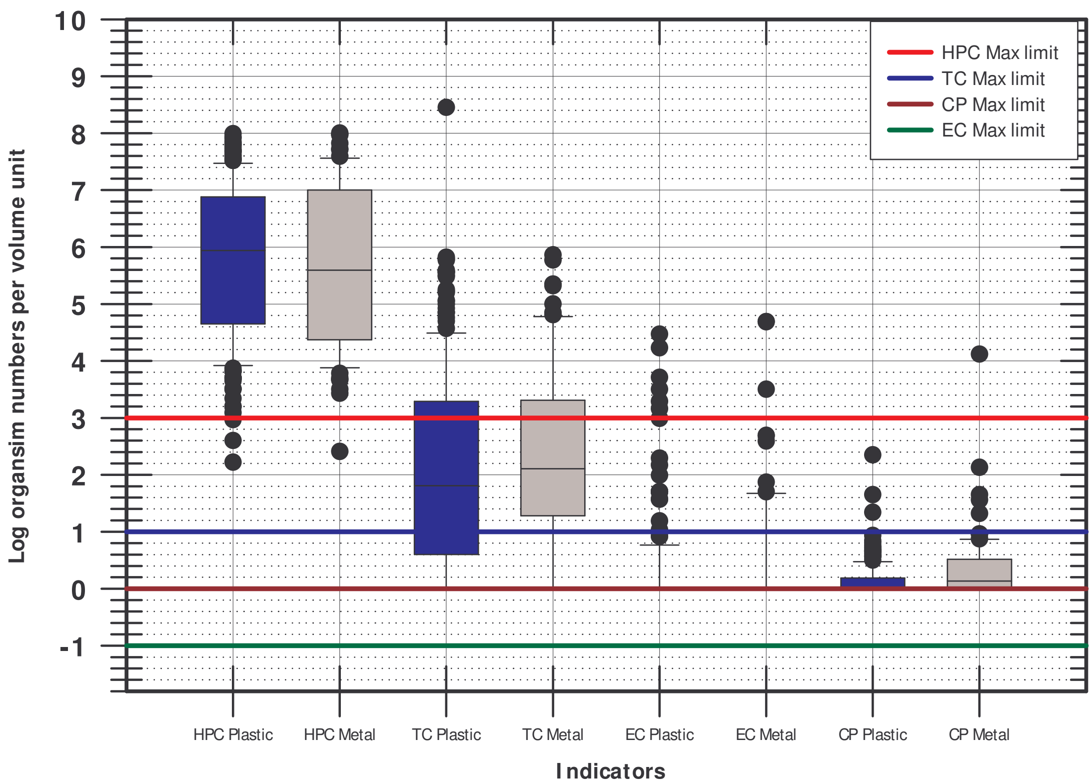

Figure 2: Numbers of indicators in plastic and metal containers

Median values for heterotrophic bacteria in stored water of both (P=0.723) plastic and metal containers were above the negligible risk (≤ 100 organisms / 100mL) limits (DWAF, 1996). The numbers of heterotrophic bacteria were found to be high in the plastic container stored water than in the metal container stored water.

Total coliform numbers in stored water from plastic and metal containers (P=0.268) did not comply with the limits for negligible risk of microbial infection (10 organisms / 100mL), (DWAF, 1996). High-risk level was found in stored water from metal containers than in plastic containers used by the case and control groups. It can be concluded that there is possible faecal contamination in the water stored in both types of containers.

Stored water from metal containers showed a higher risk level of *E.coli* than stored water in plastic containers. It was further found that microbiological quality of the water used by the case and control groups from the plastic and metal containers is similar in both types of containers as the numbers exceeded the negligible risk (0 organisms / 100mL) limits for drinking water (DWAF, 1993)

With regard to *C. perfringens* results in figure2, showed that organism numbers in the stored water from metal containers did not comply with the limits for insignificant risk (1 organism / 100mL) as proposed by the Water Quality Criteria in South Africa (Aucamp and Vivier, 1990). Results further indicated a statistically significant difference in the water quality used from both the plastic and metal containers (P=0.001).

Effect of distance on microbiological water quality

Table 1: Results of the Tukey multiple comparison tests for communal and yard taps in the case group

Cases (communal / yard taps)	Difference of the Means	*q*	*P* < 0.05?
Communal taps >10m<100m vs Yard taps.	1.68	5.48	Yes
Communal taps >10m<100m vs. Communal taps >100m	1.37	3.94	Yes
Communal taps > 100m vs. Yard taps	0.31	0.92	No
*** *q* test statistic indicates the number of means spanned.**			

In *table1* the difference of the means is a gauge of the size of the difference the three groups compared. It was found that there is a statistically significant difference in the distance (Communal taps >10m<100m versus Yard taps) and (Communal taps >10m<100m versus Communal taps>100m) in the case group. No significant difference was found in the distance (Communal taps >100m versus Yard taps). From the results in *table1* it can be concluded that 10m and 100m distance is the one that differs from the other two distances.

This implies that households within a maximum 10m (yard taps) distance from the taps often rinse their containers because taps are nearer the homes. Households where the taps were between 10m and 100m away used big open containers to fetch water (Theron, 2000). Further, it was indicated by Jagals et al. (1997) that water fetched at this distance was exposed to the surrounding environmental conditions (dust) on the way home resulting in high numbers of indicators.

Effect of volume consumed per person per day

Through the study it was found that the average volume **(15 l)** and **(19 l)** of water available per person per day in the case and control groups respectively could not have had an influence on the occurrence of diarrhoea in the case group. Therefore the available water volume per person in both groups could not be identified to be an environmental health risk factor contributing to the occurrence of diarrhoea in the case group.

CONCLUSIONS

- In general, the microbiological quality of container-stored water did not comply with standard limits for indicator organisms in drinking water (DWAF, 1996). The water used by the case and control groups was similar in microbiological quality, with no statistically significant differences between the two groups. No direct link could be found between microbiological water quality and occurrence of diarrhoea in the case group. This indicates that both the study groups were equally at risk of microbial infection.
- Households of the case group living between 10 and 100 meters from their respective communal taps were found to be exposed to higher total coliform numbers from container-stored water, which could be attributed to the type of container used as well as the way water was fetched and stored.

To improve the situation in developing countries with similar conditions would require two types of action:

- Installing in-house taps to bring water closer to the households in order to shorten the "tap-to-glass" sequence.
- Educating communities on the importance of using more water for personal hygiene, even if it means extra efforts to increase stored household water volumes. Such an environmental health education practice will also have to focus on container hygiene, anti-contamination measures for water haulage, as

well as for water handling and usage during storage.

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CONCLUSIONS

- In general, the microbiological quality of container-stored water did not comply with infection limits for drinking water proposed by DWAF (1996). The water used by the case and control groups was similar in microbiological quality, with no statistically significant differences between the two groups. This indicates that both the study groups were equally at risk of microbial infection from their domestically stored water.
- This deterioration in quality is probably due to storage containers that are not kept hygienically clean.

To improve the microbiological quality of stored water, in households in developing countries with similar conditions, would require two types of action:

- Engineering intervention such as installing in-house taps to bring water closer to the households in order to shorten the "tap-to-glass" sequence. This would however, present a problem as many communities could not afford the sanitation services that have to be installed to accommodate this action.
- This implies that community education on the importance of maintaining container hygiene.

Such environmental health education practices need, therefore, to focus on container hygiene, anti-contamination measures during for water haulage, as well as hygienic water handling and usage during storage.

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