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THE IMPACT OF AN EDUCATIONAL INTERVENTION ON THE MICROBIOLOGICAL INFECTION RISK POSED BY WATER STORED IN HOUSEHOLDS

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NTOMBIFUTHI PATIENCE NALA

Dissertation submitted in fulfilment of the requirements for the Degree

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BLOEMFONTEIN
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DECLARATION WITH REGARD TO INDEPENDENT WORK

I, NTOMBIFUTHI PATIENCE NALA, identity number [redacted] and student number [redacted] do hereby declare that this research project submitted to the Technikon Free State for the Degree MAGISTER TECHNOLOGIAE: ENVIRONMENTAL HEALTH, is my own independent work; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Technikon Free State; and has not been submitted before to any institution by myself or any other person in fulfilment of the requirements for the attainment of any qualification.

SIGNATURE OF STUDENT

16 Jan-2002

DATE

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ABSTRACT

The aim of this study was to investigate whether a water-handling hygiene education programme could contribute to improving the health-related microbiological quality of container water stored and used in households in the dense urban settlement of Botshabelo in the Free State Province.

Previous studies in the area indicated that stored container water became contaminated during the fetching, storing and handling of the water at home. These practices exposed the study population to a potential risk of microbiological infection. An intervention, in the form of the education programme, was implemented simultaneously with a water quality assessment component.

Members of a sample of households from the study population participated in a series of domestic water-handling hygiene education training sessions over a period of eight of the twelve-month study period. The sample was eventually divided into three sub-groups based on attendance of the training sessions (*never*, *intermittent* and *frequent* (NIF)) and water samples from each group analysed during and after the programme (*after* data). This was done to determine any changes in the health-related microbiological water quality during training. The water quality of the NIF groupings *before* (baseline data from previous studies) and *after* the hygiene education intervention programme, was also assessed for significant changes. Seasonal influence was also investigated. Turbidity was used to indicate biofilm formation on the inner sidewalls of storage containers, which implied changes in container-washing practices. Heterotrophic bacteria (HB) numbers were used as indicators of general microbial water quality. Total coliform (TC) bacteria were used to indicate organic pollution, while *E. coli* (EC) bacteria were used to indicate faecal pollution.

There were significant changes between the *before* and *after* data for all the indicators examined. Turbidity decreased to levels below the risk of *slight potential health effects* after the intervention period, indicating less biofilm formation that could be attributed to improved container hygiene. However, the bacterial indicators still indicated potential risk of infection for consumers. HB numbers indicated an *increased risk of infectious disease transmission*. Slight decreases in TC numbers indicated reductions in organic pollution of the container water, but still posed a *significant chance of infection*. EC numbers were also lower, but still rendered the water unsafe for domestic, especially potable use.

Despite improved container washing, large HB numbers were still being introduced into container-stored water, probably from the domestic environment during water handling. TC and EC numbers still indicated hazardous microbiological contamination of container water by faecal as well as other organic matter during water use, probably from aspects such as

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unwashed hands. Generally no s were found in water quality between NIF groupings, either *before* or *after* the programme, even though the *frequent* group attended all the training sessions. This indicated that the programme did not have a particular influence on any one group. The lower levels of turbidity did not necessarily reflect an effect from the programme but was possibly an effect of awareness created during related studies done before in the area. Climate appeared to have played a role in TC and EC counts during the programme because the counts were higher for both indicator organisms in warmer than in colder and moderate months.

Container water was still contaminated during storage despite the water-handling hygiene education programme. The water still posed a potential risk of infection when consumed. An effective hygiene education programme should be so designed and implemented that those inherent, deep-rooted, individual personal behaviours such as handling stored water with unwashed hands can be changed. The programme should bring about improved domestic water management by members of households, such as protection of container-stored water from environmental contamination. Changes such as these, brought about by sustainable awareness creation and education should contribute towards sustained improved health-related quality of water stored in domestic environments.

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UITTREKSEL

Die doel van hierdie studie was om ondersoek in te stel of 'n waterhanteringshigiëne opvoedingsprogram kon bydra om die gesondheidsverwante mikrobiologiese gehalte van water, wat in houers in huise gestoor en gebruik word, in die digbevolkte stedelike gebied van Botshabelo, Vrystaat provinsie, te verbeter

Vorige studies in die gebied het daarop gedui dat gestoorde water gekontamineer word gedurende die haal, stoor en tuis-hantering daarvan. Hierdie praktyke het die studiepopulasie blootgestel aan 'n potensiële risiko van mikrobiologiese infeksie. 'n Intervensie, in die vorm van die higiëne opvoedings program asook 'n watergehalte assesserings-komponent was gelyktydig geïmplementeer.

Lede van 'n steekproefgroep van huishoudings vanuit die studie populasie het, oor 'n periode van agt van die studie termyn van twaalf maande, deelgeneem aan 'n reeks opvoedingsprogramsessies oor huishoudelike waterhanteringshigiëne. Die steekproefgroep was uiteindelik verdeel in drie sub-groepe, gebaseer op die bywoning van die opleidingssessies (*nooit*, *periodiek* en *gereeld* (NPG)). Watermonsters van elke groep was geanaliseer *gedurende* sowel as *na* die program om vas te stel of daar enige verbetering was in die gesondheidsverwante mikrobiologiese watergehalte. Die watergehalte van die NPG groepe *vooraf* (basisdata van vorige studies) en *agterna* (data gedurende en direk na) die higiëne opvoedingsprogram was ook ondersoek vir enige beduidende veranderinge. Seisoenale invloede was ook ondersoek. Turbiditeit was gebruik om aan te dui of biofilm op die binnewande van houers gevorm het, wat veranderinge in houer-was praktyke sou impliseer. Heterotrofiese bakterië (HB) getalle was gebruik as indikatore van algemene mikrobiale watergehalte. Totale koliforme (TK) bakterië was gebruik om organiese besoedeling aan te dui, terwyl *E. coli* (EC) bakterië gebruik was om fekale besoedeling aan te dui.

Daar was beduidende veranderinge tussen die *vooraf* and *agterna* data vir al die indikatore. Turbiditeitsvlakke het, *na* die intervensie, afgeneem tot onder die risikovlakke van *geringe potensiële gesondheidseffekte*, wat gedui het op verminderde biofilmvorming, waarskynlik as gevolg van verbeterde houer-higiëne. Nietemin, die bakteriële indikatore het steeds 'n potensiële risiko van infeksie vir verbruikers aangedui. HB getalle het *vehoogde risiko van infektiewe siekte oordraging* aangedui. Geringe afnames in TK getalle het gedui op afnames in organiese besoedeling van die houer water, maar het steeds op 'n *beduidende kans op infeksie* gedui. EC getalle was ook laer, maar het steeds veroorsaak dat die water onveilig was vir huishoudelike gebruik, veral vir drinkdoeleindes.

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Ten spyte van verbeterde houer teeds in groot getalle tot houer-gestoorde water toegang gekry, waarskynlik vanuit die huishoudelike omgewing gedurende water-hantering. TK and EK getalle het steeds 'n mate van gevaarhoudende mikrobiologiese kontaminasie van houerwater deur fekale sowel as ander organiese materie gedurende watergebruik, aangedui, waarskynlik vanaf aspekte soos ongewasde hande. In die algemeen kon geen beduidende veranderinge gevind word tussen die NPG groepe nie, hetsy *voor* of *na* die program, selfs al het die *gereelde* groep al die opleidingssessies bygewoon. Hierdie het daarop gedui dat die program nie enige besonderse uitwerking op enige van die groepe gehad het nie. Die laer turbiditeits vlakke na die program het nie noodwendig 'n effek van die program gereflekteer nie, maar was moontlik 'n effek van bewusmakings aksie wat plaasgevind het voor die aanvang van die program, waarskynlik gedurende vorige verwante studies in die gebied. Klimaat het geblyk 'n rol te speel in die TK sowel as EK getalle aangesien hierdie hoër was gedurende die warmer as die kouer en gematigde maande.

Houerwater was steeds gekontamineer tydens die stoor daarvan ten spyte van die waterhateringshigiëne opvoedingsprogram. Die water het steeds 'n potensële risiko vir infeksie ingehou indien dit ingeneem sou word. 'n Effetiewe higiëne opvoedingsprogram, behoort ontwerp en geïmplementeer te word wat diep-gewortelde inherente gedrag, soos hantering van water met ongewasde hande, kan verander. Die program behoort ook verbeterde huishoudelike bestuur, soos om byvoorbeeld gestoorde water teen omgewingskontaminasie te beskerm, teweeg te bring. Veranderinge soos hierdie, teweeggebring deur volhoubare bewusmaking en opleiding, behoort by te dra tot volhoubare verbeterde gesondheidsverwante gehalte van water wat in huishoudelike omgewings gestoor word.

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Chapter 1 INTRODUCTION

1 STUDY BACKGROUND

Households in Botshabelo, Free State Province, South Africa, participated in a water quality study done in 1999 (Bokako, 2000) to assess the health-related microbiological quality of the water they stored in containers at home. The results of the particular study indicated that the stored water posed a potential risk of microbial infection to consumers. A water-handling hygiene education programme was implemented in the particular community in an effort to improve the quality of the stored water. This study assessed the effectiveness of the education programme.

Improving water supply in developing urban areas without educating people on how to make maximum use of such improvements, might not achieve the improvement in quality of life as can be expected with such improvements (Isley, 1995; Jagals et al., 1999). In many areas in South Africa the good quality of water supplied at collection points (i.e. communal taps), deteriorate in a chain of events until used by consumers. It is especially after collection and during storage that the health-related microbiological quality of container-stored water deteriorates to such an extent that such waters pose a potential risk of infection by microorganisms to consumers (Macy and Quick, 1998; Medical Research Council (MRC), 1999; Thevos et al., 2000).

Engineering interventions, such as installing individual water taps for households just outside their homes (i.e. yard taps replacing taps at remote communal supply points), is expected to contribute to the improvement of the overall quality of life of people in disadvantaged communities. From a water-handling quality point of view, these improvements would generally be defined as a safe water supply (good health-related microbiological water quality) as well as accessibility, and availability of the water supply (Jagals et al., 1997; Kravitz et al., 1999). Reports indicate that the health-related microbiological quality of stored water do improve after engineering interventions. However, these improvements did not always match the effort and cost. The net result appeared to be that stored water still posed a potential risk of microbial infection to people (Jagals et al., 1999).

Installing a yard-tap does not negate the fact that people's domestic needs still require water to be stored in their homes, especially at night and early morning for activities such as cooking and drinking at home. In other words, the storage of water in containers at home implies that the tap-to-glass chain or sequence is still interrupted (Gorter et al., 1991; Jagals et al., 1999; Bokako, 2000). In turn this implies that while the people have a good water supply much closer to home (more accessible, available and of a safe quality), water-

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handling hygiene during collecti se at home may have a negative influence on the health-related microbiological water quality of the water used from containers.

To ensure that a costly intervention, such as improving access and availability by expanding a water reticulation system is effective in the context of health-related microbiological quality of stored water, concurrent community development programmes should support such interventions. These are programmes such as hygiene promotion that would encourage people to gain the maximum benefit from their improved infrastructure (Bardwell et al., 1994; Xlintz et al., 1995; Reif et al., 1996; Jagals et al, 1999).

During this study, a simple water-handling hygiene education programme was conducted to provide a form of supportive intervention for engineering improvements. The study was conducted over a period of eight months in Section-K in Botshabelo, a dense urban settlement within the Mangaung local municipality in the Free State Province, South Africa. Previous studies done in the area indicated that stored water became contaminated with unwanted microorganisms during the fetching, storing and handling of the water (Jagals et al., 1997; 1999; Bokako, 2000; Nala and Jagals, 2000). All these studies concluded that household members were continually exposed to a potential of risk microbiological infection from stored water, even after taps were installed closer to home. This implied that some other intervention, such as the water-handling hygiene education programme, had to be instigated to supplement the improvement of the infrastructure. This led to the implementation of the study reported on in this document.

The study consisted of an educational as well as a water quality assessment component designed to involve and encourage a selected group of households in Section-K to improve their domestic water-handling practices. The health-related microbiological quality of the stored water in the selected households was measured during the programme to monitor the effectiveness of the hygiene education.

2 THE RESEARCH PROBLEM

It was not clear to what extent the health-related microbiological water quality of water, stored in containers within households could be improved by means of a hygiene education programme that would focus on improving domestic water handling practices.

Statistical hypotheses were formulated of which the null-hypotheses (H_0) were generally based on *no changes* in the health-related microbiological water quality from what it was before the education programme to what it turned out to be during and right after the programme. Rejection of these hypotheses would imply significant changes, which in the case of improvement, would indicate that the programme had an effect on the water-handling practices of the people.

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3 MICROBIOLOGICAL W AND HEALTH

The essence of this type of study was to monitor whether teaching people how to use and handle container-stored water could have an effect on their water quality. This particular study is not an epidemiological study because it was not aimed at assessing the condition (disease) of the people that used the water, but rather on the microbiological quality of the product they had used and the potential risk of microbial infection the product might pose.

Water related diseases are among the most serious health problems in the world today (World Health Organisation (WHO), 1997a). Water contaminated with microbiological constituents can cause a variety of diseases (Nevondo and Cloete, 1999) and also plays a major role in the spread of these diseases. Many people worldwide die daily as a result of water related diseases (Grabow, 1996; Jagals et al., 1997).

Microorganisms are the major cause of reported water-borne illnesses throughout the world (Cartwright, 1998). Genthe and Seager (1996) reported that, in South Africa, communicable water-related diseases, especially diarrhoea, are the most widespread health problems related to consumption of contaminated water at the point of use. Water-borne diseases of concern are those caused by a biological agent of disease. The transmission and prevention of water-related infections depend in part on the microbiological water quality (Genthe and Seager, 1996).

4 QUALITY OF WATER STORED IN CONTAINERS AT HOME

In many areas of South Africa, water of acceptable drinking quality supplied at collection points (i.e. communal taps), deteriorate after collection and during storage in containers to such an extent that the water pose a potential risk of infection by mocroorganisms to consumers (Department of Water Affairs and Forestry (DWAF), 1996; Jagals et al., 1999; MRC, 1999). It is generally believed that by bringing the supply point of treated water nearer to domestic environments, people would have easier access to the supply with a consequent improvement in quality of life (Pillay and Terry, 1991; African National Congress (ANC), 1994; Republic of South Africa, 1994). It is also generally accepted that when people have more comfortable access to treated supply, the potential of water contamination with microorganisms would be reduced (WHO, 1997a). However, Jagals et al. (1999) reported that this might not be the case.

In South Africa, improvement of water supplies in many instances means installing a communal tap much nearer to people's homes or even individual yard taps. Due to limited resources, households are often not provided with in-house water supply since the sanitation infrastructure to remove wastewater from the houses does not exist. Installing a yard-tap therefore provides an affordable alternative (Jagals et al., 1999). However, this

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does not negate the fact that pe [illegible] eds still require volumes of water to be stored in their homes for use (Nala and Jagals, 2000).

In other words, the storage of water in containers at home implies that people still have to collect good quality water from their yard taps and store it in containers. It is in these containers that the health-related microbiological water quality, through a variety of causes, deteriorates to the level of infection risk to consumers (Ahmed et al., 1998; Jagals et al., 1997; 1999; Bokako, 2000).

5 IMPROVED WATER SUPPLY AND COMMUNITY AWARENESS TO BENEFIT HEALTH

A complex relationship exists between water quality, hygiene and human health (Bukenya and Nwokolo, 1991). Improved infrastructure for water supply on its own, or in conjunction with improved sanitation, should yield positive benefits to the community, resulting in reduction in the transmission and occurrence of disease (Ahmed et al., 1994). However, improvements in the water supply can take on a variety of shapes and configurations and have often been disappointing in that the health benefit expected to follow the improvements did not happen (Quick et al., 1999). An increasing number of reports from researchers and community developers indicated that community hygiene awareness should be promoted, along with the improvements made to the water supply (Jagals et al., 1999; Quick et al., 1999).

Improvement of water supply and sanitation facilities would undoubtedly prove to be ineffective if people do not practice good hygiene in relation to stored water use (Peterson et al., 1998). The World Health organisation (1999) also states that to have any positive effect on the health of the individual, the introduction of improved water supply must be accompanied by good hygiene in water-handling practices, especially at home. Good personal and domestic hygiene practices related to stored water would eliminate degradation of the water quality, as well as promote factors that will maintain good quality in stored water. This in turn should lead to the reduction in diarrhoeal diseases caused by consumption of microbiologically contaminated water (Almedom et al., 1997; Water Research Commission (WRC), 1999).

6 WATER-HANDLING PRACTICES THAT INFLUENCE STORED WATER QUALITY

Health-related microbiological water quality is negatively influenced by a number of factors that result in stored water becoming unfit for consumption. These factors include (Pinfold, 1990; Ahmed et al., 1998; Jagals et al., 1997; 1999; Nyong and Kanaroglou, 1999; Bokako, 2000; Theron et al., 2000):

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- Handling of water storage [illegible]lude:
    - Container hygiene pertaining to washing or rinsing of containers between fillings
    - Storage methods focussing on protecting the water contents from environmental pollution
- Handling of water related to the containers at home:
    - Hand hygiene
    - Hygiene of decantering / scooping tools
    - Collection and transport

6.1 HANDLING OF WATER STORAGE CONTAINERS

6.1.1 Container hygiene

Water that is safe at the source often becomes contaminated in storage containers (Genthe et al., 1995; Jagals et al., 1999). The sanitary condition of storage containers could be a risk factor even with improved supply (Almedom et al., 1997; Ahmed et al., 1998; Theron et al., 2000). Previous studies indicated that the internal surfaces of storage containers were contaminated with some sort of biofilm that can harbour microorganisms during storage (Bokako, 2000). This will re-contaminate clean water when the container is refilled. It might have a negative impact on the health of consumers when such contaminated water is consumed in sufficient quantities (Ahmed et al., 1994).

In the context of sanitation and water supply, effective container hygiene forms an integral part of educational programmes since the cleaning and maintenance of these containers pertains to a simple technology that can readily be transferred to household members through a series of participatory activities (Almedom et al., 1997; Mvula Trust, 1998).

The hygiene education programme focussed on educating selected household members on basic “container cleanliness”. This implied washing and rinsing containers before water fetching as well as in between storage sessions. This was aimed at reducing the accumulation of unwanted elements such as biofilm formation (Bokako, 2000) in storage containers.

6.1.2 Storage methods at home

Pinfold (1990), Ahmed et al. (1998) and Jagals et al., (1997; 1999) reported that people contaminate water at home during storage and handling, thereby contributing to microbiological contamination. Water storage and handling must therefore be taken into consideration in any water supply programme, to ensure that consumers have safe drinking water at the point of consumption (Cartwright, 1998).

The method and place of storage at home may impact negatively on water quality (Kravitz et al., 1999). Theron (2000) had found that in approximately 84 % of households in

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the study area, containers are pl [illegible] indows or even on the ground without any form of protection from contamination by dust, young children with dirty hands or even the household pets.

Stored water quality can be improved at home through the following measures (Mintz et al., 1995):

- Only using water from a treated or protected source for drinking purposes
- Keeping storage containers clean and covered
- Keeping storage containers out of reach of children and domestic animals
- Boiling water where practical

Of the above aspects, the hygiene education programme focussed on the positioning of filled storage containers in the home as Theron (2000) reported that most households in the study area placed containers within pathways of pollution such as open windows, household pets and children.

6.1.3 Storage container protection

It has been reported that container type (especially the material of manufacture) can be associated with poor microbiological water quality of stored water (Tyagi et al., 1998; Bokako, 2000). Every type of container imaginable has been used for household water storage (Stockholm Environment Institute, 1999). However, most do not adequately protect water from contamination (Quick et al., 1996a). Many are open without lid or cover. Open plastic and metal buckets are commonplace (Nala and Jagals, 1999; Theron, 2000). People also buy containers previously used for other purposes such as holding paint, because these are more affordable (Mintz et al., 1995; Nala and Jagals, 2000).

Contamination level of stored water can be increased or decreased by the shape (construction) of the container (Quick et al., 1996a). Jagals et al. (1997) reported that the use of open-ended containers, which left uncovered, exposed the water to unhygienic surroundings that pose a greater contamination potential than when water is stored under cover or in screw-top containers.

The hygiene education focussed predominantly on protecting the water contents of the storage container by covering container openings. This was to limit contamination that might result from the home environment and during collection and transportation.

6.2 HANDLING OF WATER RELATED TO THE CONTAINERS AT HOME

Households need to have a ready supply of potable water handy since it is necessary to satisfy fundamental human needs (Republic of South Africa, 1994). In many developing areas where water have to be collected either from communal taps or yard taps, the water is stored in the dwelling for various purposes such as for drinking, dishwashing, washing of

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clothes, and personal hygiene. [illegible] activities that the water gets severely contaminated.

6.2.1 Collection and transport

Collection of water in these developing areas is always accompanied by transport of collected water from the collection point to households. It is during this transportation phase by household members that water is often exposed to contamination before use. Various methods are used for transporting water in the study area. These include the use of wheelbarrows, carrying filled containers by hand or on the heads and rolling of filled plastic drums on the ground. Theron (2000) found that 52.6 % of containers filled in the study area are not closed by any means during transportation, which could lead to contamination from environmental elements such as dust particles of various origins such as soil and cattle dung (Jagals, 2000). This plays an important role because microorganisms gain access during transportation and may increase through replication in the containers during home storage (Bokako, 2000; Nala and Jagals, 2000).

The hygiene education programme also focused on the manner of water collection and transport. Hand hygiene during filling, tap cleaning before filling, as well as covering container openings during transportation to limit water contamination were aspects covered.

6.2.2 Hand hygiene

A significant factor that can influence water quality at home is the personal behaviour related to hand hygiene. Hand washing is an important household intervention to reduce the occurrence of diarrhoea (Pinfold, 1990; Ahmed et al., 1998). Hands are possibly the most used parts of the body and therefore more susceptible to contamination because they touch the ground, taps, other people's bodies, and prepare food (Breslin and Dau, 1998). Therefore, to minimise infection risks, the way that people maintain hand hygiene when they work with domestically stored water need to improve before an improvement in the microbiological quality of stored water can be expected (Pinfold, 1990; Ahmed et al., 1998; Jagals et al., 1997).

Hand hygiene education played an important role in the study because most of the organic pollution in water appeared to result from contact of stored water with contaminated hands either after toilet use or contact with other contaminated utensils in the home (Pinfold, 1990; Ahmed et al. 1998; Nyong and Kanaroglou, 1999).

6.2.3 Hygiene of decanting / scooping tools (mugs)

How people transfer water from storage containers to the point of use plays a role in the deterioration or maintenance of the quality of container water. The study population mainly used various types of "mugs" for scooping water from storage containers (Nala and Jagals, 1999). The use of mugs can have a negative impact on water quality because of the

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tendency of household member ng the same mug for various other purposes such as drinking from it (Theron et al., 2000). Water was also scooped from open containers instead of it being poured out. This would inevitably lead to people's (often unwashed) hands touching the water in the container (Rosenberg et al., 1997; Ahmed et al., 1998; Theron, 2000). Furthermore, Bokako (2000) reported that the mugs used were neither washed nor disinfected prior to use. Mugs were also not protected from unhygienic environmental conditions between uses. This observed behaviour implied poor mug hygiene as well as contamination of stored water when used.

Handling and contact of water with unwashed hands and mugs could therefore contaminate stored water because of poor personal hygiene and general household hygiene practices (Luby et al., 1998). Improved scooping mug hygiene habits need to be sustained in order to positively affect stored water quality. For this to happen, it is necessary for the community to receive hygiene education on these issues.

Scooping tool hygiene was therefore also important in the education programme because contaminated tools were reported to contribute to stored water contamination by other related studies. The focus was therefore on the manner of use of the scooping mugs to limit any form of contamination.

7 HYGIENE EDUCATION

It is more likely that people will sustain good water-related hygiene practices at home if they have access to water of microbiological quality that complies with negligible or low risk limits as proposed by the South African Water Quality Guidelines of the Department of Water Affairs and Forestry (DWAF, 1996), Guidelines for Drinking water Quality of the World Health Organisation (WHO, 1996) as well as proper sanitation services (Republic of South Africa, 2001; Coulson, 2000). However, millions of people do not have access to these essential services. People still have to collect safe water from remote supply points and transport it back to their domestic environments that often do not have basic sanitation (Republic of South Africa, 1997). For these people, sound hygiene practices such as regular hands washing, proper transport and storage of water after collection will be a valuable tool to maintain and even improve their water quality.

One way of improving water handling practices is through promoting water-handling hygiene (Coulson, 2000). Hygiene promotion is about changing people's negative behaviour to promoting behaviour, especially behaviour that leads to good hygiene practices, such as regular hand washing and proper transport and domestic storage of water after collection (Graeff et al., 1993; Kaltenthaler and Drasar, 1996; Coulson, 2000).

According to the International Water and Sanitation Centre (IWSC) (2001), a strong pillar of hygiene promotion is hygiene education. Teaching people improved water-handling

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hygiene practices could require ral change with regard to water handling and storage of container water.

In instances where accessibility to the supply has been improved, sound hygiene practices should be taught and maintained in order to ensure that water people store and use at home does not endanger their health (Dunston et al., 2000).

This study therefore focussed on subjecting members of the study population to an active education rather than a prolonged community awareness programme, in order to achieve results in as short a period of time as possible. The focus was on teaching and putting the knowledge in practice, toward improving water handling.

8 THE STUDY

The study was conducted in a residential area (Section-K) located within the city of Botshabelo, 65-km south-east of Bloemfontein in Mangaung local municipality district. Pit latrines are used for sanitation in the area. Water is collected from communal taps and a number of yards taps and then stored in storage containers at the households. Eighty households were subjected to the hygiene education programme on basic water-related hygiene practices.

The study consisted of two components:

- A hygiene education programme designed to involve and encourage a selected group of households in Section-K, Botshabelo to improve their domestic water handling practices.
- Stored water monitoring to measure the effect the educational hygiene programme had on health-related microbiological quality of the stored water.

The hygiene education programme included:

- One initial meeting with the study group
- Three participatory training sessions with members of the selected households
- Results feedback on the microbiological analyses at each session
- The group were trained in methods to sustain container hygiene as well as hygienic water handling practices at home

8.1 THE HYGIENE EDUCATION PROGRAMME

An hygiene education approach was used in this study to teach people to adopt safer practices such as keeping the container closed at all times, as well as effective cleaning of storage containers before each filling. People were taught how they could maintain their

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stored water quality to such qua the South African Water Quality Guidelines, (DWAF, 1996).

8.1.1 Application of PHAST methodology

Participatory hygiene and sanitation transformation (PHAST) methodology was used to facilitate the contact sessions and educational tools (WHO, 1998) were used for identification of contamination routes and protective measures for water storage and handling. The tools were used in the activities such as *problem analysis, identifying and blocking contamination routes of stored water* and *selecting improved hygiene practices / behaviours*.

The *problem analysis activity* was adapted from PHAST methodology and was used to enhance community participation through a learning process. This activity enabled the community to direct their focus on the problem that has been identified (deterioration in stored water quality). *Identifying and blocking contamination routes of stored water* activity was used to help the action group analyse the effectiveness of various storage methods and choose those that are appropriate to use in order to improve their stored water quality. The activity for *selecting improved hygiene behaviours* was used to assist the action group to decide which hygiene behaviours or practices are needed to improve stored water quality.

8.1.2 Overview of the hygiene education programme

Household members participated in one meeting and three training sessions during the programme. During the training sessions, household members participated in identifying their problem (deteriorated microbiological water quality) and in deciding on the best options that would lead to improvement of the health-related microbiological water quality.

Based on the options selected, the household members were trained in basic hygiene methods to clean their containers, maintain proper container hygiene and hygienic water handling practices at home.

Results on microbiological water quality analyses conducted periodically during the programme sessions were communicated during the meetings to keep the household members informed on their progress in achieving their goal, which was to improve the health-related microbiological water quality of stored water. Representatives of selected households signed the attendance list during each training session in order to monitor the attendance. Progressive water monitoring was also implemented to assess the effectiveness of the training sessions. It was apparent that not all the selected households were represented in all training sessions that lead to grouping of the study sample into three groups based on their attendance profile. The grouping strategy will be discussed in detail in Chapter 2.

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8.2 HEALTH-RELATED WATI

The health-related quality of water is often judged by its clarity as well as microbiological content (Bokako, 2000). Microorganisms and other unwanted particles impact directly on water quality resulting in water unfit for consumption. The most important impact is the transmission of diseases caused by pathogenic microorganisms in water (Jagals et al., 1997; Quick et al., 1997).

In South Africa, criteria for health-related microbiological water quality are found in the South African Water Quality Guidelines (DWAF, 1996), as well as an Assessment Guide on Water Quality issued by the Water Research Commission (WRC, 1998). These guides provide information on limits of infection risk posed by the quality of water intended for human use. It also advises on how to test the water quality (WRC, 2001).

During this study, two quality aspects of the health-related water stored and used by the study group were focussed on:

- The general hygienic condition of the containers and its water content were assessed based on clarity (turbidity) and heterotrophic bacteria numbers. This aspect relates to whether the containers and the water in it are kept "clean". This approach was supported by assessments of the occurrence of biofilm formation inside containers (Bokako, 2000), as well as the general microbiological quality of the container water. This is an indication of the cleanliness and correct storage and handling procedures of the vessels.
- Level and type of pollution of the water in containers that poses a potential health risk to the consumer. This aspect relates to whether the waters from the containers are hazardous to the health of people. It was assessed using specific indicator microorganisms such as total coliforms and *Escherichia coli*.

8.2.1 Indicators of general container and stored water hygiene

Turbidity

Turbidity testing is used to measure the clarity of water. The lower the turbidity levels, the clearer the water. Turbidity in water is caused by the presence of suspended matter, which usually consists of a mixture of inorganic and organic matter that can be living matter such as microorganisms (DWAF, 1996; WRC, 1998). The suspended matter provides a basis for biofilm formation on the inner walls of storage containers. Harmful bacteria and other microorganisms colonise the biofilm, which may then be consumed during domestic water handling, thus negatively affecting human health when the water is consumed (DWAF, 1996; Jones and Bradshaw, 1996; Bokako, 2000).

Organic and inorganic matter gains access to storage containers during collection, transportation, and during unprotected water storage at home in open containers (Coulson,

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2000). The presence of microorg sociated with turbidity in water. Turbid water therefore is not aesthetically acceptable and may also be an indication of water quality that may impact negatively on health (WRC, 1998). Turbidity testing could therefore be used to measure the hygienic status of the containers used by selected households to store water at home (Bokako, 2000). In this study, turbidity was used to indicate the presence or absence of biofilm formation in the containers as a function of container cleanliness.

Heterotrophic bacteria

Heterotrophic bacteria counts (HPC) indicate the number of culturable bacteria in a water sample (Pawliuk and Amores, 2000) and may be used to indicate the general microbial quality of water. Their presence indicates post-treatment contamination or bacterial aftergrowth in the distribution system (DWAF, 1996). Bokako (2000) used heterotrophic bacteria numbers to indicate the effect that growth of biofilm in storage containers, used by people in the study area, had on the general hygienic status of the containers as well as the water quality.

Testing for heterotrophic bacteria provides useful information about general microbiological water quality in distribution systems (Pawliuk and Amores, 2000). Domestic water storage containers were also seen as distribution systems in the context of this study. Heterotrophic bacteria numbers were therefore used in this study to assess the hygienic quality of the containers used to store water at home.

Another function of testing for heterotrophic bacteria numbers for this study, as was the case with the studies of Bokako (2000) and Kastl and Fisher (1997), is that excessive HPC's were taken as an indication of unnaturally high levels of bacteria introduced into stored water by poor water-handling practices of households. Any improvement in HPC levels after the education intervention was assumed to be a potential reflection of the influence the programme had on the domestic water handling of the selected study population sample.

8.2.2 Indicators of hazardous microbiological pollution of stored water

Microbiological indicator microorganisms

Microorganisms are found everywhere in our environment and a variety of these may be transmitted by water (DWAF, 1996). Bacteria in water cannot be seen and, most of the health related symptoms are not immediately visible. The vast majority of microorganisms however, do not cause disease (Parrott et al., 1996). A few microorganisms (pathogens) can cause disease in humans under suitable conditions and are referred to as *pathogens* (Lloyd and Helmer, 1991; United States Environmental Protection Agency (USEPA), 2000). Enteric pathogens, which can grow in the human or animal gut, are the most dangerous in

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contaminated drinking water. Th often known as water-borne pathogens (DWAF, 1996). Drinking water should not contain pathogenic microorganisms and should also be free from bacteria of faecal origin, such as *Escherichia coli* (Haack, 2000).

Genthe and Kfir (1995) stated that it is not really possible to directly test for all pathogens related to water-borne diseases because it is a complex, time consuming and not cost effective exercise. Indicator microorganisms are tested for instead. Indicators are easy to detect, not dangerous to analysts and are inexpensive to test for (Grabow, 1996). The number of specific indicator organisms found could be indicative of the level of actual pathogens present in a water body (Parrott et al., 1996). Indicator organisms have therefore become bench-markers in the assessment of the microbiological quality of stored water (Genthe and Kfir, 1995).

The level of occurrence of indicator organisms in drinking water also indicates the likelihood of clinical infections occurring in consumers (WRC, 1998). In the context of this study, the presence of these organisms in the container water was also an indication of the potential microbiological risk of infection expected in the study population.

Two indicator bacteria groups were selected for the water quality component of this study - each with its own particular characteristic indicator value. These were total coliform bacteria and *Escherichia coli*.

Total coliform indicator bacteria

Total coliforms are a group of closely related, mostly harmless bacteria that live in water, organic matter in the environment, as well as the gut of animals. Genthe and Kfir, (1995), as well as Jagals (2000), reported that the extent to which total coliforms are present in drinking water could indicate the likelihood of the water being contaminated by organic matter from the environment. In the context of this study, total coliforms would indicate the hygienic quality of stored water (Grabow, 1996; Standard Methods, 1998) although these indicator organisms may not always be directly related to the presence of faecal contamination in drinking water. For this study, the total coliform indicator bacteria were used to measure the level of environmental contamination (potential level of organic pollution) of water stored in containers.

Escherichia coli

The total coliform bacteria include bacteria of faecal origin such as *Escherichia coli*. *E. coli* indicate the possible presence of bacterial pathogens such as *Salmonella spp.,* which can cause infectious diseases such as gastroenteritis and salmonellosis (DWAF, 1996). *E. coli* are specific bacterial indicators of faecal pollution in water (Grabow, 1996; Jagals, 2000) and are a very specific indication of pathogens present in water. For the purpose of this study, *E. coli* were used to indicate the worst and most dangerous form of bacterial pollution perceived in these circumstances, namely faecal pollution. Their presence would also have

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the added value of indicating the [illegible] of pathogens responsible for the transmission of infectious diseases (DWAF, 1996).

9 AIM AND OBJECTIVES OF THE STUDY

The aim of the study was to investigate whether intervention, through a hygiene education programme, based on PHAST methodology (WHO, 1997b; Mvula Trust, 1998), would in the end improve the health-related microbiological quality of stored water of a selected group of households in the residential Section-K, Botshabelo.

The following objectives towards achieving the aim were set:

- A selected group of households from the study area were to be subjected to a hygiene education programme to change their domestic water-handling practices.
- The health-related microbiological water quality of water stored in containers at the selected households was assessed to monitor for any changes, either in quality improvement or quality deterioration, during the education programme.
- The results so obtained were to be statistically compared with data on health-related microbiological water quality from containers in the same households from previous studies in order to measure whether the hygiene education programme had any effect on changing (preferably improving) the situation.

The educational procedures followed during the hygiene education programme are just discussed in Chapter 2; Methodologies (and not in Chapter 3: Results and Discussion) since there were no empirical measurements of behavioural changes in the knowledge, attitudes and practices of the study population. Instead it was assumed that the outcome of the programme will reflect in changes, or absence of changes, in the health-related microbiological water quality of water stored in containers at the homes of the study group.

Chapter 3: Results and Discussion will therefore focus on changes that may have occurred in the health-related water quality results during, and right after the water-handling hygiene education intervention.

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Chapter 2 METHODOLOGIES

This study was conducted over a period of one year. The study was divided into two components. Selected members of the study group participated in a series of water hygiene education sessions over eight of the twelve months. This activity was aimed at improving their domestic stored water handling practices. This was done to improve the general health-related microbiological, as well as aesthetic quality of the water they had collected and manually transported in containers from remote municipal supply points and then stored at home.

The health-related microbiological, as well as aesthetic quality of the water were tested over the same period of time to assess whether the quality of the water improved from a situation of infection risk levels before the education programme started to a minimal risk situation after the programme was completed. Water samples were collected in between the participatory contact sessions in order to continuously monitor for any improvement in the water quality.

1 STUDY DESIGN

The design of the study is illustrated in Figure 2.1. The methodology for the educational component was adapted from the PHAST (WHO, 1998) approach while water sampling was done in tandem with the water hygiene education programme events.

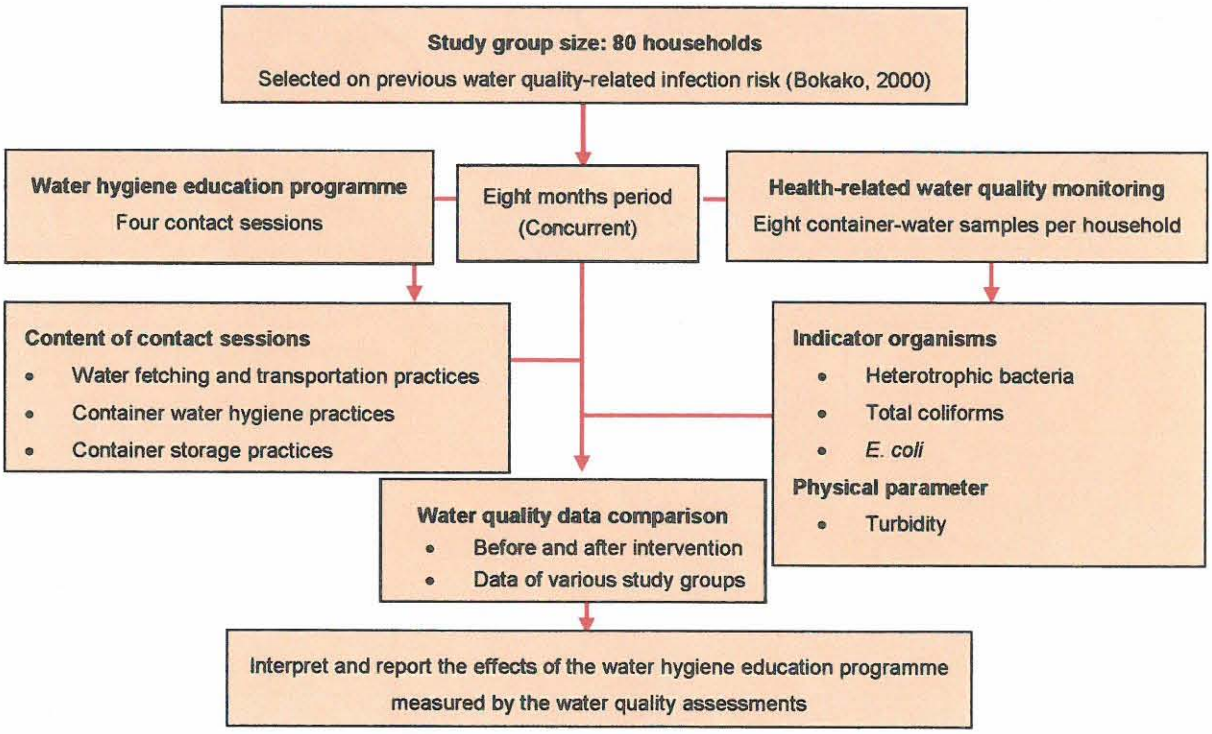

Figure 2.1: Flow diagram of the study phases

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2 THE STUDY AREA

The particular area of study was in a suburb of Botshabelo referred to as Section-K. The area has an estimated population of 220 000 people (Jagals, 2000). The city is a low socio-economic dense urban development with a high rate of unemployment (Bokako, 2000; Jagals, 2000; Theron, 2000).

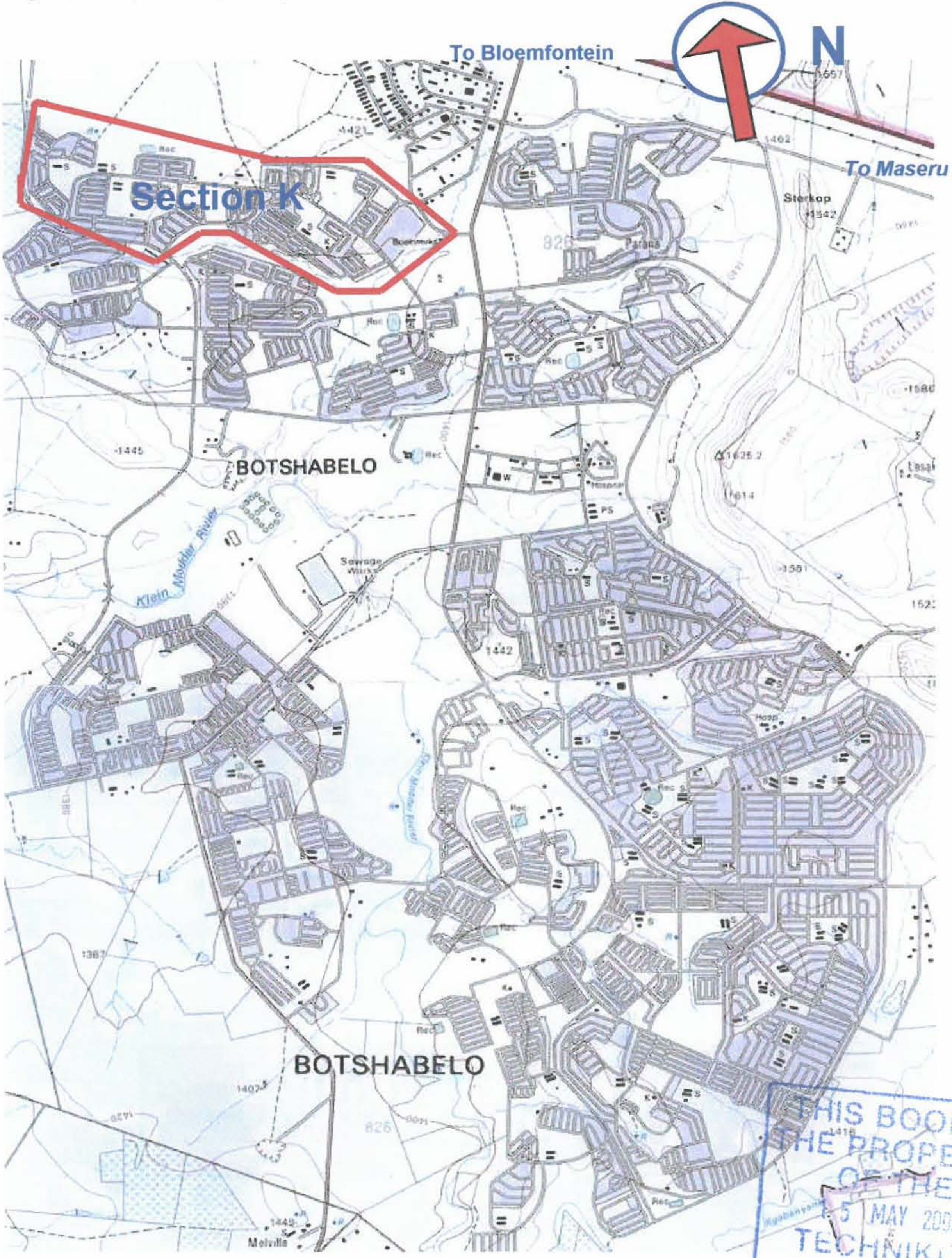

Figure 2.2: A map of Botshabelo, showing the study area of Section-K

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Communal standpipes generally supply treated domestic water. Only a small percentage of the houses in the area have in-house water supply and waterborne sanitation. The rest of the houses in the area have either pit latrines or night-soil buckets as a means of sewage sanitation (Jagals, 1994; 2000).

3 THE STUDY POPULATION

Section-K has approximately 3,100 households (Central Statistical Service, 1996; Theron, 2000). Theron (2000) had randomly selected approximately 10% of these households for her study while Bokako (2000) worked with 120 of the Theron household selection. The population sample for this study consisted of 80 households, whose selection was based on the samples used in the previous studies of Bokako (2000) and Theron (2000).

3.1 SELECTION OF THE STUDY SAMPLE

The process of selecting the study population sample is outlined in Figure 2.3.

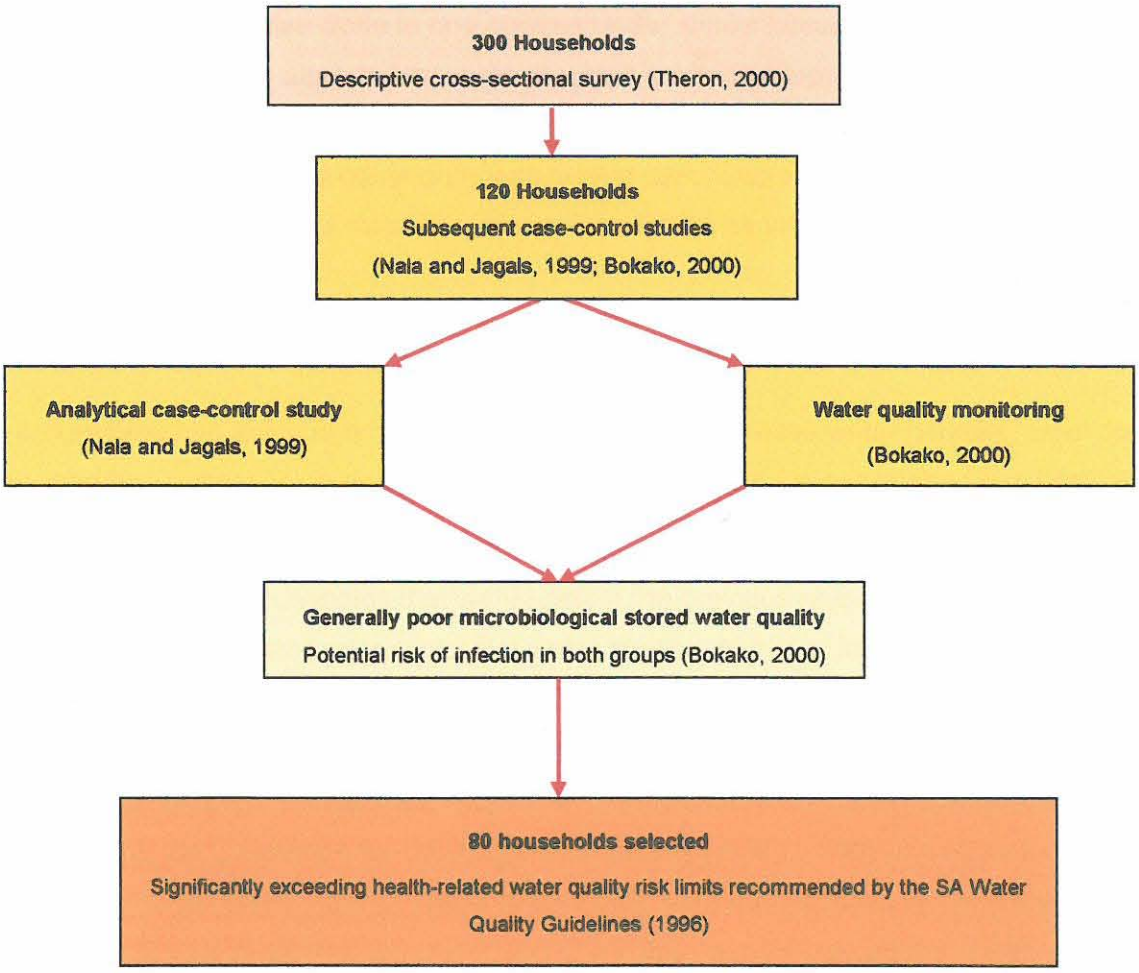

Figure 2.3: Outline of the process of selecting the study sample

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In the first study, 300 household d for poor domestic water handling practices (Theron, 2000) and the second case control study done by (Nala and Jagals, 1999; Bokako, 2000) was based on health-related domestic water quality of 120 households (53 cases/ 67 controls) selected from the first study (Theron, 2000).

No statistically significant differences could be found in the water quality of the cases and controls. Eighty households that constantly returned the poorest microbiological health-related water quality results in the Bokako (2000) study (done over a period of one year) were then selected for this current study (Figure 2.3). This sampling method can be described as a non-random sampling method (Katzenellenbogen et al., 1997) since it allowed for selection of individuals from the continuum of study interest - in this case, water quality that posed a microbiological infection risk. Further determining factors in selecting the sample size were practical considerations such as time, financial implications and human resources.

3.2 A CONTROL SAMPLE

A control sample from the same population group was NOT selected in this study. Households in the area live close to one another under similar circumstances. It was accepted that those who attended the water hygiene education programme would easily influence other community members who did not attend. It was furthermore not a practical alternative to select a control community with similar circumstances outside the area of study since these were some distance away and could not be included due to cost constraints.

4 DESIGNING THE WATER HYGIENE EDUCATION PROGRAMME

The programme had to focus on the sample population's domestic water handling practices. It was therefore necessary to design the programme based on the established practices of the study group.

The case and control households that were used in the previous studies were exposed to water of poor health-related microbiological water quality. In this study the population sample of 80 households therefore included households from both the previous case and control groups which were exposed to water of such poor microbiological quality that it posed a risk of infection if consumed in terms of the South African Water Quality Guidelines (DWAF, 1996), the Guidelines for Drinking Water Quality (WHO, 1996) as well as the Assessment Guide (WRC, 1998). These households were further found to have poor water handling practices and general water hygiene that could have influenced the quality of the water they stored and used at home (Nala and Jagals, 2000).

In order to design appropriate study material, it was decided to conduct another survey using questionnaires (Appendix A) to finally characterise particular behaviours to be

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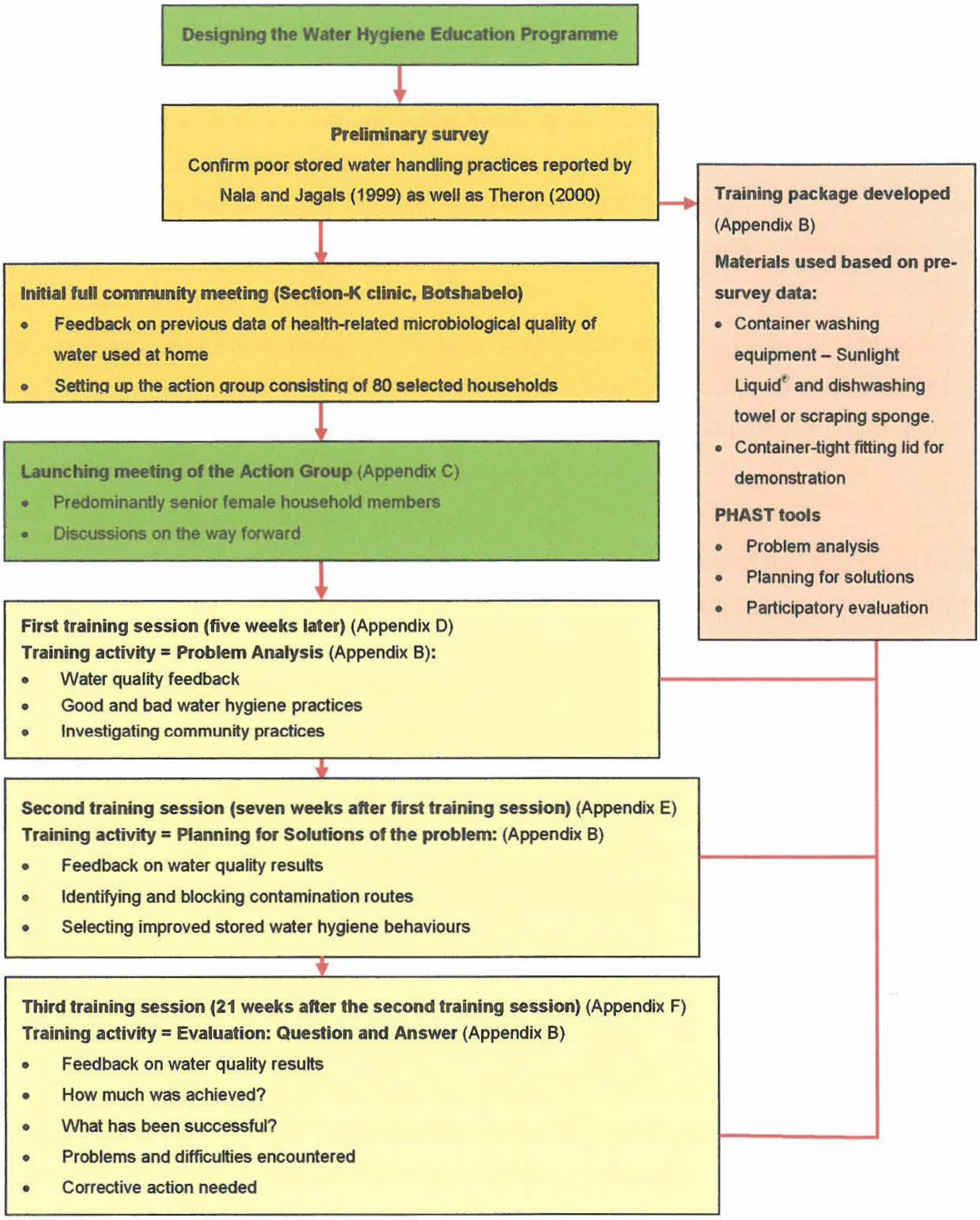
addressed in the water-handling programme. The process followed for this part of the study is summarised and illustrated in Figure 2.4



Designing the Water Hygiene Education Programme

Preliminary survey
Confirm poor stored water handling practices reported by Nala and Jagals (1999) as well as Theron (2000)

Training package developed (Appendix B)

Materials used based on pre-survey data:
- Container washing equipment – Sunlight Liquid® and dishwashing towel or scraping sponge.
- Container-tight fitting lid for demonstration

PHAST tools
- Problem analysis
- Planning for solutions
- Participatory evaluation

Initial full community meeting (Section-K clinic, Botshabelo)
- Feedback on previous data of health-related microbiological quality of water used at home
- Setting up the action group consisting of 80 selected households

Launching meeting of the Action Group (Appendix C)
- Predominantly senior female household members
- Discussions on the way forward

First training session (five weeks later) (Appendix D)
Training activity = Problem Analysis (Appendix B):
- Water quality feedback
- Good and bad water hygiene practices
- Investigating community practices

Second training session (seven weeks after first training session) (Appendix E)
Training activity = Planning for Solutions of the problem: (Appendix B)
- Feedback on water quality results
- Identifying and blocking contamination routes
- Selecting improved stored water hygiene behaviours

Third training session (21 weeks after the second training session) (Appendix F)
Training activity = Evaluation: Question and Answer (Appendix B)
- Feedback on water quality results
- How much was achieved?
- What has been successful?
- Problems and difficulties encountered
- Corrective action needed

Figure 2.4: Domestic water hygiene education programme design

4.1 SURVEY BEFORE COMMENCING WATER HYGIENE EDUCATION PROGRAMME

Practices of the selected household members were investigated to confirm the Nala and Jagals findings of 1999, which indicated that the selected households then had adverse water-handling ethics such as poor container water hygiene and lack of knowledge on water safety. This component assisted in planning and steering the water hygiene education

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programme by providing informa [illegible] e that had to be transferred for improving domestic water quality.

4.1.1 Data sheet development

A data sheet consisting of structured questions and provision for observations was developed and used to gather data on water handling practices of the study group (Appendix A). The variables included:

- Stored water handling (e.g. hand washing before water handling)
- Storage container handling, including cleaning methods and storage for containers

4.1.2 Training of field workers

A group of third year Epidemiology students from the Technikon Free State (Bloemfontein) were trained on how to administer the data sheet to capture the relevant data. Data sheet development and administration formed part of this third year subject practical curriculum (Nala, 2000; Tsubane 2001).

4.1.3 Data sheet administration and data handling

During interviewing, the field workers translated the English questions in the data sheet to the language best understood by the interviewee (generally Southern Sotho). This ensured optimal understanding of questions and answers between the interviewer and the interviewee (Duncker, 2001). The field workers were divided in such a manner that at least one or more members of the group understood and could speak Southern Sotho. Fieldworkers also observed and noted the actual practices such as tightly covered containers etc. on the data sheet (Appendix A). The fieldworkers were divided into groups of four and each group allocated twenty households to interview. The interviews were completed within two successive days with ten households interviewed per day by each group of field workers. The coding and entering of data was done on the programme Epi Info 2000 (Version 0.1).

4.2 THE HYGIENE EDUCATION PROGRAMME

The educational programme in this study was designed to focus on precautionary measures to limit contamination of water collected, transported and stored in containers. The outcome expected would be improvement of the health-related microbiological water quality.

The water hygiene education programme in this study consisted of the study materials (summarised in Appendix B), as well as a number of steps and activities aimed at encouraging full participation of the selected group members to improve the management of their water stored in containers at home.

The programme involved people in the analysis of their own problem that affect them and in the design of potential solutions as intended in the PHAST approach (Byers, 1996; WHO, 1998). Although more time consuming than traditional development approaches, this

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method generally leads to devel are sustainable over the long term (Lammerink et al., 2001).

Members of the selected households who attended the contact sessions were taught about keeping container water safe during fetching, storage and use. These members were educated and trained with slight variations (Appendix B) of the participatory hygiene and sanitation transformation (PHAST) methodology (Almedom et al., 1997; WHO, 1998).

4.2.1 Hygiene education programme steps

Setting up the action group (organising the group)

An initial general community meeting was held and feedback of previous microbiological health-related water quality results from the study by Nala and Jagals (1999) as well as Bokako (2000) was given to the attending community members. The results indicated the deterioration in quality of stored water, influenced by poor handling practices that negatively impact on water safety in storage containers. The community consented to the continued use of only 80 households (selected for the study sample) as representative of their situation in general. The identities and other personal information of the selected households were not required to be made known. Section-K clinic, Botshabelo in the Free State province was chosen as the central venue for future contact sessions.

Initial consultation with the action group (agenda and minutes Appendix C)

At a following meeting, at least one senior female member of each of the 80 households selected for the study sample was invited to become the action group. It was decided to predominantly involve female members because females are the members responsible for the health of households (De Castro and Hirschowitz, 1995). The senior female member of the household usually has the best knowledge about the activities in and around the house involving other household members.

The purpose of the study was explained to the action group. At first their particular microbiological health-related water quality results from the Bokako (2000) study were fed back to the members to again illustrate the risk of infection posed to their particular households. The main objective was then explained to the members. This was to improve stored water quality to the minimum risk limits according to the South African Water Quality Guidelines (DWAF, 1996) as well as the Assessment Guide (WRC, 1998). To achieve this objective, improvements in the following water-handling issues were suggested:

- Collection from the supply point and transportation
- Container water hygiene and storage methods
- Period of storage. This impacted on water quality because of biofilm formation when containers are not washed before refilling (Baltazar et al., 1993)
- Frequency of water collection per day and intermediate steps before refilling
- Types of cleaning materials for storage containers

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- Hand washing

The members were made aware that they would be subjected to a water hygiene education programme over a series of three additional contact sessions. Discussions were held in general to address the importance of improved container water hygiene and handling practices as well as how knowledge of this information could positively impact on their stored water quality.

Members of the action group were expected to share the knowledge, gained during participatory training sessions, with other household members at home. Implementation of the knowledge was to be done through sanitising the household containers as practiced during training. Furthermore, the household members were expected to start practicing proper handling of water from collection at the supply point, transportation, storage and taking water from the containers at home.

The expected improvement in their stored water quality was to be measured by continuous stored water sampling and analysis after each contact. The action group members were to be informed on water quality results at the beginning of each next contact session.

The three training sessions to follow were scheduled for Saturday afternoons when most people were expected to be at home. The action group was divided into two groups for the ensuing sessions to manage the participatory activities of the group effectively.

Contact Sessions (Training in domestic water hygiene practices)

First training session: *Problem analysis*

The second contact session was conducted five weeks after the first contact session (Agenda and minutes Appendix C). *Problem analysis* formed the essential part of the session. *Problem analysis* is an activity adapted from PHAST methodology and was used to enhance community participation through a learning process. This activity enables the community to direct their focus on the problem that has been identified (deterioration in stored water quality).

The *problem analysis* activity has four sub-activities that could be used in a technology transfer technique. For this study two of these sub-activities were used:

- Good and bad behaviours (water hygiene practices)
- Investigating community practices

The good and bad water hygiene sub-activity was used to help the action group to critically look at their common water hygiene practices related to stored water handling and to identify how these practices may be good or bad for their stored water quality.

Investigating community practices sub-activity was used to analyse actual practices in the community. The resultant information was compared to what the action group has

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discovered to be good or bad wa es in the “Good and Bad Behaviours” sub-activity. Tools used for *problem analyses* sub-activities (Appendix B), were *three pile sorting* (Figure 2.5) and *pocket charts* (WHO, 1998).

Figure 2.5: Participants identifying proper as well as poor water-related hygienic practices generally encountered in their community

Second training session: *Solution of the problem* (Agenda and minutes Appendix D) This session focused on *solutions and options* for keeping stored water safe for consumption and was conducted seven weeks after the first training session.

The researcher and the action group discussed matters of the previous training session to review what was learned. Two main activities were used to identify solutions and options namely (WHO, 1998):

- Identifying and blocking contamination routes (for stored water)
- Selecting improved (water) hygiene behaviours

Selecting protective storage methods-activity was used to help the action group to analyse the effectiveness of various storage methods and choose which they want to use in order to improve their stored water quality. Selecting improved water hygiene behaviour-activity was used to assist the action group to decide which water hygiene behaviours or practices are needed to improve stored water quality.

For this session, particular PHAST tools (WHO, 1998) were essentially adjusted similar to what Almedom et al. (1997) had done. The adjusted tools were *protective options* for water

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storage tools and *three-pile sorti*

Third training session: *Evaluation*

The third training session was conducted 21 weeks after the second training session (Agenda and minutes Appendix E). This contact session focused on the progress feedback of the action group. During this session the group identified the following:

- How much has been done and what has been successful?
- Problems and difficulties encountered and what corrective action is needed?

This last session consisted of a *question and answer* activity to determine the level of understanding reached throughout the water hygiene education programme.

5 THE WATER QUALITY MONITORING PROGRAMME

Figure 2.6 indicates sampling sessions during the water hygiene education programme. These sessions were conducted in order to continuously monitor any improvement in water quality as the water hygiene education programme took effect.

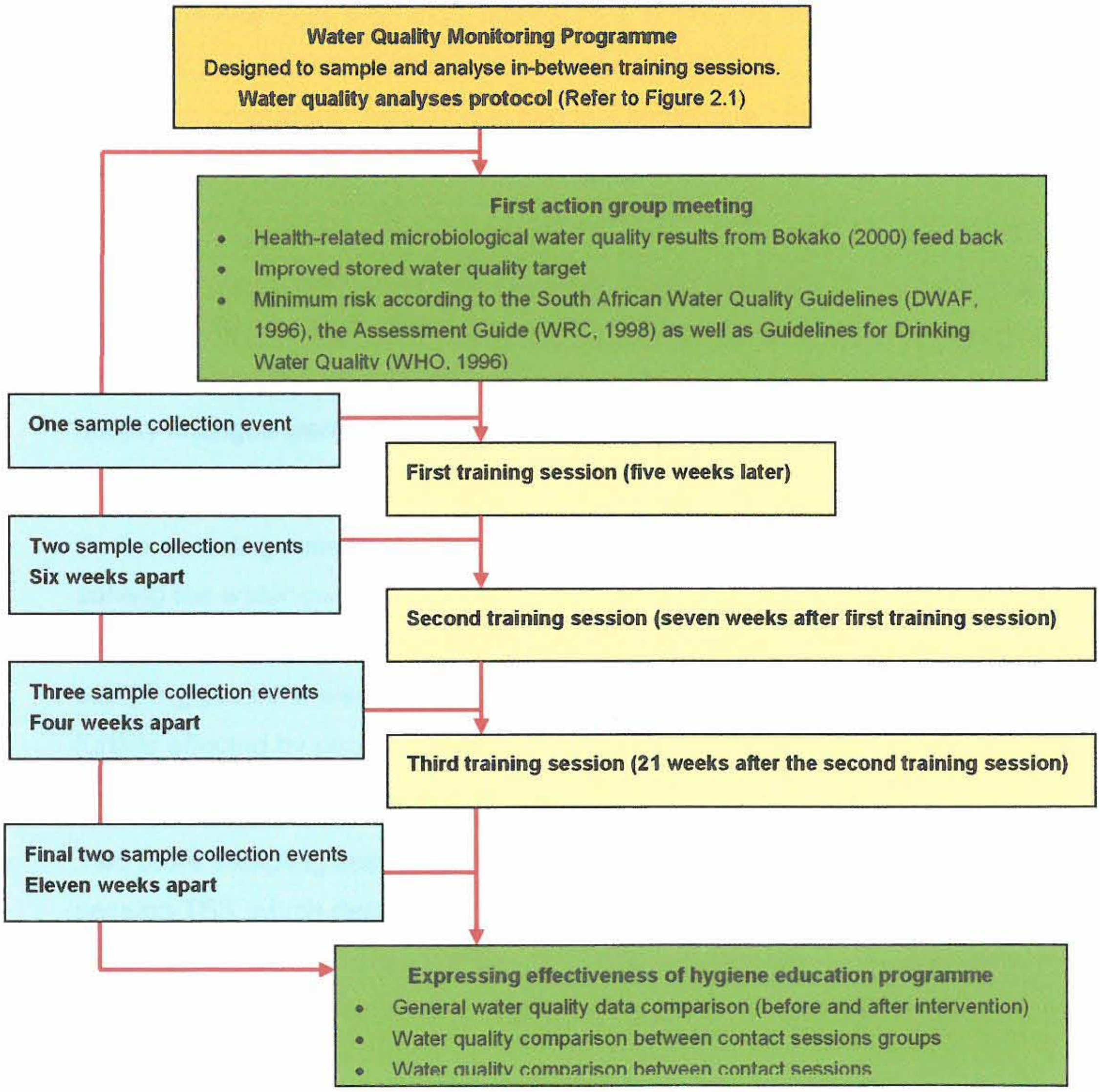

Figure 2.6: The water quality sampling frequency

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The microbiological water quality cond study by Bokako (2000) of the 80 selected households were used as baseline data to be compared with the microbiological water quality data collected during the water hygiene education programme.

5.1 SAMPLING OF THE STORED WATER

Eight sampling sessions had been conducted throughout the study period. Ideally the sampling sessions should have been done once a month with two sampling sessions fitted in between each training session (ideally to be conducted every two months). Unfortunately, circumstances such as the availability and accessibility of meeting venues and social events on the community calendar prevented such a symmetrical profile. Instead, the sampling sessions and meeting / training sessions had to be fitted in whenever the community was ready – something that did not happen within even periods. The water sampling frequencies ended up with the following configuration:

- One sampling session (Sample Week 1- after the commencement of the programme) took place one week after the initial meeting but before the first training session (TS1). This was to establish whether a novel undertaking such as the water-handling hygiene education programme would have had any immediate effect or whether the water quality would continue to resemble the combined baseline data of Bokako (2000).

- Two sampling sessions were conducted between TS1 and TS2. TS1 dealt with *analysing the problem* based on the water quality results from the first sampling session. The results from these two sampling sessions (Sample Weeks 8 and 14 - after the commencement of the programme) were meant to determine whether water quality changes were effected by the peoples newly founded perception of their water quality problem.

- Three sampling sessions were conducted between TS2 and TS3. TS2 dealt with *solving the water quality problem* if any. This was based on the water quality results from the three sessions (Sample Weeks 22, 26 and 34). The results from these three sampling sessions were also meant to determine whether water quality changes were further effected by people following the hygiene methodologies, based on solving the problem, taught during training in TS2.

- Two more sampling sessions (Sample Weeks 38 and 53) after the last training session TS3, which dealt with *evaluation of the results* achieved over the previous sampling sessions. These last two sampling sessions were intended to determine whether the results achieved during the programme as a whole, changed or whether it were sustained.

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5.1.1 Sampling methodology

Drinking water samples were collected from storage containers of selected households after contact sessions. The samples were collected from two weeks onwards after each training session, but adjustments had to be made based on the time schedule provided by the field workers who assisted in collecting and analysing the samples. This led to variation in number of weeks between samples collected after each contact session.

The stored water samples were collected aseptically in sterile Whirl Packs® from containers kept inside households. Samples were placed in cooler bags (7°C - 10°C) and transported to the laboratory at the Technikon Free State. Samples were analysed within six hours of collection (Standard Methods, 1998; WRC, 2001).

A brushing technique used by Bokako (2000) as adapted from the swabbing technique used by Jagals et al. (1997), was used (Bokako in Figure 2.7) to loosen any potential biofilm with trapped contaminants from the container sidewalls in order to suspend all possible contaminants that may be present in the containers. This was done to make sure that a realistic result of the hygiene of the container could be reflected.

Figure 2.7: The brushing technique in action

5.2 INDICATORS OF GENERAL CONTAINER AND STORED WATER HYGIENE

For this study, turbidity and heterotrophic bacteria counts were used in combination to assess the microbiological contamination status, as well as the concentration of suspended material in container-stored water (Bokako, 2000).

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5.2.1 Turbidity

For this study, turbidity was used as a physical gross parameter to assess the aesthetic water quality. This type of test is used to measure the concentration of suspended matter in water by measuring the clarity of water (WHO, 1997c). Turbidity testing could therefore be used to measure the hygienic status of the containers used by selected households to store water at home (Bokako, 2000).

The turbidity levels were determined in samples taken from containers, after any possible biofilm had been loosened from the inner sidewall surfaces of domestic water storage containers as described by Bokako (2000). The results were assumed to indicate the level to which biofilm formed in storage containers because changes in the concentration of suspended matter can be assumed to be changes in the formation of biofilm (Mohammed at al., 1997). In the case of this study, this would then be an indication of whether there had been changes in container cleaning and refilling practices that might have contributed to less biofilm forming on inner surfaces of storage containers (Bokako, 2000).

A HACH 2100 turbidity meter was used to measure turbidity levels and the measurements were recorded as Nephelometric Turbidity Units (NTU's). For the purpose of this study, two risk limits were used as guidelines according to the Assessment Guide Volume 1: Quality of Domestic Water Supplies (WRC, 1998). The lower risk limit used was the limit *for insignificant potential health effects* (<0.1 NTU's) and the higher limit for *slight potential health effects* with a range of (0.1 - 1 NTU's).

5.2.2 Heterotrophic bacteria levels

The popular reference to this test is heterotrophic plate counts (HPC) (Standard Methods, 1998). In this study, this test was used to indicate the general microbial quality of potable water (DWAF, 1996).

The pour plate heterotrophic plate technique was used to enumerate heterotrophic bacteria (Standard Methods, 1998; Pawliuk and Amores, 2000). Poured 90-mm petri plates, containing HPC agar (Biolab$^{®}$) and 0.3 mL aliquots of samples diluted in series were inverted and incubated aerobically at 35°C for 48 hours. All visible colonies on the plate were counted, with a colony counter, as heterotrophic bacteria and expressed in number of organisms per 1 mL according to the South African Water Quality Guidelines (DWAF, 1996).

Criteria for heterotrophic bacteria do not appear in Assessment Guide of the WRC (1998), therefore criteria of the South African Water Quality Guidelines (DWAF, 1996) were used. The limits range from *negligible risk of microbial infection* limit (0-100 counts / 1 mL), *slight risk of microbial infection* (100-1000 counts / 1 mL), to *increased risk of infectious disease transmission* (>1000 / 1 mL).

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5.3 INDICATORS OF HAZAR LOGICAL POLLUTION OF STORED WATER

Total coliforms were used to determine the level of organic pollution of water, while *E. coli* were used to specifically measure the extent of faecal pollution that might contribute to poor health-related microbiological water quality (DWAF, 1996; Grabow, 1996; WHO, 1996; Standard Methods, 1998; WRC, 1998).

5.3.1 Total coliforms

Total coliforms (TC) were used as indicators for organic pollution. In the context of this study, TC's would indicate the hygienic quality of stored water (Grabow, 1996; Standard Methods, 1998), although these indicator organisms may not always be directly related to the presence of faecal contamination in drinking water. The occurrence of total coliforms in containers also provides useful information on environmental contamination of water stored in household containers (Jagals, 2000).

The membrane filtration technique was used to enumerate TC's (Standard Methods, 1998). A sterile phosphate buffer was used for diluting samples in series and rinsing funnels during filtration (Millipore Corporation, 1992). Funnels were oven-sterilised by dry heat (>160°C) between each sample analysis.

TC's were cultured on Chromocult® Coliform Agar. This particular selective medium is used for simultaneous detection of TC, as well as *E. coli* in the same water samples (Merck Corporation, 1996; Jagals, 2000). Sterile gridded membranes (ø 47mm and 0.45 µm pore size) with the filtered organisms were placed on prepared triplicate 90-mm petri dishes. The prepared plates were inverted and incubated aerobically at 35°C for 24 hours. Red to salmon colonies (Merck Corporation, 1996), were counted directly from the plates and expressed as organisms per 100 mL, according to the South African Water Quality Guidelines (WRC, 1998). The numbers of *E. coli* colonies from the same plates were added to the final calculations of TC numbers because *E. coli* form part of the total coliform bacteria.

The Assessment Guide Volume 1: Quality of Domestic Water Supplies (WRC, 1998) was used for guidelines on infection risk limits associated with total coliform numbers per 100 mL. The risk limits used were the *insignificant chance of infection* limit (0-10 / 100 mL) as well as the upper limit above which *clinical infections in sensitive groups* such as children, elderly and immune-compromised individuals may occur (10 - 100 / 100 mL).

5.3.2 *Escherichia coli*

E. coli were used as indicators of faecal pollution of the water stored in containers. Examination of faecal indicator bacteria is essential in drinking water since it provides a very sensitive method of quality assessment (Grabow, 1996; Standard Methods, 1998). Furthermore, *E. coli* would provide useful information on whether the environmentally

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introduced TC's are from faecal handling water with unwashed hands after visiting the toilet (Jagals, 2000).

The membrane filtration technique was also used to enumerate *Escherichia coli* (*E. coli*) (Standard Methods, 1998). Sterile phosphate buffer was used for diluting samples and rinsing funnels during filtration (Millipore Corporation, 1992). Funnels were sterilised by dry heat between each sample analysis. These indicators were enumerated on Chromocult® Coliform Agar. Dark-blue to violet colonies were counted as *E. coli* (Merck Corporation, 1996) from the plates and expressed as organisms per 100 mL, according to the Guidelines for Drinking Water Quality (WHO, 1996).

The Guidelines for Drinking Water Quality (WHO, 1996) were used in this study to interpret the results in terms of *E. coli* numbers per 100 mL, because the two South African guideline sets do not provide for *E. coli* criteria. In terms of the WHO guidelines any presence of *E. coli* in drinking water indicate the water quality either at or above a limit referred to as the *unsafe water* limit (1 organism / 100 mL) and requires immediate remedial action. *Safe water* in terms of the WHO (1996) guidelines is regarded as water with zero counts of *E. coli* per 100 mL.

5.3.3 Colony verification

TC and *E. coli* colonies, counted from the Chromocult® Coliform Agar plates, were verified as the actual indicator organisms. This was to establish the selectivity and reliability of the Chromocult® Coliform Agar medium for detecting the selected indicators (Dionisio and Borrego, 1995; Jagals, 2000; Griesel, 2001). The verification was done with analytical profile index testing kits (API® 20E Multi-test Galleries) of bioMérieux®. The numbers of false positive organisms were established in order to accurately calculate the detected indicator numbers (Standard Methods, 1998).

6 GROUPING OF THE SAMPLE OF THE STUDY POPULATION

The study population sample was divided into three groups, based on attendance of the training sessions by the selected household members. It soon became apparent that some household members *frequently* attended the sessions while some *never* attended. A diffuse group would *intermittently* attend as the study progressed.

It was assumed that the attendance of the training sessions would have an influence on the members' knowledge and would therefore affect water handling practices of their households back home, which in turn would have an effect of positive improvement on their health-related water quality. For example, the assumption was that the health-related water quality of households of which a representative member *never* attended would show no significant change (preferably improvement) (Section 6.1 below).

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The three groups were therefore ermittent and *frequent* (NIF). The division was made according to the attendance list that each household member had to sign when attending each training session.

6.1 GROUP CRITERIA

The *frequent* group was selected based on household members represented in the launching meeting as well as the three training sessions, or the launching meeting as well as two training sessions by the same attendee. It was assumed that the health-related microbiological water quality of the *frequent group* would be improved to such a high quality that only a negligible microbial infection risk would have been posed. A *never* group was identified based on no signature of representatives found on the attendance list. In contrast to assumptions made for the water quality of the *frequent* group, it was assumed that the stored water used by the households in this group would remain of the poor health-related microbiological quality as before (from the Bokako study), therefore posing a risk of microbial infection to consumers. Table 2.1 shows a summary of the NIF grouping according to the attendance of training sessions.

Table 2.1: Grouping of study sample according to attendance list

Groups	Number of households	Number of meetings	Attendance Confirmed		Attendee	
			Attendance list	Questionnaire	Same	Different
Frequent group	3	4	x	x	x	
	1	4	x	x	x	
	4	3	x	x	x	
	1	3	x	x	x	
	3	3	x		x	
Group total	12					
Intermittent group	5	2	x	x	x	
	6	2	x	x	x	
	2	2	x	x	x	
	4	2	x		x	
	4	1	x	x	x	
	2	1	x	x	x	
	1	1	x	x	x	
	8	1	x		x	
	2	4	x			x
	3	2	x		x	
	5	1	x		x	
Group Total	42					
Never group	26	0				
Group Total	26					
Total sample	80					

The *intermittent group* was selected based on the same household representatives attending at least one or two training sessions, or even more training sessions but by different attendees from the same household. This attendance pattern was assumed to create variations in knowledge gained because each household representative was partially

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exposed to the hygiene educatio [illegible] in the intended impact of the training and knowledge transfer not being optimally implemented at home. No assumptions were made on water quality end-results for the *intermittent group*.

6.2 HEALTH-RELATED WATER QUALITY PER GROUP

After the NIF grouping had been established, their respective health-related microbiological water quality data from the study by Bokako (2000) were grouped to provide a structure for baseline (*before*) data for comparison. Each NIF group now had its own *before* data.

Data obtained during this study were referred to as the *after* data. Each NIF group now had its own *after* data. These data sets were compared in various ways according to the hypotheses formulated in Section 8 of this chapter to test for statistically significant changes. This was to determine any statistical significant changes in the data *before, after* as well as *during* the water hygiene educational intervention programme, in order to provide some measure of the effects (improvements or deterioration) the water-handling hygiene education and training might have had.

6.3 OTHER CHANGES IN HEALTH-RELATED WATER QUALITY

The training sessions (Section 4.2) that were conducted over a period of eight months, were followed up by container water sampling sessions to monitor whether the water quality of the households that had sent persons to attended the sessions changed in relation to the water quality of those households who did not attend.

Of the eight sampling sessions, three were taken in the *cold* winter months of June and August; two in the *moderate* climate zone of September and November, while three were taken in the *hot* summer months of December, February and March. In Section 4 of Chapter 3: Results and Discussion, these meeting periods and zones are illustrated to show their potential influence on the results.

7 STATISTICAL ANALYSIS OF WATER QUALITY DATA

7.1 DATA ANALYSES

Data were entered into Microsoft Excel® 2000 spreadsheets, which were set up to do the required descriptive statistical analyses such as the sample size, range, geometric mean, median and the 95 % confidence intervals. The microbiological data were transformed to $\log_{10}$ values to make the data more symmetric, more linear and more constant in variance to facilitate analyses (Helsel and Hirsch, 1995). Turbidity data were kept as linear values, since it was expected that the variations that may occur would not be as severe as the microbiological data. The statistical programme Sigma Stat® 2 (1997) was used to test for normality as well as statistical significant differences using analysis of variance (ANOVA).

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7.2 DATA PLOTTING

Sigma Plot® 7 (2001) was used to plot data in box plot graphs to visualise the data effectively. The following colours on the graph were used in Chapter 3: Results and Discussion to indicate the indicators and the aesthetic parameter used in the study.

- Heterotrophic bacteria counts (HPC) 🟨
- Total coliforms (TC) 🟥
- *Escherichia coli* (EC) 🟦
- Turbidity (Turb) ⬜

According to Helsel and Hirsch (1995), box plots provide the clearest visual summaries of the following:

- The centre of the data is the median, indicated by the black centre line in the box plot. The median is the preferred measure of central tendency for the data in the plots in Chapter 3. The median is preferred, because it is resistant to the effects of the outliers and tends to indicate a more sensible central point in data (Helsel and Hirsch, 1995).

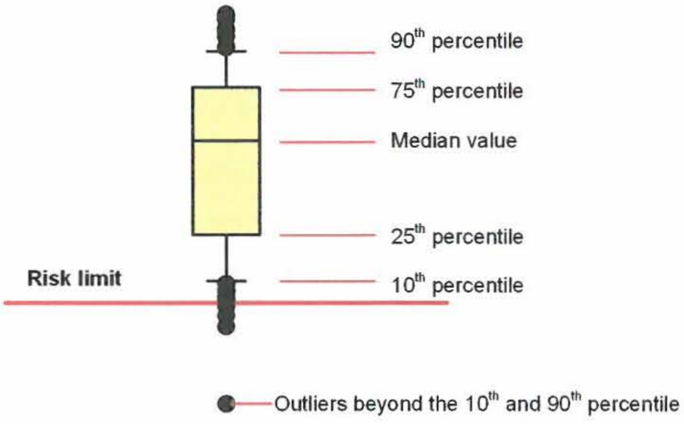

Figure 2.8: An example of a box plot

- The interquartile range (variation or spread of the data) is the boundaries forming the box height. This indicates the spread of data between the 25th and the 75th percentile. The closer the data are clustered to the median within the interquartile range, the less variation (more stable) the data set is.
- The skewness (also referred to as the quartile skew) is represented by the relative size of the box halves. The further the median line is from the middle of the box, the less normally (non-parametric) the data is distributed around the mean. This implies the use of non-parametric methods of analyses.

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- The caps whiskers on the li ve and below the 75th and the 25th percentiles represent the 10th and 90th percentile boundaries. The circle symbols beyond the caps and whiskers, indicate outliers.

7.3 STATISTICAL METHODS

7.3.1 Developing statistical hypotheses

Hypotheses are theories developed by researchers about what they expect the outcomes of their research might be (Helsel and Hirsch, 1995; Griesel, 2001). *Research* hypotheses are related to the outcomes of the research (i.e. a research problem statement). Researchers then formulate statistical hypotheses to test their research hypotheses (Katzenellenbogen et al., 1997). Statistical tests are used to determine whether the statistical hypotheses can, or should be, confirmed, adapted, or rejected outright (Glantz, 1997). For this study, statistical hypotheses were formulated for each of the various sections in Chapter 3: Results and Discussion.

7.3.2 Testing hypotheses

ANOVA normally includes a series of parametric tests done under the assumption that the data analysed are normally distributed around the mean with similar variance (Helsel and Hirsch, 1995; Glantz, 1997). In this study, the instances where data did not pass normality were considerably more than instances where data passed normality. Thus non-parametric testing for variance was used throughout the study.

Non- parametric testing display considerable power in comparing non-normal as well as normal data (Helsel and Hirsch, 1995), and were used even where data sets passed normality testing. Non-parametric testing is therefore selected because it can determine whether data from each of the two data sets came from the same population even with no assumptions about the normality or variance of the data (Sigma Stat® 2, 1997). The following tests were used in this study (Helsel and Hirsch, 1995; Glantz, 1997; Sigma Stat®, 1997):

- The *Rank Sum Test* is a nonparametric procedure used to test for a difference between two groups unequal in size. In the context of this study, the *Mann-Whitney Rank Sum Test* was used to test for variance in unequal and unpaired data sets.
- The *Signed Rank Test* is a non-parametric procedure that was applied on paired data sets. In the context of this study, the *Wilcoxon Signed Rank Test* was used to test for variance in the paired *before* and *after* data sets to test for any significant changes in the water quality intervention per NIF group.
- The *ANOVA on Ranks* is a non-parametric test, used to compare data of more than two groups. For this study, the *Kruskal-Wallis* test was used to test for changes in the different NIF groups that may be affected by a single factor such as attendance of the

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intervention programme. T ver, only test for differences between groups but cannot identify which group or groups may differ. *Multiple Comparison* tests (MCT's) have then to be used in such cases.

- *Multiple Comparison* tests (MCT's):
    - *Tukey's* MCT was used to identify any significantly different groups after using the *Kruskal-Wallis* test to identify the significantly different group/s in non-parametric data sets of equal size. *Dunn's* MCT was used when the sample sizes of the groups were not of equal size.
    - The *difference of the means* is a gauge of the size of the difference between the two groups compared. A large figure means a large span of differences – indicating significance in difference.
    - Large values of *q* indicate the more acceptable conclusion that the difference of two groups being compared is statistically significant.

8 PREVIEW OF RESULTS AND DISCUSSION (CHAPTER 3)

The results in Chapter 3 are presented and discussed from Sections 1 to 4. Tables are used to provide descriptive results as well as indicate what changes, if any, there were between two or more data sets. Figures are also used to support the tables in all sections. Figures more clearly illustrate to what extent any changes that did take place, were improvements or deteriorations of the situations under discussion.

The further value of the figures was to clearly illustrate to what extent any of the changes in the levels of the selected water quality indicators were in compliance with risk levels proposed by the South African Water Quality Guidelines (DWAF, 1996), the WHO Guidelines for Drinking Water (WHO, 1996) as well as the Assessment Guide for Quality of Domestic Water Supplies (WRC, 1998). The results and discussion are primarily based on three approaches.

- To illustrate any effect the educational intervention might have had, water quality data of the situation *before* are tabled and plotted against the data of the situation during and directly after the intervention (the *after* data).
- To distinctly report on results based on the level of exposure to the educational sessions by the selected households, the study population sample was grouped into three, according to attendance lists (the NIF groups) used during the educational contact sessions (Section 6.2).
- To determine whether the specific content of the training sessions (Section 4.2) as well as *cold*, *moderate* and *hot* climate zones within the study period (Section 6.3) had any effect on the results.

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The results are generally showe er data in the same configuration where the data of the three groups are shown. An explanation of the configuration will be given as introductory notes at the beginning of each Section. A schematic layout of the results is presented in Figure 2.9.

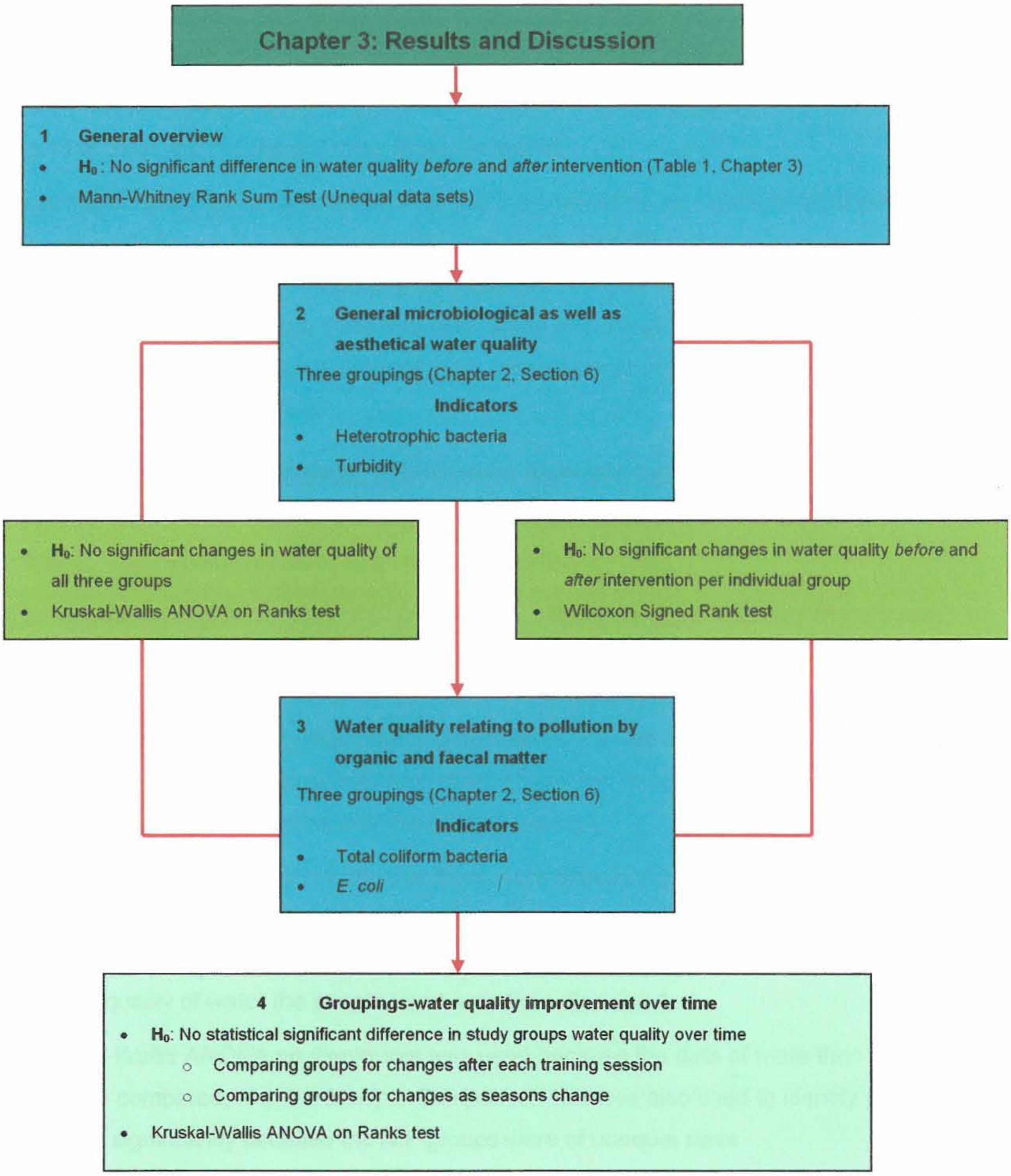

Figure 2.9: Schematic flow diagram of the results and discussions in Chapter 3

8.1 GENERAL OVERVIEW OF THE HEALTH-RELATED WATER QUALITY

Section 1 (Chapter 3) will give an overall perspective of the study results for all selected households. This is to compare the combined results of the health-related microbiological

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water quality analyses that took udy (*after* data) to the baseline results (*before* data) reported by Bokako (2000). All log values lower than $\log_0$ (which denotes the value one) should be indicated as minus values. However, in the Tables of Chapter 3, these are all shown as <1 to be consistent with the supporting graph. Since organism numbers of zero (0) cannot be shown on the linear y-axes of the graphs as zero (since this would actually depict the value of 1), the zero value is depicted as –1 in graphs. While variations between percentiles and groups in the tables may appear to be absent for values where <1 is used, the graphs will show these variations.

The null hypothesis (H_0) for this section was that there would be no statistical significant difference in the *before* and *after* results. To test this hypothesis in this section the *Mann-Whitney Rank Sum Test* was used because two unequal data sets were compared. Rejection of H_0 would imply that there had been some effect that brought about the significant change. The following sections were then so constructed to determine what could have constituted the effect.

8.2 CHANGES IN THE GENERAL CONTAINER AND STORED WATER HYGIENE

In Section 2 (Chapter 3), data for turbidity as well as heterotrophic bacteria counts are presented. Two hypotheses were formulated for Section 2.

The first H_0 stated that there would be no significant difference in water quality of the three groups (*never*, *intermittent* and *frequent* (NIF) either *before* or *after* the intervention. For the *before* results, no differences would be expected in the water quality since the three groups had not been subjected to any intervention programme. For the *after* results, significant differences would be expected in the water quality since the *frequent* group had been subjected to the training sessions and the *never* group not.

Rejection of the first H_0 would indicate that there were already significant differences in the water quality of the three groups *before* the intervention. The extent to what these differences were carried over during this study (*after* data) and the influence of this carry over on the quality of water the people used, was then discussed.

The *Kruskal-Wallis ANOVA on Ranks* test was used because the data of more than two groups were compared. *Dunn's Multiple Comparison* test was also used to identify groups that differed significantly because the NIF groups were of unequal sizes.

The second H_0 stated that there would be no significant difference in water quality for each NIF group *before* and *after* the intervention. Rejection of the second H_0 would imply that the general hygiene status of the containers, as well as the water-handling practices of the users in each group has changed since and directly after the intervention. The extent of the change and its influence on the quality of water the people used was then discussed.

Each groups' *before* data were paired to the same groups' *after* data and statistically

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compared. The *Wilcoxon Signe* ed to determine, per group, any significant change in the water quality since the intervention started. *Tukey's Multiple Comparison* test was also used to identify groups that differed significantly because the *before* and *after* data sets for each NIF group were not of equal sizes.

8.3 CHANGES IN WATER QUALITY RELATING TO HAZARDOUS MICROBIOLOGICAL POLLUTION OF STORED WATER

In Section 3 (Chapter 3), total coliforms (organic and environmental) as well as *E. coli* (faecal) were used as indicators of pollution in stored water used by the same NIF groups. Two hypotheses were also formulated for this section based on the same approach of comparing *before* and *after* data and data of each group with another. The same non-parametric statistical tests of the previous section were used.

Rejection of the first H_0 would imply that there would be significant differences in the hazardous microbiological pollution status of the water quality of the three NIF groups either *before* of *after* the intervention. This would indicate, as in Section 2, whether there were already significant differences in the water quality of the three groups *before* the intervention and to what extent these differences were carried over during this study. The extent of this carry-over and its influence on the infection risk posed to the users was then discussed.

Rejection of the second H_0 would imply that the level of hazardous microbiological pollution of the water in containers has changed. The extent of change and its influence on the quality of water the people used, as well as the infection risks posed, was then discussed.

8.4 OTHER INFLUENCES ON WATER QUALITY CHANGES

In Section 4 (Chapter 3), the results of each sampling session are plotted over the time it took to complete the programme. This is done to determine whether the various training sessions brought about changes in the water quality. The results are also plotted against a climate profile of *cold*, *moderate* and *hot* periods as described in Section 6.3 (Chapter 2) to determine whether the time of year might have had an influence on the results.

The H_0 was that there would be no significant changes in water quality of the NIF groups respectively over the study period. Rejection of the H_0 would imply that changes were taking place in the water quality between training sessions. The *Kruskal-Wallis ANOVA on Ranks* test was used to compare the data sets obtained in-between training sessions. *Dunn's Multiple Comparison* test was also used to identify groups that differed significantly because the NIF groups were of unequal sizes. Changes in the data were then discussed in the context of attendance of the sessions as well as any possible influence seasonal changes could have had.

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Chapter 3 RESULTS AND DISCUSSION

In this chapter results will be presented and discussed according to the format summarised in Section 8 of Chapter 2. The study population sample was grouped into *never*, *intermittent* and *frequent* (NIF) groups according to the list used to note the attendance of representatives from the selected households at the educational contact sessions (Chapter 2, Section 6). This was done to distinguish between the effects of the educational sessions on the health-related stored water quality of the selected households within their respective groups, based on the level of exposure to the educational sessions.

1 AN OVERVIEW OF THE HEALTH-RELATED WATER QUALITY

The purpose of this section is to give an overall initial perspective of the study results. Results for each indicator are discussed separately and in detail in the sections to follow.

This section gives an overview of whether the water storage containers of the members of the various study groups were being kept free from biofilm formation (indicating container cleansing) and whether, as a result, the microbiological quality of the water had generally improved from *before* to *after* the hygiene education programme. Table 1 is a comparison of the results of the water quality analyses done by Bokako (2000) (the "*before*" data), and the results obtained during this study (the "*after*" data).

Table 1: *Before* and *after* turbidity levels (in NTU's) as well as indicator bacteria numbers ($\log_{10}$) detected in container water used by the study population

	Statistical variables	Turbidity	Heterotrophic bacteria	Total coliforms	*Escherichia coli*
Before education intervention	n	145	132	124	151
	Median	1.88	6.06	2.49	<1(Log–1)
	25th Percentile	1.14	2.65	1.41	<1(Log–1)
	75th Percentile	3.27	6.91	3.59	<1(Log–1)
After education intervention	n	640	640	640	640
	Median	0.17	4.91	1.39	<1(Log–1)
	25th Percentile	0.13	3.46	0.38	<1(Log–1)
	75th Percentile	0.22	6.75	2.66	<1(Log 0)
Comparing *before* and *after* data Mann-Whitney Rank Sum Test		Significant difference ($P \leq 0.001$) H_0 rejected	Significant difference ($P \leq 0.001$) H_0 rejected	Significant difference ($P \leq 0.001$) H_0 rejected	Significant difference ($P \leq 0.001$) H_0 rejected

* All values at zero as well as log negative values will be indicated as <1 (Chapter 2; Section 8.1)

The results from Table 1 are reflected in Figure 1 to indicate the extent to which the water quality would have posed a risk of infection. The risk limits shown in Figure 1 were taken from the South African Water Quality Guidelines (DWAF, 1996), the Assessment Guide for Quality of Domestic Water Supplies (WRC, 1998) as well as from the Drinking Water Quality Guidelines of the World Health Organisation (WHO, 1996).

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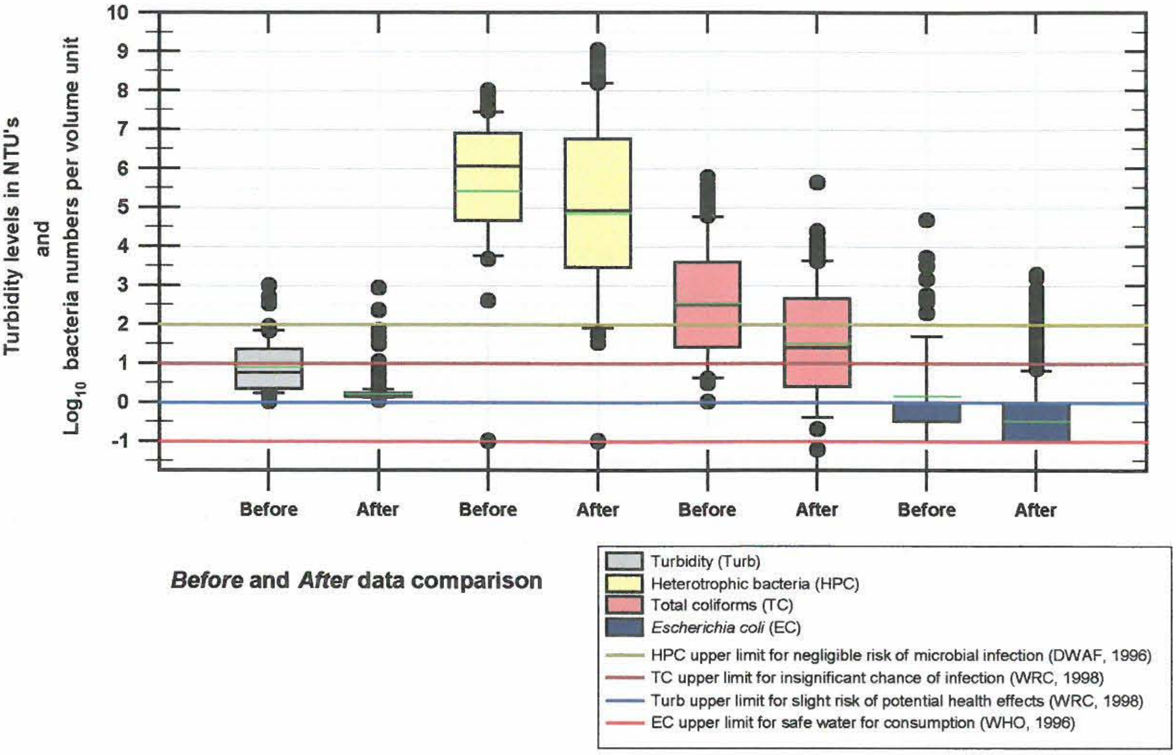

Figure 1: Comparing health-related quality parameters of container water *before* and *after* hygiene education

It appears from Figure 1 that the water quality had improved after intervention from the hygiene intervention programme. Turbidity levels decreased markedly *after* the hygiene education programme when compared to the *before* data. Most of the turbidity levels were below the risk limit of *slight potential health effects* (WRC, 1998) after the intervention.

However, for some of the indicator groups, the risk of infection for the consumer still existed. For instance, heterotrophic bacteria numbers were still indicating an *increased risk of infectious disease transmission* (>1000 organisms per 1 mL) (DWAF, 1996) after the hygiene education programme intervention.

Although the total coliform median value had dropped below the level of risk of *clinical infections* (10-100 organisms per 100 mL) (WRC, 1998), to *insignificant chance of infection* after the intervention, results indicated that a significant number of samples (35%) still tested above this limit.

The median level for *E. coli* numbers also improved but generally still remained on the limit described by the WHO (1996) as the limit for "*unsafe water for consumption*" *before* as well as *after* the intervention with the hygiene education programme (depicted as <1 for zero on the y-axis log figures). However, some samples still contained *E. coli* numbers well above the limit for "*unsafe water for consumption*" for both data sets.

Although it appears, from the overview, that some improvements in the heath-related water quality have been effected, it cannot be certain whether these improvements were brought

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about by the hygiene education i so, to what extent. For instance, the results of the *never* group were included in the overview. The results for each NIF (*frequent, intermittent* and *never*) grouping, are therefore compared in the following sections in an effort to establish what effect the educational intervention might have had, if any, on these improvements.

Furthermore, from the indicators it would appear that, while there where still substantial numbers of heterotrophic bacteria in the container water sampled afterwards, the general particle content (from loosened biofilm) of the water decreased as indicated by the turbidity results. This could imply that while people might have kept their containers clean from biofilm (decrease in turbidity) as a result of the intervention programme, the ingress of environmental elements such as bacteria from hands and dust (indicated by heterotrophic bacteria numbers) is still substantial. Nyong and Kanaroglou (1999) reported that unhygienic water-handling practices particularly during the dry season in Nigeria contribute to contamination of water during storage and forms part of the contributing factors to diarrhoea. Tunyavanich and Hewison (1990) further reported that in spite of all improvements in water supply systems in Thailand, water-handling practices still contributed to contamination of container-stored water.

The slight decrease in the *before* and *after* total coliform numbers, indicated slight reductions in organic pollution of the water in the containers during handling by people. This is supported by the fact that the *E. coli* levels, for the "*after*" data, were also generally lower than the *before* data and closer to the WHO (1996) limit proposed for *E. coli* numbers in *water safe for consumption*. In a study done by Pinfold (1990), *E. coli* numbers were reported to have decreased after an educational intervention in villages in Thailand. According to Pinfold (1990), this appeared to be because household members improved in their hand-washing practices after toilet use as well as before water handling.

2 GENERAL CONTAINER AND STORED WATER HYGIENE

Turbidity was used to measure the cleanliness of containers based on the prevention of biofilm formation through container cleaning (Chapter 2, Section 5), while heterotrophic bacteria were used to assess the general hygiene as well as bacterial content of stored water. Tables 2.1 to 2.2 compare the results of the general water quality for the NIF groupings while Figures 2.1 to 2.2 also show the results in relation to the limits for infectious disease transmission.

2.1 TURBIDITY

The results in Table 2.1 show the turbidity levels in stored container water. These turbidity levels did not differ between the groups that now formed the respective NIF groups.

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Table 2.1: Turbidity levels in contain [illegible] hree study groupings *before* and *after* the hygiene education programme

	Statistical Variables	Never	Intermittent	Frequent	Comparing groups (Kruskal-Wallis)
Before education intervention	**n**	26	42	12	No significant difference (P = 0.137) H_0 accepted
	Median	2.28	1.80	2.40	
	25th Percentile	1.48	1.05	0.53	
	75th Percentile	3.87	2.72	2.37	
After education intervention	**n**	26	42	12	No significant difference (P = 0.124) H_0 accepted
	Median	0.17	0.17	0.15	
	25th Percentile	0.15	0.15	0.13	
	75th Percentile	0.19	0.20	0.18	
Comparing *before* and *after* data Wilcoxon Signed Rank test		Significant difference ($P \leq 0.001$) H_0 rejected	Significant difference ($P \leq 0.001$) H_0 rejected	Significant difference (P = 0.002) H_0 rejected	

Judged by the turbidity results from this study, the health-related water quality of the same groups still showed no significant difference laterally between the groups although the water quality improved *after* the intervention. The improvement was, however, at a similar level. The quality of the one group did not significantly improve (or deteriorate) more than that of the others.

It appeared as if the study population had some form of awareness prior to the hygiene education programme. This could have been an awareness created during the study by Dywili and Jagals (1999) that focused on container cleaning practices in which all the selected households could have contributed in transferring information to the *never* group household members that did not attend the training sessions. Therefore this could have resulted in contamination between the groups and indicated no differences in water quality of the NIF groupings.

Figure 2.1 shows the reduction in the median risk limits from *before* to *after* the hygiene education intervention limits (from the green line to the blue line). Judging by the risk categories used for turbidity in the South African Water Quality Guidelines (DWAF, 1996), as well as the Assessment Guide for Domestic Water Quality (WRC, 1998), this reduction is substantial.

Water samples for this study were taken from the containers after the containers' inner sidewalls were brushed to release any potential biofilm (Bokako, 2000) or other unhygienic residue. The samples would therefore contain the particulate matter from the residue and would have an influence on the turbidity as Bokako (2000) had found.

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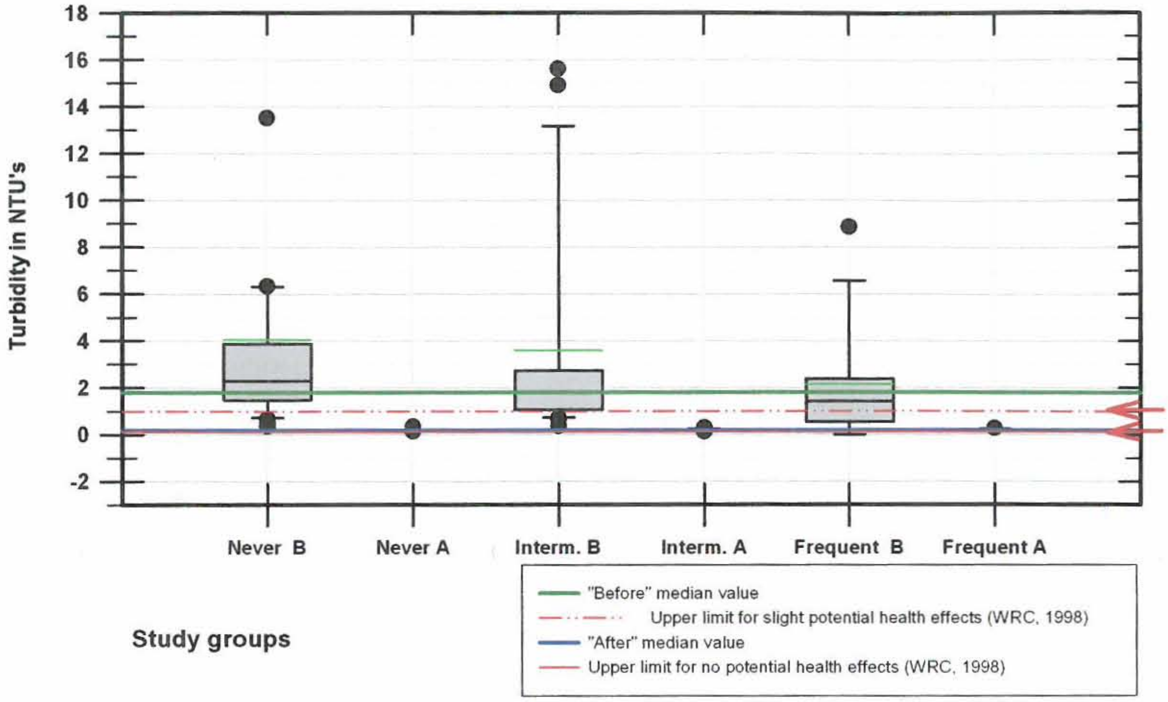

Figure 2.1: Comparison of turbidity levels in container water used by the study groups *before* and *after* the educational intervention

Lower levels of suspended particulate matter therefore indicated that less biofilm were loosened from container walls, thereby indicating more cleaning and rinsing of containers. While it is indicated in Figure 2.1 to have been a significant difference in the *before* and *after* data of the three groupings, there were no statistically significant difference between groups laterally.

Turbidity as such does not have direct health effects (WRC, 1998). This parameter also does not indicate faecal pollution. However, depending on the nature of suspended matter causing turbidity, it is one of the indicators of water quality associated with microbiological health effects (WHO, 1997c; WRC, 1998). High turbidity levels in water affect many other indicators of drinking water quality. It is therefore always recommended that turbidity levels be kept as low as possible (WHO, 1996), as was the case of the *after* results of all three groupings.

Although turbidity is associated with water clarity, the parameter was used in this study to provide a picture of whether the hygiene status of the storage containers did improve after the hygiene education programme. According to the results in Table and Figure 2.1, turbidity levels did not pose a risk of potential health effects in terms of Assessment Guide: Quality of Domestic Supplies (WRC, 1998). This is an indication that the low turbidity levels in stored water used by all three groups may be ascribed to improved container washing and refilling, thereby minimising the forming of biofilm.

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While it cannot be certain, with th able in this study, to what extent the hygiene education programme influenced the people's container hygiene practices, people appeared to be washing, or even just rinsing, their containers more during the time of this study than in the times that Bokako (2000) had done her study. However, from the turbidity results, it appears that households that had sent representatives to the training sessions (predominantly the *frequent* group) were not doing a better job of cleaning their containers than the households that *intermittently* or *never* attended the training sessions.

2.2 HETEROTROPHIC BACTERIA

The results in Table 2.2 focus on heterotrophic bacteria levels in stored water used by the study population. Other than with the turbidity results, there were generally no significant differences in the heterotrophic bacteria numbers of the groups from the time of the Bokako (2000) study and this study.

Table 2.2: Heterotrophic bacteria numbers in container water used by the study groups *before* and *after* the hygiene education programme

	Statistical Variables	**Never**	**Intermittent**	**Frequent**	**Comparing groups (Kruskal-Wallis)**
Before education intervention	**n**	26	42	12	No significant difference (P = 0.792) H_0 accepted
	Median	5.96	6.27	5.33	
	25th Percentile	4.15	4.85	4.50	
	75th Percentile	7.00	6.75	7.12	
After education intervention	**n**	26	42	12	No significant difference (P = 0.979) H_0 accepted
	Median	5.00	5.05	5.12	
	25th Percentile	4.43	4.42	4.16	
	75th Percentile	5.67	5.69	5.63	
Comparing *before* and *after* data **Wilcoxon Signed Rank test**		No significant difference (P = 0.859) H_0 accepted	Significant difference ($P \leq 0.001$) H_0 rejected	No significant difference (P = 0.677) H_0 accepted	

Furthermore, the various groups did not have any differences between them, not *before* and not *after*. It would appear that the intervention programme had no effect in reducing the levels of heterotrophic bacteria in container water. The one difference that showed was in the results for the *intermittent* group. The heterotrophic bacteria numbers reduced significantly from *before* the intervention. Nevertheless, although there were no statistical differences between the *before* and *after* data, the more-than-one log-phase reduction in the median risk limits from *before* (green median line) to the *after* (blue median line) results is illustrated by Figure 2.2.

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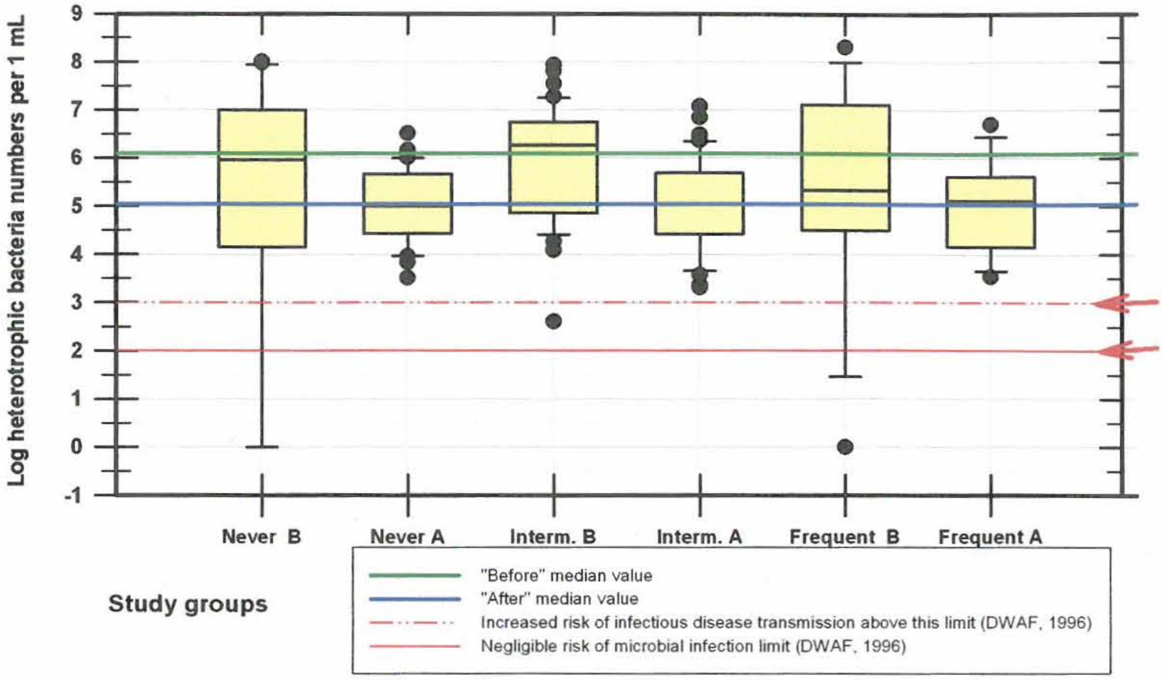

Figure 2.2: Comparison of heterotrophic bacteria levels in container water used by the various groups *before* and *after* the educational intervention.

However, there were no statistically significant differences between the three groups laterally for both the *before* and *after* data. In fact, it is the median value of the "*frequent*" *before* group that deviates the most from the median value (indicated by the green line) of the three *before* groups. This is probably because of several low number outliers in the *before* data.

On the other hand, the median values of all three the *after* groups were right on the blue median line. There appears to be no reason for the statistically significant difference found in the *before* and *after* data for the *intermittent* group. According to Helsel and Hirsch (1995) this type of difference could be a statistical artefact of non-parametric testing. No explanation within the context of this study can be provided.

In terms of the South African Water Quality Guidelines (DWAF, 1996), the risk of *transmission of infectious disease* after the intervention is still substantial despite the educational intervention. There is however, no clear-cut evidence that heterotrophic bacteria pose a public health risk. These indicators also do not indicate faecal pollution. Most heterotrophic bacteria in drinking water are not human pathogens (Rusin et al., 1997), although this group may include especially opportunistic pathogens, which makes it a useful indicator of the potential of water to transmit disease.

Although the group does not include all the bacteria in water since many species may be viable but non-culturable (WHO, 1996), the group does represent the potential total number

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of bacteria in water (DWAF, 1996 se levels are, the greater the chance of all kinds of bacteria, not related to the coliform groups, may be ingested by consumers.

While it is not certain whether this group contains pathogens, the group was used in this study to provide a rudimentary assessment of whether water-handling practices introduced excessive numbers of bacteria into the container water. Excessive levels of heterotrophic bacteria can be introduced into even relatively clean-looking water supplies by negligent water handling practices (Lehloesa and Muyima, 2000).

Judging by the results in Table and Figure 2.2, excessive numbers of heterotrophic bacteria are still being introduced into the water in the containers used by all the selected households. This is an indication that all three groups, despite maybe washing and rinsing their containers more frequently, may still be practicing poor hygienic handling of water from and in the containers during domestic chores.

3 CHANGES IN WATER QUALITY RELATING TO HAZARDOUS MICROBIOLOGICAL POLLUTION OF STORED WATER

Total coliforms were used to assess organic pollution, while *E. coli* were used to indicate faecal pollution of stored water (Chapter 2, Section 5). The results and discussion in this section focus on the microbial safety of water from storage containers.

3.1 TOTAL COLIFORMS

Results in Table and Figure 3.1 indicate total coliforms in stored water used by the study population.

Table 3.1: Total coliform numbers in container water used by the study groups *before* and *after* the hygiene education programme

	Statistical Variables	**Never**	**Intermittent**	**Frequent**	**Comparing groups (Kruskal-Wallis)**
Before education intervention	**n**	26	42	12	No significant difference (P = 0.816) H_0 accepted
	Median	2.32	2.49	2.73	
	25th Percentile	1.66	1.48	1.32	
	75th Percentile	3.11	3.63	3.14	
After education intervention	**n**	26	42	12	No significant difference (P = 0.069) H_0 accepted
	Median	1.32	1.67	1.20	
	25th Percentile	0.77	1.05	0.91	
	75th Percentile	1.95	2.75	1.40	
Comparing *before* and *after* data Wilcoxon Signed Rank test		Significant difference (P ≤ 0.001) H_0 rejected	Significant difference (P = 0.026) H_0 rejected	Significant difference (P = 0.032) H_0 rejected	

This again indicates that the educational intervention did not have a larger effect on the frequent attendees relative to the intermittent and the never attendees.

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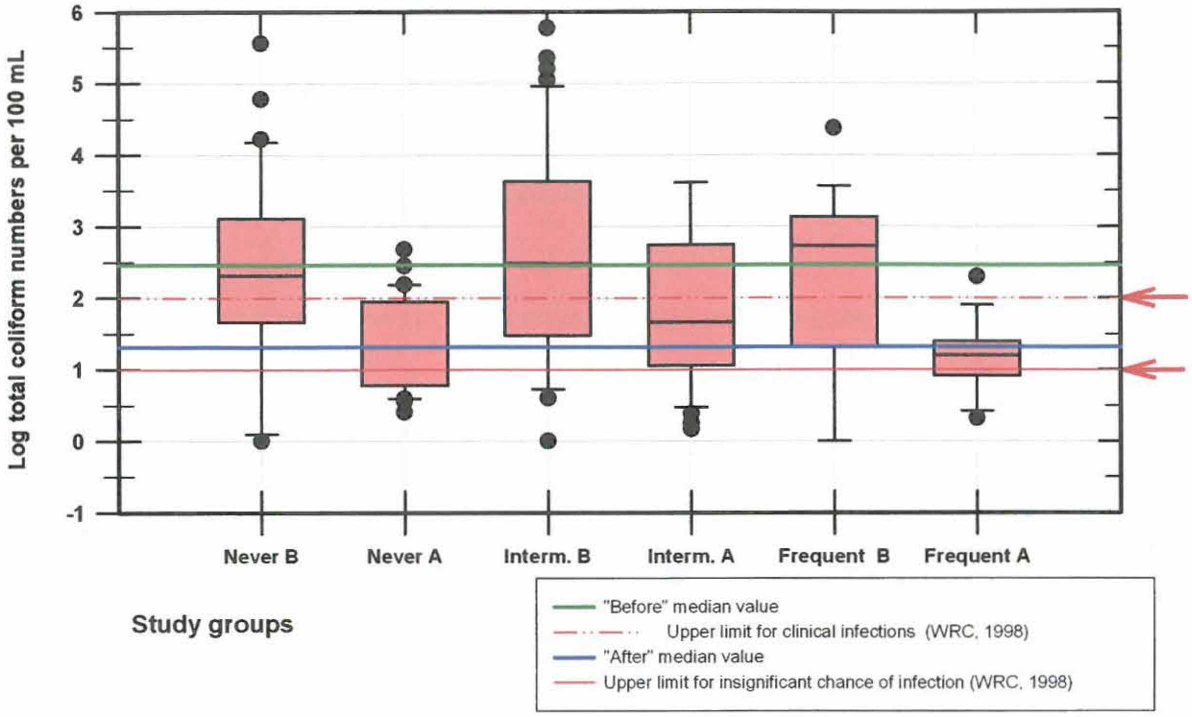

Figure 3.1: Comparison of total coliform numbers in water stored and used by the study group *before* and *after* the educational intervention

Although the median value of the *after* results (the blue line) indicated that the risk of *clinical infections* decreased by at least one log phase since the intervention, it remained substantially (>30%) above the limit for *insignificant chance of infection* in terms of the various Guides used in this study (DWAF, 1996; WRC, 1998). In terms of total coliforms, the stored water of the study population, while unlikely for healthy adults, still offered a risk of *clinical infections* to sensitive groups (WRC, 1998) such as the children, elderly and immuno-compromised persons when water is consumed.

Jones and Bradshaw (1996) reported total coliform regrowth within biofilm. Reduced biofilm therefore could lead to lower total coliform numbers in water distribution systems. The lower levels of biofilm in containers reported earlier in the results might have lead to the reduction of total coliform numbers despite the relatively high levels of heterotrophic bacteria still present in the container water during the education programme.

It is also reported that coliform bacteria from human and animal wastes might be found in drinking water if the water is not properly treated or disinfected (Symons, 1994; USEPA, 2001). Therefore the results in this study, despite of the lower total coliform numbers *after* the intervention, still indicate some hazardous microbiological contamination of container water by human waste or animal wastes during water usage at home by household members in the NIF groupings. There was still a risk of infection for consumers.

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3.2 *ESCHERICHIA COLI*

The results in Table 3.2 indicate *E. coli* numbers in the stored water of the study groups. While no statistical significant differences were found in the *E coli* numbers in the container water of the respective NIF groupings both *before* and *after* the educational intervention, the *E coli* numbers in the container water were reduced significantly since the intervention commenced.

Table 3.2: *Escherichia coli* numbers in container water used by the study groups *before* and *after* the hygiene education programme

	Statistical Variables	**Never**	**Intermittent**	**Frequent**	**Comparing groups (Kruskal-Wallis)**
Before education intervention	**n**	26	42	12	No significant difference (P = 0.540) H_0 accepted
	Median	<1 (Log 0)	<1 (Log 0)	<1 (Log 0)	
	25th Percentile	<1 (Log 0)	<1 (Log 0)	<1 (Log 0)	
	75th Percentile	<1 (Log 0)	<1 (Log 0)	<1 (Log 0)	
After education intervention	**n**	26	42	12	No significant difference (P = 0.770) H_0 accepted
	Median	<1 (Log–1.1)	<1 (Log–1.1)	<1 (Log–1.1)	
	25th Percentile	<1 (Log–1.1)	<1 (Log–1.1)	<1 (Log–1.1)	
	75th Percentile	<1 (Log–0.9)	<1 (Log–0.9)	<1 (Log–1.1)	
Comparing *before* and *after* data Wilcoxon Signed Rank test		Significant difference $(P \leq 0.001)$ H_0 rejected	Significant difference $(P \leq 0.001)$ H_0 rejected	Significant difference $(P \leq 0.001)$ H_0 rejected	

* All values at zero as well as log negative values will be indicated as <1 (Chapter 2; Section 8.1)

Figure 3.2 shows significant reductions in numbers of *E. coli* since the hygiene education intervention. However, these bacteria still intermittently occurred (shown by the outliers in the graph), although considerably less frequent than *before* the programme. Nevertheless, faecal pollution did periodically take place to render the stored water unsafe for consumption but to a lesser degree since the intervention.

According to the WHO Drinking Water Quality Guidelines (1996), water that contains any number of *E coli* (more than zero) is not safe for consumption. The risk limit for *safe water* is therefore set at zero (0) for this study. In terms of the log values used on the Y-axis of the graph in Figure 3.2, the zero value is depicted as -1. The red line therefore shows the risk limit for *safe water for consumption.*

Jagals et al. (1997; 1999) as well as Bokako (2000) also found *E. coli* in the container water in the same area. The reason for these could be attributed to poor personal hygiene practices, especially after toilet use by household members.

Pinfold (1990), Moe et al., (1991) as well as Nyong and Kanaroglou (1999) also reported the presence of faecal coliforms in drinking water stored in containers. These authors attributed this to poor personal hygiene practices such as hand washing after toilet use by household members, general domestic sanitation, as well as pets and vectors such as flies.

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	Statistical Variables	**Never**	**Intermittent**	**Frequent**	**Comparing groups (Kruskal-Wallis)**
Before education intervention	**n**	26	42	12	No significant difference
	Median	<1 (Log 0)	<1 (Log 0)	<1 (Log 0)	$(P = 0.540)$
	25th Percentile	<1 (Log 0)	<1 (Log 0)	<1 (Log 0)	H_0 accepted
	75th Percentile	<1 (Log 0)	<1 (Log 0)	<1 (Log 0)	
After education intervention	**n**	26	42	12	No significant difference
	Median	<1 (Log–1.1)	<1 (Log–1.1)	<1 (Log–1.1)	$(P = 0.770)$
	25th Percentile	<1 (Log–1.1)	<1 (Log–1.1)	<1 (Log–1.1)	H_0 accepted
	75th Percentile	<1 (Log–0.9)	<1 (Log–0.9)	<1 (Log–1.1)	
Comparing *before* and *after* data Wilcoxon Signed Rank test		Significant difference $(P \leq 0.001)$ H_0 rejected	Significant difference $(P \leq 0.001)$ H_0 rejected	Significant difference $(P \leq 0.001)$ H_0 rejected	

* All values at zero as well as log negative values will be indicated as <1 (Chapter 2; Section 8.1)

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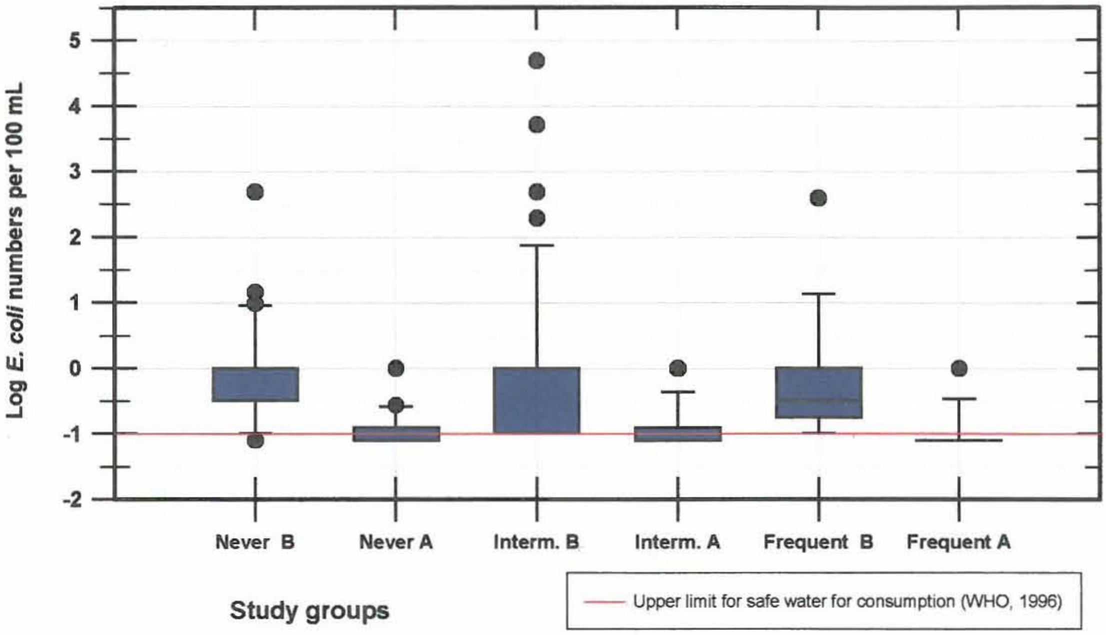

Figure 3.2: Comparison of *E. coli* numbers in container water used by the study groups *before* and *after* the educational intervention

Keeping domestic and other related livestock within household limits is customary in developing dense urban settlements. These domestic animals also contribute to faecal pollution of the domestic environment (Moe et al., 1991), which could have landed in container-stored water (Jagals, 2000).

Judging by the results in Table and Figure 3.2, people were still exposed to unsafe water from their containers since the intervention but to a substantially lesser extent than before the intervention. Indications were again that the educational intervention did not have any particular influence on any one group but could have played a role somehow in reducing the risk of the study population consuming unsafe water.

4 OTHER INFLUENCES ON WATER QUALITY CHANGES

In the previous sections, it was shown that some improvement in health-related water quality had taken place during the hygiene education programme. This section focuses on potential changes in the water quality over the time that the study was conducted and whether a tendency based on periods between training sessions, as well as periods of climate change (*cold, moderate* and *hot*) could be detected that could have influenced these changes.

Since no significant differences could be found in the overall water quality of the NIF groups during this study (Sections 1 – 3), the data of the three groups are combined for discussion in this section. In all, there were four contact sessions with the study group (Section 4.2.1,

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Chapter 2). Table 4 summarises on the data sets for the four quality indicators.

Table 4: Comparison of all indicator values in container water used by the study groups during the hygiene education programme

Variables		Cold		Moderate		Hot			Cold	ANOVA results (Kruskal-Wallis)
		26/06/00 Week 1	19/08/00 Week 8	28/09/00 Week 14	21/11/00 Week 22	18/12/00 Week 26	12/02/01 Week 34	12/03/01 Week 38	28/06/01 Week 53	
Turb	n	80	80	80	80	80	80	80	80	Significant difference (P ≤ 0.001) H_0 rejected
	Median	0.19	0.11	0.15	0.19	0.22	0.18	0.18	0.16	
	25th %	0.14	0.07	0.12	0.14	0.15	0.15	0.14	0.15	
	75th %	0.26	0.17	0.21	0.22	0.28	0.21	0.22	0.20	
HPC	n	80	80	80	80	80	80	80	80	Significant difference (P ≤ 0.001) H_0 rejected
	Median	< 1	4.20	4.75	4.81	4.48	6.71	4.93	6.75	
	25th %	< 1	2.82	3.46	3.51	3.61	5.38	3.81	6.31	
	75th %	< 1	6.71	5.51	7.06	6.39	7.71	6.29	7.77	
TC	n	80	80	80	80	80	80	80	80	Significant difference (P ≤ 0.001) H_0 rejected
	Median	< 1	0.73	0.91	2.32	2.20	2.21	2.08	1.64	
	25th %	< 1	0.38	0.08	1.41	1.17	1.13	1.42	1.09	
	75th %	0.08	1.37	1.82	3.34	3.29	3.22	2.96	2.73	
EC	n	80	80	80	80	80	80	80	80	Significant difference (P ≤ 0.001) H_0 rejected
	Median	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	
	25th %	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	
	75th %	< 1	< 1	< 1	0.32	0.47	0.77	0.32	< 1	

* All values at zero as well as log negative values will be indicated as <1 (Chapter 2; Section 8.1)

It was remarkable that the changes that took place were from *before* to *after* the programme but not between the NIF groups. This was to be expected *before* the intervention programme since no members of the three groups were subjected to an intervention programme then. However, it appeared that subjecting people to the hygiene education programme during this study provided no advantage for them over those from the other groups that did not attend.

In the graphs that follow (Figures 4.1(a and b) – 4.2(a and b), the M1 tick label (with the blue line) on the upper X-axis refers to the setting-up meeting, while the three TS tick labels (with the blue line) refer to the series of three training sessions (Section 5.1, Chapter 2). The climate zones are indicated by the green boundaries.

4.1 GENERAL CONTAINER AND STORED WATER HYGIENE

Figure 4.1a shows the significant overall improvement (from the baseline) in the turbidity of container water for each sample session.

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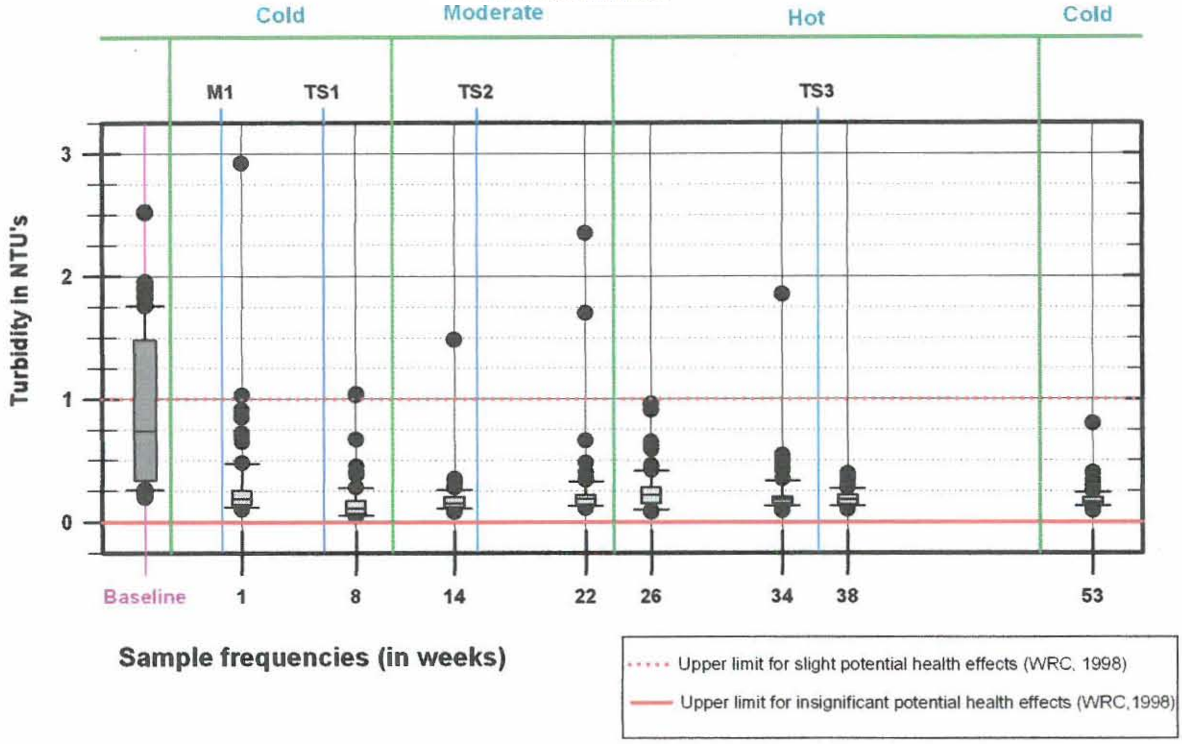

Figure 4.1a: Turbidity levels in container water of the study population during the education programme

Table 4.1a shows that the only data set that differed significantly from the others was the data from the sampling session conducted on August 19; 2000. This session was held shortly after the first training session, which dealt with problem analysis, which had included biofilm formation in containers.

Table 4.1a: Multiple comparison test results to determine the significantly different turbidity group

Indicator	Sample dates compared	Diff of Ranks	*q*	P<0.05?
Turbidity	18/12/00 vs 19/08/00	16449	9.946	Yes
	26/06/00 vs 19/08/00	14546.5	8.796	Yes
	21/11/00 vs 19/08/00	14163.5	8.564	Yes
	12/02/01 vs 19/08/00	13234.5	8.003	Yes
	12/03/01 vs 19/08/00	12418.5	7.509	Yes
	28/06/01 vs 19/08/00	10924	6.606	Yes
	28/09/00 vs 19/08/00	7607.5	4.600	Yes

However, the data of the other two NIF groups were also included in this set. The improvement can therefore not be ascribed to eagerness that may have taken hold of the *frequent* group and that they had made a special effort to keep their buckets clean, thus forcing the median value down. It rather indicated that less biofilm formed in the containers, which implied that the study population were physically washing or rinsing their containers more than before the study.

Except for the few wide outliers in the hot months, climate changes did not appear to play a role in the levels of turbidity in the container water.

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The median heterotrophic bacter d for each sample session, are shown in Figure 4.1b. While Figures 1 and 2.1 had shown that there were statistically significant differences between the *before* data (now combined as the *baseline* data set), and combined sets of the *after* data, these differences are not so apparent in Figure 4.1b.

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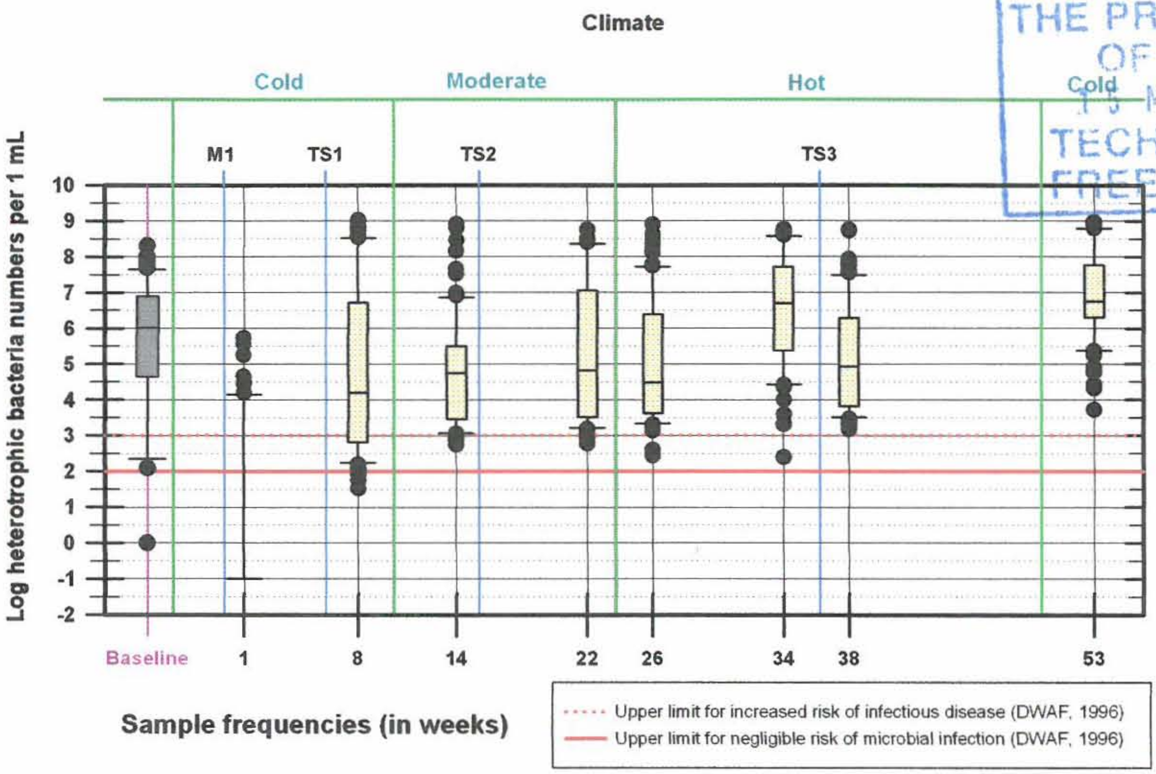

Figure 4.1b: Heterotrophic bacteria numbers in container water of the study population during the education programme

Nevertheless, it can be seen that the median values of the yellow boxes, with the exception of Weeks 34 and 53, are well below that of the baseline data box. Table 4.1b shows that the median HPC levels for these two weeks were significantly in excess of the other sampling dates.

The box of Sampling Week 1 shows unusually low values, a feature not again repeated during the other sampling sessions. It could be reasoned that this is a characteristic of bacteria numbers in the colder winter months. However, the levels for the sessions in August 2000 (Week 8) and June 2001 (Week 53) were significantly higher (Table 4.1b), indicating that the climate and especially temperature did not appear to play a meaningful role in the higher bacteria numbers in stored container water.

Furthermore, where the turbidity levels declined from Week 1 to Week 8, the HPC numbers rose. It would appear therefore, that the results of Week 1 could have been due to laboratory error and not a reflection of peoples' hygienic handling of their container water.

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Table 4.1b: MCT results to determi ria values that differed significantly from the others

Indicator	Sample dates compared	Diff of Ranks	*q*	P<0.05?
Heterotrophic bacteria	28/06/01 vs 26/06/00	32683.500	19.763	Yes
	28/06/01 vs 28/09/00	15651.500	9.464	Yes
	28/06/01 vs 19/08/00	15306.000	9.255	Yes
	28/06/01 vs 18/12/00	13575.500	8.209	Yes
	28/06/01 vs 21/11/00	11960.500	7.232	Yes
	28/06/01 vs 12/03/01	15306.000	7.142	Yes
	12/02 /01 vs 26/06/00	29824.500	18.034	Yes
	12/02/01 vs 28/09/00	12792.500	7.735	Yes
	12/02/01 vs 19/08/00	12447.000	7.526	Yes
	12/02/01 vs 18/12/00	10716.500	6.480	Yes
	12/02/01 vs 21/11/00	9101.500	5.504	Yes
	12/02/01 vs 12/03/01	8953.000	5.414	Yes
	12/02/01 vs 26/06/00	20871.500	12.621	Yes
	26/06/00 vs 21/11/00	20723.000	12.531	Yes
	26/06/00 vs 18/12/00	19108.000	11.554	Yes
	26/06/00 vs 19/08/00	17377.500	10.508	Yes
	26/06/00 vs 28/09/00	17032.000	10.299	Yes

The overall tendency throughout the eight sampling sessions over 53 weeks showed little variation between the groups. Judged by the relatively constant level of most of the results of the sampling sessions between the training sessions, the water-handling hygiene education programme did not appear to have had a meaningful impact on the heterotrophic bacteria numbers in container water of the study population sample during the study. People appeared to have already gotten the message of cleaning containers more frequent regardless of their attendance (or not) of the training sessions.

4.2 CHANGES IN WATER QUALITY RELATING TO HAZARDOUS MICROBIOLOGICAL POLLUTION

Figure 4.2a shows the significant overall improvement (lower numbers than the baseline data) in the total coliform numbers in container water for each sample session during the education programme period. However, the results for the samples taken in the warmer months showed a definite increase, indicating that climate did play a role in the occurrence of total coliforms in container water. The trend in the data does not appear to have a tendency related to the training sessions. This is in accordance with the tendency shown in Figure 3.1, which indicated that there were no significant differences between the total coliform numbers in the containers of those who attended the programme and those who did not.

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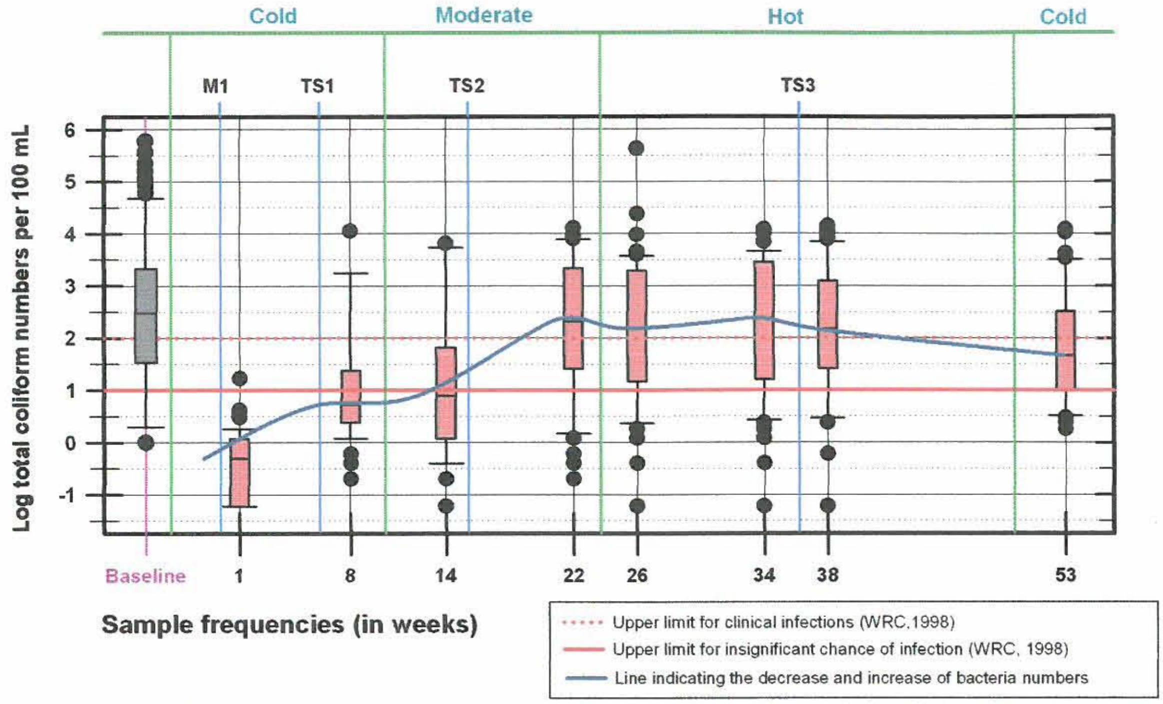

Figure 4.2a: Total coliform numbers in container water of the the study population during the programme

The results for the sample session in June 2001 (Week 53) showed a decline towards the cold month of June but were still significantly higher (Table 4.2a) than the results for the earlier winter months of June and August 2000 (Weeks 1 and 8).

Table 4.2a: MCT results to determine the total coliform groups that differed significantly from the others

Indicators	Comparison	Diff of Ranks	Q	P<0.05
Total coliforms	21/11/00 vs 26/06/00	26868.000	16.247	Yes
	21/11/00 vs 19/08/00	12280.500	7.426	Yes
	21/11/00 vs 28/09/00	11505.000	6.957	Yes
	12/03/01 vs 26/06/00	26331.500	15.922	Yes
	12/03/01 vs 19/08/00	11744.000	7.101	Yes
	12/03/01 vs 28/09/00	10968.500	6.632	Yes
	18/12/00 vs 26/06/00	25837.000	15.623	Yes
	18/12/00 vs 19/08/00	11249.500	6.802	Yes
	18/12/00 vs 28/09/00	10474.000	6.333	Yes
	12/02/01 vs 26/06/00	25429.500	15.377	Yes
	12/02/01 vs 19/08/00	10842.000	6.556	Yes
	12/02/01 vs 28/09/00	10066.500	6.087	Yes
	28/06/01 vs 26/06/00	23755.500	14.365	Yes
	28/06/01 vs 19/08/00	9168.000	5.544	Yes
	28/06/01 vs 28/09/00	8392.500	5.075	Yes
	28/09/00 vs 26/06/00	15363.000	9.290	Yes
	19/08/00 vs 26/06/00	14587.500	8.821	Yes

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Figure 4.2b shows the rising ten indicator bacteria numbers during the warmer months with the most significant increases in December and February, the warmest sampling months during the study (Table 4.2b).

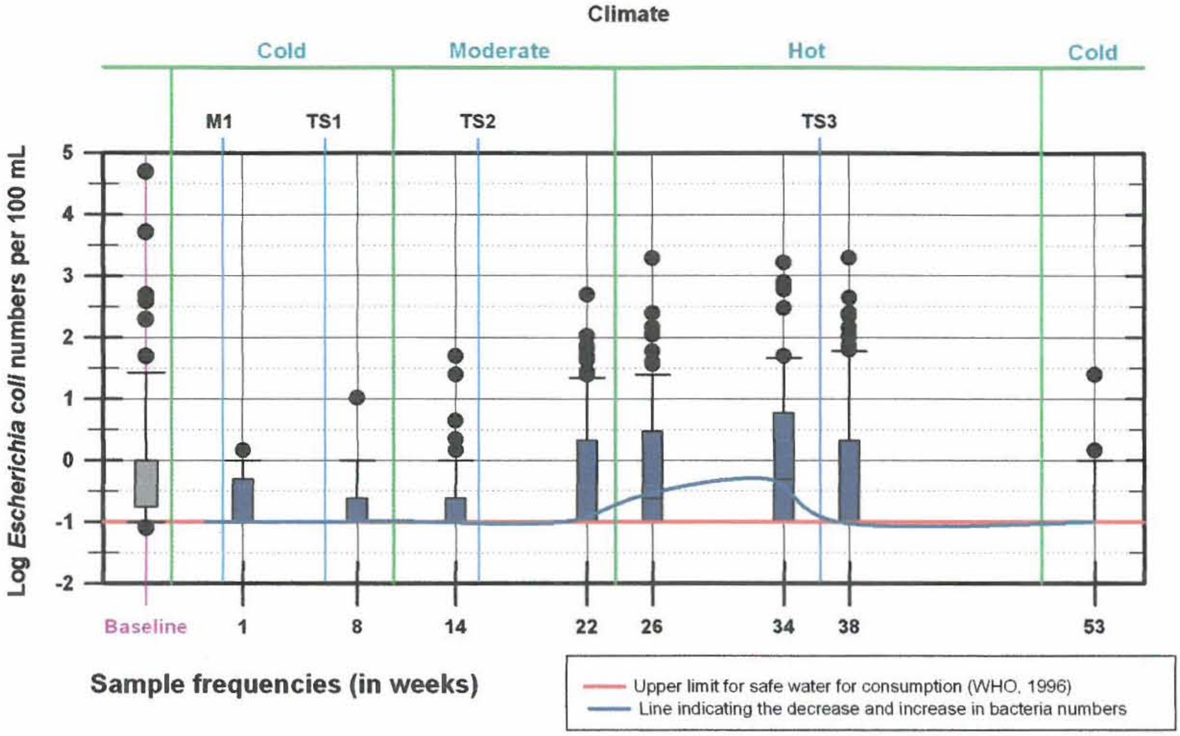

Figure 4.2b: *E. coli* numbers in container water of the study population during the education programme

Contrary to the total coliforms, the last June sample session (Week 53), were significantly lower than the other colder month sample session results (Table 4.2b).

Table 4.2b: MCT results to determine the *E. coli* values that differed significantly from the others

Indicators	Comparison	Diff of Ranks	q	P<0.05
E. coli	12/02/01 vs 28/06/01	12838.500	7.763	Yes
	12/02/01 vs 19/08/00	10103.500	6.109	Yes
	12/02/01 vs 26/06/00	9388.500	6.109	Yes
	12/02/01 vs 28/09/00	9040.500	5.467	Yes
	18/12/00 vs 28/06/01	11744.000	7.101	Yes
	18/12/00 vs 19/08/00	9009.000	5.448	Yes
	18/12/00 vs 26/06/00	8294.000	5.015	Yes
	18/12/00 vs 28/09/00	7946.000	4.805	Yes
	28/06/01 vs 12/03/01	9088.500	5.496	Yes
	28/06/01 vs 21/11/00	8090.000	4.892	Yes

It appeared that water samples taken from storage containers during the warmer months contained higher levels of *E. coli*, indicating faecal pollution of container water that might have resulted form poor personal hygiene practices after toilet use despite efforts to train the community to protect themselves against the risk posed by this tendency. This tendency of high *E. coli* numbers in warmer months observed in this study can be related to the study by Jagals (2000), that reported slow die off of *E. coli* in human faeces during the

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warmer months. In addition th e related to a favourable temperature during the warmer months, although this parameter was not measured in this study (WHO, 1993; Lehloesa and Muyima, 2000). Judging by the median total coliform values, all the households in the study group were exposed to a risk of *clinical infections* especially during the summer months.

5 GENERAL DISCUSSION

5.1 GENERAL CONTAINER AND STORED WATER HYGIENE

The lower turbidity levels that were measured after the intervention indicated that the containers had less biofilm in them, which indicated that people kept their water storage containers cleaner. In the Bokako (2000) study, no chlorine could be detected in the water in storage containers since it had dissipated from supply water during filling and storing. In this study turbidity caused by loosened biofilm that might have formed in storage containers used in the study area was significantly lower although chlorine was still not detectable in the water from the containers. This could only mean that the lower levels of turbidity indicated improved or frequent container washing and rinsing as an effect of some awareness created, but not necessarily by the hygiene education programme.

The reduced biofilm formation indicated by the turbidity levels should therefore have resulted in lower numbers of indicator bacteria, especially since educing biofilm in pipelines had been reported to reduce the occurrence of heterotrophic bacteria (Jesse et al., 1996; Schaule et al., 1996; Schaule and Flemming, 1997). However, heterotrophic bacteria in the containers were not reduced significantly. This could therefore not be linked to the regrowth of bacteria in the form of biofilm in the storage containers (Elliot, 1986; Volk and LeChevallier, 1999). Judging by the results in cannot be concluded that heterotrophic bacteria were still prominent because of regrowth in storage containers (Block et al., 1996; Kastl and Fisher, 1997). Some other factors had to be responsible for this. This indicated that excessive numbers of heterotrophic bacteria are still introduced in the containers in selected households by poor hygienic handling of water from and in the containers in selected households by poor hygienic handling of water from and in the containers during every day water related activities.

The educational intervention appeared to have had very little impact in reducing the number of heretrophic bacteria. These levels were still above the limit of *negligible risk of microbial infection* (DWAF, 1996). High levels of heterotrophic bacteria can also be caused by exposure of water to particulate matter (USEPA, 2001) for instance from the atmosphere. This could have been the result of inadequate implementation of water handling practices suggested and taught during the hygiene education programme.

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5.2 CHANGES IN WATER QU TO HAZARDOUS MICROBIOLOGICAL POLLUTION OF STORED WATER

The findings in the study indicated that levels in numbers of total coliform bacteria and *E. coli* have been reduced to levels below limits of risks of *clinical infections* (WRC, 1998) as well as consumption of *unsafe water* (WHO, 1996) since the hygiene education intervention. It appeared that attending the training sessions did not play a meaningful role.

In general total coliforms in water used by the selected households were found to be below the *clinical infections limit* according to the Assessment Guide: Volume 1: Quality of Domestic Water Supplies (WRC, 1998). The results indicated that the hygienic quality of stored water had improved *after* the hygiene education although total coliform bacteria numbers were still above the *insignificant chance of infection* limit. The reduction of total coliform numbers, despite the high heterotrophic bacteria numbers still present in the container water during the education programme, seemed to be influenced by lower levels of biofilm (Jones and Bradshaw, 1996). Nonetheless, numbers of total coliform bacteria found *after* the intervention indicated domestic activities that still introduced some form of organic pollution into stored water used by the selected households.

Field investigations in Malawi (Swerdlow et al., 1991), and Peru (Swerdlow et al., 1992; Ries et al., 1992) reported organic contamination of water in households of cholera patients, resulting from fingertip contact with water scooped from open containers. Findings in these studies and other studies (Tuttle et al., 1995), suggested that hands and objects (mugs) introduced into container water were sources of contamination. Judging by the fact that generally water is scooped from the containers rather than poured, these findings could hold true for the organic pollution found in stored water of all NIF groupings in this study.

The *E. coli* numbers in the container water were reduced significantly during and immediately after the intervention, with intermittent occurrences considerably less frequent than *before* the programme. The intermittent occurrences indicated that periodical faecal pollution rendered the stored water *unsafe for consumption* but to a lesser degree since the intervention. This periodical faecal pollution of container water is related to poor personal hygiene practices as well as unhygienic domestic environments in the study area (Henry et al. 1990; Stanton et al., 1992, Mintz et al., 1995). Some *E coli* can also be found in distribution systems (*containers*) below detectable concentrations in biofilm, even when water is adequately treated (Szewzyk et al., 1994). Thus the reduction of intermittent occurrence of *E. coli* in container water after the intervention in this study could also be linked to reduced levels of biofilm.

A seasonal factor such as climate appeared to have played a role in indicator levels during the intervention programme with the exception of heterotrophic bacteria numbers that were still high even in the cold months as well as turbidity levels that were still minimal during the

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months of sample collection. [illegible] found that water samples, collected in warmer months, contained higher level of total coliforms and *E. coli*. The potential risk of infection to consumers of the container water appeared to be higher in the summer months, despite the efforts to alert the selected households, during the educational intervention, to protect them against the risk posed by this tendency.

5.3 THE WATER HANDLING HYGIENE EDUCATION PROGRAMME

It appeared that the programme did not contribute to any specific groups' behavioural change, whether the particular group attended the sessions or not. At the end of 1999, an awareness campaign to clean containers was conducted in the study area (Dywili and Jagals, 1999). This awareness, supplemented by the onset of the first few meetings held during this study, appeared to have increased peoples awareness about cleaning containers judged by the significant and sustained decrease in turbidity. This change, however, was not sufficient. Indicator bacteria levels were still above limited risk levels. This indicated that the education part of the study was not effective. This could be because people had been taught to change certain deep-rooted behavioural patterns such as washing hands more frequently with only a limited volume of water supply stored at home (WHO, 2001).

From the general outcome of this study, it can be deduced that changing behaviour (water-related practices) of people is complex. Hygiene awareness (promotion) alone appeared not to be sufficient to bring about behaviour change (Miller and Rollnick; 1991; Byers, 1996). Others reported that hygiene promotion, while an important contributor to raising awareness of water-borne diseases and how to prevent them, should be supported by a formal educational component whereby adverse hygiene behaviours are repetitively trained out of people (Quick et al., 1996b; Curtis et al., 1997). It is important, however, to choose a behaviour that is not difficult for people to adopt. For example collecting and storing water for cooking and drinking in separate containers as well as frequent proper cleaning of containers may be much easier than getting people to wash their hands after defecation (Coulson, 2000). Therefore, it is important to promote and teach behaviours that people can easily adapt to.

For this study this was thought to be behaviours related to good hygiene practices such as regular hand washing and proper transport and domestic storage of water after collection. However, there are different theories and strategies for bringing about behaviour change in a population (Miller and Rollnick, 1991; Byers, 1996). Setting up a programme in a manner of changing the behaviour of a community towards a predetermined goal in a lasting way is done over a longer period and involves more role players within families (Byers, 1996).

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Chapter 4 CONCLUSION

1 SUMMARY

General health-related microbiological water quality of water stored by the study population in households still posed a potential risk of infection according to the Assessment Guide for quality of domestic water supplies (WRC, 1998), the South African Water Quality Guidelines (DWAF, 1996) as well as the Guidelines for drinking-water quality (WHO, 1996). In this study water quality improved significantly *after* the intervention with the exception of heterotrophic bacteria with a slight decrease still above the potential *increased risk of infectious disease transmission* (DWAF, 1996*)*. The results indicated that container water is still contaminated during storage even *after* the intervention.

- The container water still indicated some form of contamination related to water handling practices during storage and use at home despite the improvement of container washing and rinsing indicated by a significant decrease in turbidity levels after the intervention.
- Turbidity levels indicated less biofilm formation *after* the intervention that was related to improvement in container washing in this study.
- A significant decrease in bacteria numbers was observed with the exception of heterotrophic bacteria still above the recommended limits in the guidelines used for this study.
- No statistical significant differences were found in health-related microbiological water quality of the NIF groupings *after* the intervention.
- The hygiene educational intervention did not have a larger effect on the frequent group relative to the intermittent and never group.

2 LIMITATIONS OF THE EDUCATION PROGRAMME

Interventions that involve community participation, such as the water-handling hygiene education programme, have some limitations that must be considered prior to implementation (Byers, 1996):

- Inadequate systematic data collection to measure the consumers' gained knowledge and practices after the intervention.
- Inadequate programme communication. This covers identification, segmentation and channelling, the communication channels used by the study population needed to be identified prior training sessions. Specific groups are reached through:

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  - Strategies and message practices
  - Various mass media and interpersonal channels; and
  - Improved fieldworker and supervisor training methods, this then binds advocacy and programme communication.

- Physical environmental elements such as climate changes were important to investigate to determine contributing factors that might have acted as confounding factors toward the ultimate goal (improvement in health-related water quality).

3 RECOMMENDATIONS

- In the Southern African context, people will for a long time yet, be dependant of remote water supplies, despite huge efforts by governments to supply potable water in distribution systems within urban areas. This implies that the practice of storing water in containers at home will also be a reality for a long time to come. This study, as well as several others, has indicated that water so stored pose a risk to consumers. Programmes to make people aware of this as well as education and training programmes to change the behaviour of people that can negatively impact on the quality of the stored water must be implemented alongside water supply projects.

- Hygiene education informs communities about the correct use, storage and disposal of water and general hygiene that is of prime importance in all dense urban areas where water is still collected and stored in containers. Therefore it is necessary for community members themselves to contribute towards the development and sustainability of an appropriate hygiene programme towards improvement of their water supply. Educational programmes should therefore be designed with the direct inputs of the community.

- The process should be systematically planned and monitored and the impact on the targeted behaviour (practices) towards achieving the goal must be measured to verify effectiveness of such programme.

- Hygiene education programme should be consumer–orientated and demand-led. This process includes the following stages (Cairncross, 1992; Curtis et al., 1997):
  - Stage 1 Collaborative data collection
  - Stage 2 Feedback and discussion with all key stakeholders
  - Stage 3 Formulation of the hygiene promotion plan
  - Stage 4 Implementation, monitoring and evaluation

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4 FUTURE RESEARCH

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Although container hygiene appeared to have improved, the potential risk of microbial infection was still indicated even after the intervention. Future research should focus on effective hygiene education programmes so designed and implemented that those inherent, deep-rooted, individual personal behaviours such as handling stored water with unwashed hands can be changed. These programmes should bring about improved domestic water management by members of households, such as protection of container-stored water from environmental contamination. Changes such as these, brought about by sustainable awareness creation and education should contribute towards sustained improved health-related quality of water stored in domestic environments.

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APPENDICES

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APPENDIX A

Study on stored water storage and handling practices
Department of Environmental Sciences
Technikon Free State
May – 2000

Number of Questionnaire ☐☐☐

Date of interview ______________________________

Stand number ____________________

Name of interviewee ______________________________

Status: Mother ☐ Father ☐ Grandmother ☐ Grandfather ☐ Female Teen ☐ Male Teen ☐

DEMOGRAPHIC DATA

1) How many people live in the dwelling? ☐

2) What is the age and sex distribution in the household?

AGE DISTRIBUTION	NUMBER	SEX								
a) 0 – 3 months										
b) 4 – 12 months										
c) 1 – 13 yrs										
d) 14 – 21 yrs										
e) 22 – 50 yrs										
f) > 50 yrs										

3) What is the source of income?

a) no income ☐

b) one person works ☐

c) more than one person ☐

d) specify other: ____

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WATER A ND AVAILABILITY

1) What is the main source of your water supply?

a) yard tap ☐
b) communal tap ☐
c) specify other:____________________________________

2) Is the water readily available at the source?

a) Yes ☐
b) No ☐

3) If no, how often do you experience water cuts?

a) daily ☐
b) once a week ☐
c) twice a week ☐
d) a month ☐
e) once a month ☐
f) twice a month ☐
g) other ☐

4) What types of container material do you use to collect water?

a) plastic ☐
b) metal ☐
c) plastic and metal ☐
d) clay ☐
e) specify other ______________________________

5) How many of each type do you use in normal circumstances?

Type of container	5L	10L	20L	25L	50L
a) plastic					
b) metal					
c) plastic and metal					
d) clay					
e) other					

6) Do you add more containers during water cuts?

a) Yes ☐
b) No ☐

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7) **If yes, how many do you**

Type of containers	5L	10L	20L	25L	50L
a) plastic					
b) metal					
c) plastic and metal					
d) clay					
e) other					

8) **How often do you collect water a day?**

	1	2	3	4	5	6
a) 5 L						
b) 10 L						
c) 20 L						
d) 25 L						
e) 50 L						

9) **How often do you collect water in a week?**

	1	2	3	4	5	6
a) 5 L						
b) 10 L						
c) 20 L						
d) 25 L						
e) 50 L						

10) **Who often collects the water?**

a) children ☐
b) adults ☐

11) **How is the water transported from the source to the house?**

a) carrying (head/hand) ☐
b) wheel barrow ☐
c) rolling on the ground ☐
d) specify other____

12) **If any of the above, is the container**

a) open ☐
b) closed ☐

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1) Do you think it is important to wash the container?

a) Yes ☐
b) No ☐

2) What do you do with the container before filling it?

a) wash it ☐
b) wipe it ☐
c) just pour water ☐
d) rinse it ☐
e) specify other____

3) If a, what do you use?

a) soap ☐
b) disinfectant soap ☐
c) water only ☐
d) specify other____

4) Do you cover the containers during storage?

a) Yes ☐
b) No ☐

5) What do you use to scoop the water from the container?

a) cup ☐
b) plastic jar ☐
c) metal jar ☐
d) specify other____

6) Do you wash your scooping equipment (mug)?

a) Yes ☐
b) No ☐

7) If yes, how often?

a) after drinking ☐
b) before drinking ☐
c) once a day ☐

8) How old is the storage container?

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a) < 3 months ☐

b) 3 –12 months ☐

c) 1 year ☐

d) > 1 year ☐

AESTHETIC QUALITY

1) How does the water taste?

a) pleasant ☐

b) neutral ☐

c) unpleasant ☐

2) If c, describe

____

____

____

3) What is the appearance of the water?

a) clear ☐

b) clear with particles ☐

c) cloudy ☐

d) discoloured ☐

4) Is the appearance of the water always like this?

a) Yes ☐

b) No ☐

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APPENDIX B

HYGIENE EDUCATION PROGRAMME

ACTIVITIES AND TOOLS

THIS BOOK IS
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1 KEY POINTS ADDRES ITIES AND TOOLS USED IN THE HYGIENE EDUCATION PROGRAMME

The programme activities were used to help the selected households through the process of developing improved container water handling practices. The information transferred through the activities was aimed at improving health-related microbiological container water quality during and after the intervention.

The activities were therefore adjusted from (Lammerink et al., 2001; WHO 1998) and were focused on the following key points:

- **Sanitary condition of storage containers** – frequency of washing of storage containers by the sample population
- **Hand hygiene** – the frequency of hand washing especially after toilet use
- **Scooping mug hygiene** – protection and storage of scooping mug
- **Collection and transport** – protection of container water during collection and transportation

2 ACTIVITIES AND RELATED TOOLS USED FOR THE PARTICIPATORY PROCESS

2.1 PROBLEM ANALYSIS (MAIN ACTIVITY)

Sub-activity:	Good and bad hygiene practices (behaviours)
Sub-activity:	Investigating community practices
Tools:	Three pile sorting
	Pocket chart

(WHO, 1998)

The "Good and bad hygiene practices" activity is one of the problem analysis sub-activities that help the group to critically look at common container water hygiene practices and to identify how these practices may impact positively or negatively on their health. "Investigating community practices" also forms part of problem analysis. Community members use a pocket chart to collect and analyse data on actual practices in the community. This sub-activity helps to compare what people are actually doing with what the group has discovered to be good or bad for their health.

2.1.1 Sub-activity: Good and bad hygiene practices (behaviours)

Purpose of the sub-activity:

To exchange information and discuss in a group common hygiene practices according to their good and bad impacts on health-related microbiological water quality.

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Materials:

- Two sets of ten three pile sorting drawings (WHO, 1998)
- Two sets of heading cards, with the words "Good" and "Bad"

Procedure:

Each of the two groups was given two sets of pictures to choose bad and good practices that are common in their community in relation to stored water handling during storage at home.

The groups were given a chance to discuss their choices and reach consensus about the actual behaviours that are in practice in their homes. This helped the group to realise their own bad practices around their stored water at home.

2.1.2 Sub-activity: Investigating community practices

Purpose of the sub-activity:

To help the group organise and analyse information on water handling practices in the community.

Materials:

- A pocket chart
- Three pile sorting pictures
- Voting materials (e.g. paper blocks) (WHO, 1998)

Procedure:

All group members used paper slips to vote on common practices that could influence water quality in storage containers. Different types of bad hygiene pictures were placed on the pocket chart and group members placed their votes on the most common practices they knew. Discussion after this sub-activity helped the group members to realise how simple behaviours could impact negatively on their stored water quality.

2.2 IDENTIFYING AND BLOCKING CONTAMINATION ROUTES OF STORED WATER AND SELECTING IMPROVED HYGIENE PRACTICES (MAIN ACTIVITIES)

Tool: Blocking the routes (WHO, 1998)

Purpose of the activities:

To help participants discover how stored water can be contaminated by their practices around their home environment and what measures could be implemented to remedy the situation.

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Materials:

- A set of pictures, depicting contamination routes through bad hygiene practices.
- A set of pictures, depicting protective measures for stored water at home.

Procedure:

The group placed the pictures in sequence of contamination up to the point where water is consumed. The sequence was explained by the group to the researcher and how such sequence can impact negatively on stored water quality and ultimately on health. The group further used the other set of pictures to identify protective measures to prevent water contamination at home (Almedom et al., 1997; WHO, 1998).

The activity was used to assist the community members to describe how diseases are transmitted in the environment through contaminated stored water and how such contamination could be influenced by unhygienic practices / behaviour.

When people understand how contamination of stored water takes place as well as transmission of related water diseases, people will be able to weigh the advantages of preventing such contamination in households at the point of water storage (Dietz and Nagata, 1995).

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APPENDIX C

LAUNCHING MEETING OF THE ACTION GROUP

AGENDA 1

Date: 20 – June – 2000

1. Introduction
2. Opening prayer
3. Word of thanks
4. Update on research
5. Information on general water quality
    - Container hygiene
    - Storage methods
6. Main factors affecting good / poor container hygiene and stored water
7. How knowledge can improve quality of stored water
8. Training procedure (discussion)
9. Conclusion

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LAUNCHING MEETING MIN CTION GROUP HELD ON THE 20TH JUNE 2000 AT SECTION K CLINIC AT 15H00

People who attended the meeting:

Miss NP Nala **(Researcher)**
Mr. T Tsubane **(Research student)**
Mr. D Masemola **(Research student)**
33 household representatives from households

1 INTRODUCTION

Ms Nala briefly introduced the two research students she worked with to the community members.

The purpose for using the particular action group was clearly stated by Ms Nala to the household members and that their participation was also acknowledged and highly appreciated.

2 OPENING PRAYER

One member of the action group opened the meeting with a prayer.

3 WORD OF THANKS AND UPDATE ON RESEARCH

Ms Nala thanked the action group for their patience and participation throughout other related studies that related to this study.

The action group was then informed about the findings in previous stored water related studies that focused on water quality and also stated why this study had to be implemented.

4 INFORMATION ON GENERAL WATER QUALITY

The action group was informed on possible ways that could lead to deterioration of stored water. The information was based on environmental contaminants such as dust particles as well as method and duration of storage.

4.1 FACTORS AFFECTING STORED WATER (CONTAINER HYGIENE AND STORAGE METHODS)

Ms Nala informed the action group that previous studies indicated that most households do not replenish their water frequently and that leads to formation of biofilm, which in turn is believed to contribute to the presence of spore forming microorganisms that become

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reactivated after suspension of the biofilm. Ms Nala explained the biofilm as a slimy layer that forms on the sides of containers during water storage.

It was further stated that containers used were not cleaned properly to ensure disinfection of storage containers and that, storage containers were not usually kept closed with tight fitting lids. The group was encouraged to use materials such as sunlight liquid and scrubbing material for effective cleaning of storage containers.

5 HOW KNOWLEDGE CAN IMPROVE QUALITY OF STORED WATER

The researcher communicated to the action group how knowledge on type of detergents as well as methods for cleaning containers and proper handling of stored water could improve quality of stored water.

6 TRAINING PROCEDURE

Ms Nala explained to the action group that they would be divided into two groups during the participatory activities of the programme. One group of 40 will be trained by Mr Tsubane and the other group of 40 by the researcher.

The action group was informed that during the intervention there would be ongoing water sampling. This was to sensitise the group to the process of water sampling in the community.

7 OTHER MATTERS

The action group asked Ms Nala to communicate with the councillors in connection with water cut offs. They indicated that in this way they would not have to store water for a long time without washing their containers as they would be informed in advance if water is to be cut off and for how long.

Ms Nala was also asked to arrange a meeting between the action group and the then TLC to discuss the issue of bringing taps in yards. According to the action group this would improve water quality and related hygiene practices.

8 CONCLUSION

It was finally concluded that meetings or training would be held on Saturdays, because most mothers are at work during the week.

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APPENDIX D

FIRST TRAINING SESSION MEETING WITH THE ACTION GROUP

AGENDA 2

Date: 29 – July – 2000

1. Opening prayer
2. Feed back from councillors
3. Knowledge transfer
    - Types of disinfecting soaps
    - Method for cleaning containers
    - Water storage
    - Handling of scooping mug
    - General water related personal hygiene
4. Activity: Problem analysis
    - Sub-activities: Good and bad hygiene practices
      Investigating community practices
5. Discussion
6. Next probable sampling date
7. Closure (Prayer)

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FIRST TRAINING SESSION MINUTES OF THE ACTION GROUP MEETING HELD ON THE 29TH JULY 2000 AT SECTION K CLINIC AT 15H00

People who attended the meeting:

Miss NP Nala **(Researcher)**
Mr. T Tsubane **(Research student)**
Mr. V. Nkojoa **(Assistant research student)**
36 action group members from 36/80 selected households

1 OPENING

One member of the action group opened the meeting with a prayer.

2 WELCOMING

Miss Nala welcomed the action group members and other representatives of the action group mothers that could not come to the meeting (teenage boys and girls).

3 FEEDBACK FROM COUNCILLORS

Miss Nala and the councillors have finalised that the community will be informed prior to water cut-off for any reason that might be.

Notices for the meetings were to be announced on local radio station and distributed to the selected households to remind action group members about meetings.

4 KNOWLEDGE TRANSFER

4.1 PROBLEM ANALYSIS - ACTIVITY

Miss Nala involved the action group in a participatory activity (problem analysis). The activity consisted of two sub-activities namely:

- Good and bad hygiene practices (behaviours) and;
- Investigating community practices (Appendix B)

The above-mentioned sub-activities helped the group to identify poor hygiene practices that are commonly carried out in their households around stored water.

4.2 QUESTION AND ANSWER – ACTIVITY

A question and answer activity was conducted to stimulate discussion in the action group. Questions relating to the following were addressed:

- Types of disinfectant soaps such as Sunlight liquid versus “Handy-Andy” or powder soap
- Scrubbing as efficient container cleaning method

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- Water storage and period of storage
- Hygienic handling of scooping mugs
- General water related personal hygiene

5 DISCUSSION – NEW MATTERS

The action group and Ms Nala discussed matters dealt with during knowledge transfer. It was also discussed that action group members should be given certificates that will permit them to educate other community members on water related hygiene practices in households as well as at water collection points when necessary.

Ms Nala informed the action group members that samples will be collected until December 2000 and that she would appreciate their undivided participation.

The next probable dates for sampling were said to be in August 2000 and September 2000 before the next meeting.

6 CLOSURE

A member of the action group closed the meeting with a prayer.

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APPENDIX E

SECOND TRAINING SESSION MEETING WITH THE ACTION GROUP

AGENDA 3

Date: 30 – September – 2000

1. Opening prayer
2. Welcoming
3. General discussion
4. Lecture: Home water treatment
5. Review on main factors affecting good / poor container hygiene and stored water quality
    - Container hygiene
    - Storage methods
6. Knowledge transfer

6.1. Activity: Identifying and blocking contamination routes of stored water

6.2. Activity: Selecting improved hygiene practices

7. Discussion
8. New matters
9. Conclusion

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SECOND TRAINING SESS F THE ACTION GROUP MEETING HELD ON THE 30TH SEPTEMBER 2000 AT SECTION-K CLINIC AT 15h00

People who attended the meeting:

Miss N.P. Nala **(Researcher)**

Mr. T. Tsubane **(Research student)**

30 household representatives from 30/80 selected households.

1 OPENING PRAYER

One household member opened the meeting with a prayer.

2 WELCOMING

Miss Nala welcomed all the mothers and other representatives of mothers who could not come to the meeting (teenage boys and girls).

3 UPDATE ON RESEARCH RESULTS

Miss Nala updated the action group about the results of the analysed samples before this contact session. The results were said to indicate slight improvement in stored water quality but still yield health-related microbiological water quality that is above the South African Water Quality Guidelines (1996) and other guidelines used in this study. The group members were edged to re-evaluate their hygiene practices at home and try to improve or change their current practices towards water handling.

4 HOME WATER TREATMENT

Miss Nala trained the action group on how to treat their domestically stored water including aspects such as how long one can store the water and frequency of disinfecting with jik-bleach. The group was also trained on container water protection measures during collection. A poster was used to illustrate the steps of disinfecting stored water (Chapter 2, Figure 2.5).

5 REVIEW OF MAIN FACTORS AFFECTING GOOD / POOR CONTAINER HYGIENE AND STORED WATER QUALITY

The action group was re-informed about examples of possible ways that lead to deterioration of their stored water.

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6 KNOWLEDGE TRANSF N)

6.1 IDENTIFYING AND BLOCKING CONTAMINATION ROUTES OF STORED WATER – ACTIVITY

Miss Nala conducted an activity, in which the action group had to work with pictures used for indicating potential contamination routes or pathways of stored water as well as pictures that indicated prevention of container stored water from contamination.

6.2 SELECTING IMPROVED HYGIENE PRACTICES /BEHAVIOURS – ACTIVITY

The action group identified some common behaviour practices that are water related in their community by use of pictures – *three pile sorting* (Appendix B).

The action group discussed with the researcher why the selected pictures were regarded as common practices as well as how such practices impacted negatively on the stored water quality. Through the activity the group came into consensus on good hygiene practices that need to be implemented at home for improvement of stored water quality.

7 DISCUSSION OF OUTCOMES

Miss Nala discussed the outcomes with the action group. This entailed explanation of the action group on pictures that they chose for specific activity steps. All members showed interest and ideas were exchanged and final decisions were taken on exact contamination and preventative measures to be taken and the action group gave reasons for choosing certain pictures for prevention of stored water contamination.

8 NEW MATTERS

No new matters were discussed.

9 CONCLUSION

It was concluded by the action group that the activities had a great influence on determining how much information they have acquired throughout the training sessions. Also that they have gained much more knowledge on important stored water related practices / behaviours. Miss Nala acknowledged the action group participation and interest in bringing about change that concerns their health.

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APPENDIX F

THIRD TRAINING SESSION MEETING WITH THE ACTION GROUP

AGENDA 4

Date: 24 – February – 2000

1. Opening prayer
2. Welcoming
3. General discussion

Activity: Question and answer session

- Achievement of the project
- Problems and difficulties encountered
- A way forward

4. Vote of thanks

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THIRD TRAINING SESSION MINUTES OF ACTION GROUP MEETING HELD ON THE 24TH FEBRUARY 2001 AT SECTION K-CLINIC AT 15H00

People who attended the meeting:

Miss N.P. Nala **(Researcher)**

Mr. T. Tsubane **(Research student)**

24 household representatives from 24/80 selected households.

1 OPENING PRAYER

A member of the action group opened the meeting with a prayer.

2 WELCOMING

Miss Nala welcomed the household representatives – predominantly mothers.

3 GENERAL DISCUSSION

Activity: Question and answer

During the question and answer session, it was concluded that all household members have gained knowledge – though the implementation of such knowledge was said to be difficult to implement constantly at the household level. Some of the reasons included issues such as the bad habits around stored water would require a much longer time for change. The action group mentioned that even though they have acquired knowledge change would take some time because the bad habits are embedded in their mindset. Some action group members further indicated that at times they are not at home and it is not practical to constantly monitor the practices of their children with relation to stored water handling.

It could then be concluded from this session that change in behaviour goes with time and constant practice.

Suggestions by the action group included; the distribution of pamphlets with stepwise procedures to ensure protection of stored water from contamination as well as big posters in the area to constantly remind the community of the importance of clean uncontaminated water during storage.

4 CONCLUSION

The action group was determined that with time there would be a considerable improvement in their stored water quality. The final conclusion was that, where there is a will there is a way.

A member of the action group closed the meeting with a prayer.

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