

# EXECUTIVE SUMMARY

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## BACKGROUND

Water is essential for life and this is true for animals, humans and even plants. However, the quality as well as the quantity of water can be affected by human activities and behaviour. The consequences of these activities can lead to contamination with microorganisms as well as chemical compounds that can be toxic to humans. The contamination may lead to diseases with subsequent negative impact on the health of humans as well as the world's economy.

Water provision cannot be separated from sanitation and health, and the primary cause of water contamination is poor sanitation which often leads to infections. These infections remain one of the main causes of illness and death. An estimated 94% of diarrhoeal cases are preventable through the increased interventions in the availability of clean water, and improved sanitation and hygiene. This can be enhanced by effective treatment at the household level which can remove, kill or inactivate most microbial pathogens which also minimises the risk of recontamination that can occur in even improved water supplies.

Participative approaches to understanding the problems that beset different communities are being developed and these include surveys that investigate the attitudes of a population group in relation to different social and health factors. Another method that has been recently described (within the last two decades) is "photovoice". This is a method through which communities tell their stories in pictorial form to engage researchers and policy makers. The photovoice is a useful tool that can be used in rural communities to understand water related problems such as its uses, availability and quality. At the same time it empowers the communities and increases their participation in the management of water resources in their respective areas.

Natural waters generally contain chemical substances that can have an impact on taste as well as the immediate or long term health of individuals consuming that water. Therefore, it is essential to identify the chemicals that are found in water sources in specific regions in order to advise on issues relevant to treatment or removal of those chemicals. Over the past decade, parasitic organisms have been responsible for diarrhoeal outbreaks across the globe.

In developed countries such as the United States of America (USA) and the United Kingdom (UK), there are organisations that are responsible for maintaining surveillance systems for waterborne diseases and outbreaks. These organisations collect and report data related to waterborne-disease outbreaks associated with drinking water. However, in developing countries including South Africa, the system for reporting waterborne disease outbreaks is not systematic and data on such outbreaks are scarce. A few scientific studies have been conducted in South Africa and these have documented the occurrence of parasitic organisms such as *Cryptosporidium* and *Giardia* in sewage systems as well as environmental waters particularly in the Gauteng and the Cape regions. Previous studies have demonstrated that water sources in the Limpopo Province have been contaminated with bacterial organisms but no studies have been conducted on parasitic organisms. Considering the fact that the Limpopo Province is mostly rural, it is expected that water sources are contaminated with parasitic organisms. However, in order to provide tools that could be used by decision makers to improve water quality and hence the health of the local population, scientific studies have to demonstrate and document the occurrence and the extent of contamination as well as the different types of parasitic pathogens commonly found in the region.

## Parasite and related interactions in water resources and rural communities

Water is a basic need of all living organisms, but it can also transmit diseases to both human beings and animals. Previous studies in the Limpopo Province have mainly focused on the detection of bacterial pathogens and have indicated that most water sources in the region were contaminated with potentially pathogenic bacterial organisms. However, no study has been conducted on the occurrence of parasitic organisms in the region. In addition, relatively few studies have been conducted on the potential impact on the socio-economic characteristics of rural communities as they affect human health and water quality, particularly in relation to chemistry and parasitic contamination. Recently, several outbreaks of cryptosporidiosis have been described in both immune-competent and immune-suppressed individuals throughout the world. The control of these diseases, particularly in rural areas where the risk of

contamination is generally high, should include a description of social and scientific factors. A recent study on the occurrence of an outbreak of cryptosporidiosis in a splash park in Idaho (USA) indicated that educational efforts and enactment of regulations requiring enhanced disinfection technology, exclusion of persons with diarrhoea, adequate hygiene facilities, and preconstruction consultation with health departments could reduce the risk for recreational water illness at splash parks (CDC, 2009). In South Africa, *Cryptosporidium* has been found in environmental waters. However, very few studies have combined social and microbiological methodologies in order to understand the issues related to health in rural communities.

In the present study, surveys were conducted in 22 villages around the Limpopo Province which included a photovoice project in one village in order to understand the perceptions of the community in relation to water quality and health. Water samples were collected from the homes of the respondents of the survey and analysed for chemical content. Water and wastewater samples were also collected for microbiological analysis of parasitic organisms as well as physico-chemical characteristics. Meetings with community leaders and community members were organised before and after the survey in order to inform the community about the project and its results and for further education.

## **AIMS OF THE STUDY**

1. To identify the socio-economic characteristics of the communities as they affect water quality and health correlates.
2. To evaluate the applicability of the photovoice in the interaction between scientists and community members as well as to understand the issues related to water from the community members point of view.
3. To determine the chemical profile of drinking water from homes as well as water sources where the population get their drinking water such as boreholes and rivers.
4. To determine the physicochemical characteristics of water sources mainly rivers, boreholes and dams and the level of parasitic contamination of these sources.
5. To determine the physicochemical characteristics and the prevalence of parasitic organisms in wastewater from sewage treatment plants in the Limpopo Province.

## **METHODOLOGY**

In order to understand the socio-economic characteristics of the population and their impact on water quality and health, a survey was conducted in 22 different villages in the Limpopo Province using semi structured questionnaire (Chapter 1). Data on the survey were analysed using descriptive statistics. Drinking water samples were collected from the households of different villages, communal taps, boreholes, and rivers were analysed for physico-chemical characteristics (Chapter 4).

One community was selected for the photovoice project. Following several meetings with representatives of this community, a group of twelve people that included males and females of all ages who volunteered to participate, were trained on how to use a camera to take pictures. They were then given cameras and were Parasite and related interactions in water resources and rural communities requested to take pictures of significance to them expressing their feelings about water related issues in their community. All the photographs were developed and each participant chose the one that was most significant to them and their feelings about that picture were recorded and reported (Chapter 2). Influent and effluent wastewater samples were collected from all the six sewage treatment plants in the Vhembe District from August 2009 to July 2010. Centrifugation and ferric sulphate flocculation were used as concentration methods for the samples. Helminths were detected in the samples' concentrates through the use of microscopic analysis. Coccidian organisms including *Cryptosporidium*, *Cyclospora* and *Isospora* were detected in the concentrates by the use of the modified acid fast staining. Molecular methods particularly conventional PCR and real time PCR were used for the detection of *Cryptosporidium* and *Giardia* from the samples. In order to establish the ultra structure of *Cryptosporidium*, scanning electron microscopy was deployed to observe the oocysts isolated from the wastewater samples and stool samples (Chapter 3). The water samples that were collected from rivers, boreholes and dams throughout the Limpopo Province were concentrated by filtration using envirocheck filters. The concentrates were then analysed by molecular methods for the detection of *Cryptosporidium* and *Giardia* (Chapter 5)

## **RESULTS AND DISCUSSION**

The survey was conducted in 914 households comprising of 5512 individuals from the five districts of Limpopo Province covering a total of 22 villages. From descriptive analysis, 12.5% of the households have had at least one member with diarrhoea 3 months prior to the survey. Close to 34% of the households get water from unsafe sources, and only 11.9% of the households treat the water they use. It was also found that water source, sex of household head and the presence of children under the age of 5 years significantly affect the treatment of water at point of use. Close to 41% of the population surveyed stated that their water was salty.

The photovoice method was demonstrated to be an effective method of communicating the perceptions and understandings of issues related to the life of the community, especially from the population facing the issues on a daily basis. Issues raised by the participants included the shortage of water, dirty water, long queues, government involvement in water supply and the ever present risk of being infected from contaminated water.

The study has indicated high concentrations of nitrate and phosphate in the water samples as well as lead and cadmium. Although we were not able to identify the source of contamination, animal waste, human waste, poor hygiene and sanitation standards, underground chemistry and possibly the presence of land disposal could be causes of water sources contamination.

The efficiency of the sewage treatment plants in the elimination of parasitic organisms was very low (less than 50%) and various helminths were found in the final effluent from the plants.

*Cryptosporidium* was found in about half of the samples collected from drinking water sources including rivers, dams and boreholes. The proximity of the boreholes to latrines in certain village settings might be the cause of contamination.

However, further studies are needed to verify this hypothesis. *Giardia intestinalis* was very common in the drinking water sources especially genotype B which is known to cause persistent diarrhoea particularly among children and HIV-positive people.

Parasite and related interactions in water resources and rural communities

## CONCLUSIONS AND RECOMMENDATIONS

The present study has found that many families in the region are headed by females. This means that females should be empowered as well as girls in order to prepare them for such responsibilities.

Homebased water treatment was not common in the population surveyed and the level of diarrhoea was significantly associated with the number of people staying in the same household. The level of hygiene in these communities was found to be very low in terms of fruit washing, hand washing with soap, water storage and waste disposal. Therefore further education in the communities will be useful in reducing the number of diarrhoea and other hygiene and sanitation-related diseases. Interactions between scientists and the communities should be encouraged and participative approaches such as the photovoice are useful tools in identifying problems in different communities from the community members' point of view.

Nitrate, phosphate, lead and cadmium constitute some of the main contaminants of water sources in rural areas in the Limpopo Province. There is a need to establish the origins of these chemical contaminants in the water sources particularly the nitrate. Further investigations on the potential role of the high level of nitrate on children's health are needed. The saltiness of drinking water reported by participants could be related to the high content of chemicals such as sodium, chloride or sulphate in these water sources.

Advanced technologies such as cation/anion exchange, ultrafiltration, reverse osmosis or distillation and others are needed in order to improve the quality of drinking water in these communities.

*Cryptosporidium* and other parasitic organisms are present in wastewater samples in the sewage treatment plants in the Vhembe District and are not completely eliminated from the wastewater. In addition drinking water sources are often contaminated with *Cryptosporidium* and *Giardia* since almost 50% of the samples tested contained these parasites. The regular consumption of such water exposes the population to potential outbreaks or chronic infections by these pathogens with potential negative effects on the health of the population. These findings suggest the need for better monitoring of water quality for parasitic organisms and identification of sources of contamination. Further studies could now concentrate on the detection procedures of parasitic organisms from water samples and the molecular characterisation of those organisms.

Both surface and groundwater sources in the Limpopo Province are contaminated with low levels of parasitic organisms such as *Cryptosporidium* and *Giardia*. *Giardia intestinalis* genotype B is more common compared to genotype A in the water sources in the Limpopo Province. This information is important in the development of diagnostic methods for the better detection of parasitic organisms and epidemiological studies or vaccine development. Further studies are needed on a larger scale to evaluate the extent of the problem and possibly investigate the relationship between the presence of these parasitic organisms and the occurrence of diarrhoea in the population. It is possible that there are interactions between groundwater and surface water as shown by the occurrence of these parasitic organisms both in surface water and groundwater. Further molecular studies could yield more information on this hypothesis.

*Cryptosporidium* is common in environmental samples such as wastewater and rivers in the Limpopo Province. Although the local population is aware of hygiene and sanitation issues, it is important that emphasis be made in the application of such measures. *Cryptosporidium* has the potential to infect many people in a situation of a point-source outbreak.

Further research still needs to be done in order to:

- Determine the occurrence of *Cryptosporidium* in larger volumes of borehole and treated water samples.
- Clarify the relationship between low numbers of oocysts in drinking water and the frequency of cryptosporidial infections in rural populations.  
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- Determine the asymptomatic carrier rate for *Cryptosporidium* in immune-compromised persons and the possibility of these individuals developing cryptosporidiosis when their CD4 counts drop to a lower level.
- Calculate the relative risks of infection from drinking water, contact with animals, unsafe sexual practices, and nosocomial contact to see where focus on preventative strategies should be placed.
- Improve communication for reporting cases of cryptosporidiosis and identifying outbreaks.
- Continue to develop more effective therapies for ameliorating cryptosporidiosis symptoms  
Further studies could also determine the prevalence of intestinal parasitic infections and their relation with socio-economic factors and hygienic and sanitation habits in populations in these rural areas.

## **CAPACITY BUILDING**

Two Masters students and one Honours student were trained in the present study.

## **KNOWLEDGE DISSEMINATION**

The following publications will be prepared from the data obtained during the study:

- Effect of water and sanitation on human health in Limpopo Province.
- An Analysis of Household characteristic associated with Household water treatment in the Limpopo Province of South Africa.
- Perceptions on water and its attributes in rural communities of Limpopo Province.
- Photovoice as a participatory approach for understanding water related issues from rural communities in the Limpopo Province.
- Occurrence and efficiency of sewage treatment plants in the elimination of parasitic helminths in the Vhembe District, South Africa.
- Occurrence and efficiency of STPs in the elimination of *Cryptosporidium* in wastewater in the Limpopo Province.
- Molecular detection and genotyping of *Giardia intestinalis* in sewage treatment plants in the Limpopo Province.
- Occurrence of *Cryptosporidium* and *Giardia* in water sources in rural communities in the Limpopo Province, South Africa.
- Physical and chemical characteristics of water sources and drinking water in the Limpopo Province, South Africa.

Data collected during the study is kept at the Department of Microbiology, University of Venda, Thohoyandou, South Africa