CHALMERS

Drinking Water Quality Monitoring and Communication in Rural South Africa

Case study in Hantam Municipality

Master of Science Thesis in the Master's Programme Geo and water engineering

HANNA LINDFORS

Department of Civil and Environmental Engineering
Division of Water Environment Technology
CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover:
One of the interviewees in Hantam municipality, at his borehole site in Middelpos, see Section 2.1.3. and Chapter 7.

Department of Civil and Environmental Engineering Göteborg, Sweden 2011

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ABSTRACT

The development of a new field test kit along with a report system is currently taking place within the international cooperative project called the Aquatest programme. It aims at improving drinking water quality management in remote areas of developing countries. The feasibility of such system in Hantam municipality, a rural municipality of South Africa, is evaluated in this report. Relevant guidelines, policies and laws of South Africa are assessed and analyzed in order to evaluate how the system may interact with the strategies leading the country and the responsibilities of actors within the water service sector. The focus is drinking water quality monitoring and communication in rural areas. Several methods with this aim are presented, both those used since long and others recently introduced in South Africa. A field study is performed in Hantam municipality where such a system has been introduced. Several interviews are conducted with municipal staff using the field test kit and report system in their daily work. The interviews aim at providing information about how drinking water quality management has changed since the introduction of the field test kit and the Report system. The extension of drinking water quality monitoring is evaluated as well as the information communicated to consumers and national government. The interviews also aim to create an understanding of the experiences of municipal staff in working with the system. Such field test kit and report system turned out to possess the ability to integrate well in the local structures and to be managed in an accurate and sustainable way. It improves microbiological monitoring and increases frequency of drinking water quality communication. While communication between actors increases, the water quality information communicated to consumers is still very limited. Furthermore, the use of the system has the potential to increase the municipal Blue Drop Score, which is a national classification of drinking water quality management systems.

Key words: Drinking water quality, Monitoring, Communication, Aquatest programme, H_2S field test kit, Reporting System, Aquatest device, Rural areas, Hantam municipality, South Africa.

Övervakning och kommunikation av dricksvattenkvalitet på Sydafrikas landsbygd

Case study i Hantam´s kommun

Examensarbete inom Geo and Water Engineering
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SAMMANFATTNING

Inom Aquatest programmet, ett pågående internationellt forskningssamarbete, är en testmetod och ett kommunikationssystem under utveckling. Programmet syftar till att förbättra dricksvattenförsörjning och kvalitet i glesbygdsområden i utvecklingsländer. Lämpligheten av ett sådant system i Hantam's kommun, ett glesbefolkat samhälle på Sydafrikas landsbygd, utvärderas i denna rapport. Relevanta riktlinjer och lagar beskrivs och analyseras för att sedan utvärdera hur systemet passar med de strategier som vägleder utvecklingen i landet och med det ansvar som olika parter har inom vattenförsörjningen. Rapporten är fokuserad på övervakning och kommunikation av dricksvattenkvalitet i glesbygdsområden och presenterar flera av de metoder som används i Sydafrika för sådant syfte. En fältstudie genomförs i Hantam's kommun där flera intervjuer hålls med kommunalanställda som använder testmetoden och kommunikationssystemet i deras dagliga arbete. Intervjuerna syftar till att bidra med information kring hur dricksvattenförsörjningen har förändrats sedan implementeringen samt hur personalen upplever det nya systemet. Det visar sig att testmetoden och kommunikationssystemet har potentialen att integreras väl i den lokala strukturen och används på ett väl lämpat och hållbart sätt. Det leder till förbättringar både inom övervakning av mikrobiell dricksvattenkvalitet samt inom kommunikation av dricksvattenkvaliteten. Kommunikationen mellan aktörer inom dricksvattenförsörjningen visar sig öka medan information om vattenkvaliteten till konsumenter fortfarande är mycket begränsad. Systemet har också potentialen att höja kommunens Blue Drop Score, vilket är det nationella systemet som används för att klassificera dricksvattenförsörjningssystem.

Nyckelord: Dricksvattenkvalitet, Övervakning, Kommunikation, Aquatest programmet, H_2S fält test kit, Kommunikationssystem, Aquatest-utrustning, Glesbygdsområden, Hantam's kommun, Sydafrika.

Contents

Preface

The project has mainly been carried out at the University of Cape Town during spring 2011, together with the iCOMMS research team as part of their work within the Aquatest programme. It is an international research project aiming at improving drinking water quality management in developing countries.

I am very thankful for the invitation to University of Cape Town, from Ulrike Rivett who was my supervisor in field, offering guidance and support during my stay in South Africa. I highly appreciate the support and cooperation of researchers and staff within the iCOMMS research group and for taking me on an unforgettable trip to the Northern Cape and Hantam municipality.

Several interviews were conducted with municipal staff during the stay in Hantam municipality, South Africa. I want to thank all the interviewees in Hantam municipality for taking their time to share information and to demonstrate how to perform important parts of their daily work. You have provided valuable information for this report and inspired me in all aspects.

The project is partly carried out at the Department of Civil and Environmental Engineering, Water Environment Technology at Chalmers University of Technology in Sweden. I would like to thank my supervisor in Sweden, Sebastién Rauch for guidance and support throughout this project.

This report is the outcome of a Minor Field Study (MFS) through the Swedish International Development Agency (Sida). It has also been supported by Friends of Chalmers through the Ulla-Britt Bergkvist scholarship- I am very grateful for their support, enabling me to perform this project.

Göteborg June 2011

Hanna Lindfors

List of tables and figures

Abbrevisions used

ANC	African National Congress
BDS	Blue Drop System
CMA	Catchment Management Agencies
CSIR	Council for Scientific and Industrial Research
DoH	Department of Health
DWA	Department of Water Affairs
DWQ	Drinking Water Quality
DWQM	Drinking Water Quality Management framework.
E.coli	Escherichia coli
eWQMS	electronic Water Quality Management System
GDWQ	Guidelines for Drinking Water Quality
GPRS	General Packet Radio Service
H_2S	Hydrogen Sulfide
iCOMMS	Information for Community Oriented Municipal Services
MDG	Millennium Development Goal
MUG reagent	4-methylumbelliferyl-β-D-glucuronide
NHLS	National Health Laboratory Service
P/A	Presence/Absence
PCM	Phase Change Material
RDP	Reconstruction and Development Programme
SANS	South African National Standards
SALGA	South African Local Government Association
UCT	University of Cape Town
WHO	World Health Organization
WSA	Water Service Authorities

1 Introduction

This study examines the implementation of the H_2S field test kit along with a report system and its contribution to drinking water quality management in Hantam municipality, a South African rural municipality. It is performed in cooperation with the iCOMMS team of University of Cape Town who is responsible for the implementation of the Aquatest device and forms part of the international Aquatest research programme. The programme is aimed at assisting improvement of rural water supply by developing a low-cost device for water quality assessment along with a cell phone-based communication system.

1.1 Background

The importance of safe drinking-water supply is vital for human health and well-being. Several efforts have been made in recent years to increase the number of people having access to clean water in order to achieve the target 10 of Millennium Development Goal (MDG) 7. It aims at halving the proportion of the population without access to clean water between 1990 and 2015, and to ultimately achieve the vision of universal access.

Progress is being made and estimations confirm that the MDG target referring to safe drinking water is expected to be reached, but still millions of people throughout the developing world are denied access to safe drinking water *United Nations Children´s Fund (2008).* In 2008, 87 % of the world population received water from improved sources but in Sub-Saharan Africa only 60 % of the population had such access. *World Health Organization/United Nations Children´s Fund (2010).* Furthermore, it is becoming increasingly clear that even though the world is on track to meet the target in terms of sources constructed it may not be on track with regards to water quality. The microbial contamination of drinking water is a serious concern, as is the chemical contamination. Water related diseases resulting from insufficient safe water supplies and poor sanitation and hygiene cause 3.4 million deaths a year, mostly children, whereof almost 2 million as a result of diarrheal diseases. *United Nations Children´s Fund (2008)*

The emphasis in water supply has for many years been on delivery of drinking water from improved water sources. It is now time to shift the focus towards provision of safe drinking-water *World Health Organization/United Nations Children´s Fund (2010).* Additional to water provision, adequate sanitation and hygiene awareness as the precondition to reduce water born diseases regular monitoring of water quality has to be undertaken. Water quality monitoring indicates how the commitment of safe water provision is fulfilled, as well as the direct health impact enabling water suppliers to react if water shows to be of insufficient quality. Water quality monitoring is usually based on microbiological, chemical and physical test of water sample. The microbiological testing is often a challenge since it requires the use of instrumentation and/or laboratories and is usually cost and labour intensive. *Rivett U. et al (2009).* Water quality interventions have proofed to have greater impact on devastating outbreaks of diarrheal diseases than previously thought *United Nations Children´s Fund (2008)* and the need of accessing a rapid, reliable and cheap way of measuring water quality is confirmed by, for example, *World Health Organization/United Nations Children´s Fund (2010).*

The National government of South Africa is committed, since 1994 when the democratic government was established, to make progress to improve basic water service over time in line with the Reconstruction and Development Programme (RDP). The RDP programme was eventually discontinued and improvement forms now part of the Integrated Development Plans of each municipality. The primary priority is to give all its citizens access to at least basic water demand, which is considered 25 litres per person. To secure sustainability of water services the government has introduced a policy of free basic water services *Department of Water Affairs and Forestry (2003).* They have succeeded to increase the percentage of the population with access to potable water from 69% to 88% within fourteen years between 1994 and 2008 *Financial and Fiscal Commission (2009).* According to the *Human Development Report 2010*, still 9% of the population in South Africa did lack access to improved water service in 2008 *United Nations Development Programme (2010)*.

1.1.1 Rural Water Supply in Developing Countries

Inequalities worldwide are obvious when looking at the estimations above, but there are also significant disparities between the proportion of population in rural and urban areas gaining access to improved drinking water supply within countries. In South Africa inequalities also remain as a result of the apartheid policies, which promoted a differential access to economical and social resources *McIntyre D., Gibson L. (2002).* To coop with those disparities between rural versus urban areas is a currant challenge in big parts of the developing world where 94 % of the urban population uses improved sources while it is only 76% of the rural population *World Health Organization/United Nations Children´s Fund (2010).* In South Africa the gap is major, with almost twice as many gaining accesses in urban areas than in rural areas. Figure 1 below illustrates the existing disparities in access to services, including water service delivery.

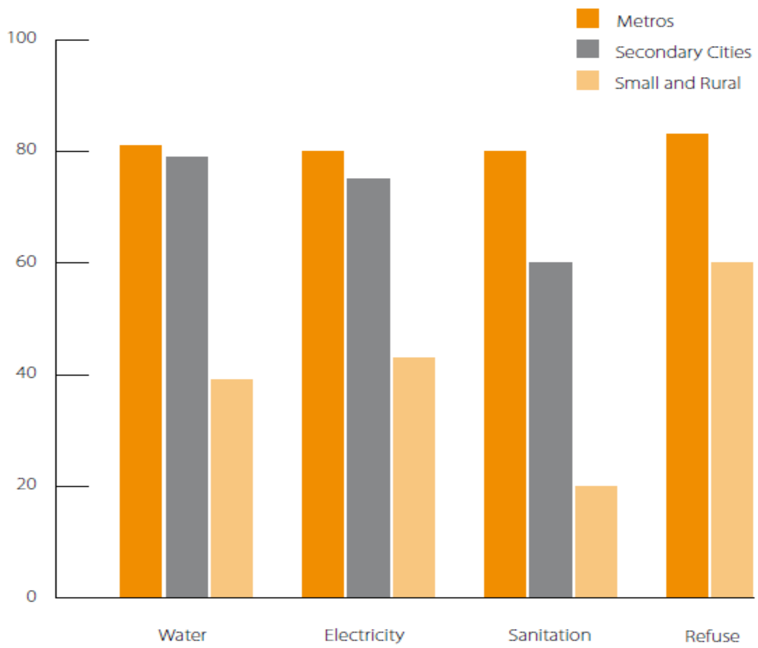


Figure 1 Representing the access to services by different type of municipalities. ***Adopted from Financial and Fiscal Commission (2009)***

As indicated by the figure, metropolitan municipalities have generally less difficulties in offering this basic provision than rural areas *Financial and Fiscal Commission (2009)*. In those remote areas water quality monitoring is as well challenging. Distances between supplies are long and connecting roads are often inadequate, the number of trained staff is often limited and distances to the closest laboratory may be long. Consequently, sampling is irregular and the cost and time factor is high. Additionally, if contamination is detected in the samples, the communities and consumers are seldom informed. *Rivett U. et al (2009)*

1.1.2 The Aquatest Programme

The Aquatest project aims at improving water quality by developing sampling and information management. The project is funded by Bill and Melinda Gates and is formed as collaboration between a number of international organizations, with the University of Bristol in the main role. The project includes the development of a low cost field kit for microbiological contamination. The device is portable, easy to use and accurately measures key water quality parameters without the need for laboratory or special training. It is developed in conjunction with a cell phone based data collection tool, which seeks to "shorten the distances" between communities and allow results to be transmitted effectively. The hypothesis is that efficiency of existing monitoring will be improved, that the reach of monitoring will be expanded and that information flow between actors will increase.

The project was initiated in 2007 and field work has been done in South Africa since, to understand the water quality information needs and the feasibility of a cell phone system. The Aquatest device is under development and will not be available for use before September 2011. The field work is thus done by using the microbiological H_2S field test kit as a substitute. The H_2S field test kit along with the Reporting system have been implemented at four different research sites in South Africa, each with different characteristics to be as representative as plausible for the diversity of the South African rural areas. It soon became clear that travel time to sample sites, transport costs and logistics to laboratory, and laboratory fees limited the performance of monitoring. Compliance monitoring, when samples are transported to laboratories for being analyzed, was shown to be undertaken very rarely in smaller towns. Operational monitoring, when basic water quality parameters are analyzed at the spot, was generally not performed at all *Rivett U. et al (2009).* Hantam Municipality, in the Northern Cape district of South Africa is where the field study is made in this thesis.

1.1.3 South Africa Background

South Africa is Africa's southern most county, covering an area of 1 220 813 sq km *Statistics South Africa (2010a)* and has a population of 49.99 million people (in mid 2010) *Statistics South Africa (2010b).* South Africa has eleven official languages; isiZulu, isiXhosa, Afrikaans, Sepedi, English, Setswana, Sesotho, Xitsonga, isiNdebele, Tshivenda and siSwati *CIA (2011).* The climate is mostly semiarid with an average rainfall of 450 mm per annum (global average is 860 mm per year) resulting in the country having relatively little water available. Water use in South Africa is dominated by irrigation for agriculture, accounting for around 62 % of all water use in the country, domestic and urban use (including water for industrial use supplied by water boards) accounting for 27 % and mining, industry and power generation accounting for 8 % and commercial forestry plantations for less than 3% *CSIR (2010)*.

The social structure of the nation is still influenced by the Apartheid policies established by the National Party gaining power in 1948. Apartheid (the state of being apart) classified every individual by race, allowing only a certain race access to specific areas or the beneficing certain rights. Blacks were prohibited from towns without permission and compelled to carry identity documents at all times. About 80 % of the country's population was restricted to Homelands covering only 14 % of the land area. The Homelands were claimed to be self-sufficient and self-governing states but in reality those areas lacked access to basic needs and had very limited possibilities for economical development. Different levels of services was one of the consequences caused by fragmented and allocated responsibility of water supply to local governments in the four provinces and ten homelands. Often, the white local government offered standards equal to those in industrialized countries. *Muller M. (2002)*

The African National Congress (ANC) succeeded power in the first democratic election in 1994 and has since then struggled to address apartheid-era imbalances in decent housing, health care and education. Despite programs, legislations and investments inequalities are still remarkable. The proportion of population below income poverty line PPP $1.25 a day is still high, namely 26.2 percent in 2008 *United Nations Development Programme (2010)*. Large areas, especially rural areas including the former Homelands, are lacking in basic provision such as safe drinking water supply. *Human Science Research Council (2009)*

Water quality and accessibility is a major concern in South Africa. Despite the fact that it is limiting development and economic growth it has caused thousands of disease outbreaks followed by hundreds of deaths during the last years. As diarrhea represents 10% of all deaths among children under five years of age, it is the third highest cause of death among children in South Africa, after HIV/Aids and low birth weight. In total, almost 2000 children die annually before they reach one month, and further 51 300 die between 29 days and five years *CSIR (2010)*. The world Health organization recognizes diarrheal diseases as the main cause of death in developing countries and it has been estimated that as many as 43 000 South Africans might die annually as a result of diarrheal diseases *Department of Water Affairs and Forestry (2002)*.

The microbial content of water is one of the primary concerns in term of its suitability for domestic use. The major sources of deteriorating microbial water quality in South Africa are human settlements, inadequate sanitation and waste removal practices, storm water wash-off and sewage spills *CSIR (2010).*

1.2 Study Objectives

The purpose of this thesis is to assess the feasibility of the H_2S test device in conjunction with the cell phone-based report system, in Hantam municipality. The system has to be coherent with national legislation and policies and possess the potential to improve the national drinking water quality management. Thus, the first part of this study constitutes an analysis of the legislation and policies of South Africa as well as a review of the current situation of the state. The place for drinking water quality monitoring and communication in this situation will be assessed.

The implementation of the H_2S field test kit and the Reporting system also has to depend on the municipal structures with which it will interact. Those structures will be assessed in the second part of this report constituting the case study in Hantam municipality. The purpose of the H_2S field test kit and the Report system at community level will be assessed, as well as the capacity of the Hantam community to manage, operate and maintain the H_2S and the Reporting system.

The final evaluation will depend on the feasibility of the system in the local context, when analyzing its contribution to drinking water quality management.

1.3 Disposition of the report

The introduction is followed by a chapter describing the methodology of the report. It includes the aims of and the method used during the case study, which variables to be analyzed and how specific municipal data is collected. The interview design is described and a short presentation of the people interviewed is provided, as well as the limitations of the study.

Then follows a review of legislations, policies and guidelines leading the water sector in South Africa. The chapter describes the roles and responsibilities within the sector and overview the development of water provision services since 1994, leading up to the current situation.

The following chapter provides information regarding drinking water quality and reviews both international and national documents that concerns safe drinking water supply. The roles and responsibilities of actors are then specified, concerning only the area of monitoring and communication. Furthermore, the national standards, specifying acceptable limits of water quality parameters are presented.

Monitoring is then described in Chapter 5 including the importance of monitoring on national as well as community level. This monitoring may take different forms depending on the context. The use of field test kit is described, whereof two kits in detail, namely the H_2S test and the Aquatest device.

The following chapter present different kinds of communication and the importance of those. Methods to simplify communication used in South Africa are reviewed and recently developed methods presented, among them the Report system developed within the Aquatest programme.

Chapter 7 provides some details on the Hantam Municipality where the Case study is conducted. Demographics, existing services, water availability and challenges regarding water service management specific for the area are described.

The following chapter covers the research findings. It describes the roles and responsibilities of actors within the municipality and the implementation of the H_2S test and Report system followed by an evaluation of its integration in the municipal structures as well as within the institutional framework.

Then, based on those findings, follows the discussion rising interesting aspects in the light of the research objectives. The affects of the system are evaluated and the suitability in different aspects are assessed. Possible sources of error that may cause uncertainties are made explicit.

Finally, in Chapter 10 the conclusions are presented. The suitability of the H_2S test and Report system is confirmed and recommendations are given, suggesting better use of the system in providing information to consumers as well as extended acceptance and use of the system in national regulations.

2 Methodology

This study will be based on literature review as well as field studies in Hantam municipality. Review of literature focusing on South Africa will make up the content of the first part. Legislations and policies will be analyzed to present an overview of the leading documents of the country as well as recent research and scientific articles discussing the current state of South Africa and its service delivery.

To comprehend the value of monitoring and communication regarding water quality, international literature will also be analyzed. Research and scientific articles will be used for the presentation of existing techniques.

The approach used in the evaluation of the H_2S and Reporting system will be one of a case study. In this part of the study data and management arrangements for the municipality are gathered in order to evaluate the feasibility of the H_2S and Reporting system in the municipal context, community awareness and communication as well as its contribution to the national drinking water quality management.

2.1 Case Study

The case study is performed in Hantam municipality, a rural South African municipality where the H_2S test and the Reporting system have been implemented. Observation studies will be performed in one of the smaller towns of Hantam municipality, where the Supply Tester will demonstrate the sampling procedure. In order to evaluate the feasibility in the municipal context the acceptance of the technology by the municipal workers involved in the research project will be evaluated. This will be done by evaluating the;

- perceived ease of use, and
- perceived usefulness

since those are considered essential to achieve sustainability of the project and offers a good indication of affect the water quality management. The evaluation is based on interviews of three Supply Testers and the Water Service Manager, as well as discussions with researchers and an interview with the head of the ICOMMS group. Both international literature and South African legislations and policies argue that;

- community awareness and
- consumer communication

are essential in good drinking water quality management. The interviews with municipal workers and statistical data about Hantam municipality will be evaluated to analyze how and if those are affected. Furthermore, in order to assess the contribution of the H_2S field test kit and Report system in the national drinking water quality management, the extension of

- monitoring and communication

due to the system will be analyzed. This is done through interviews and review of the comprehensive drinking water quality reports for the municipality, provided monthly by the UCT. The role of the H_2S field test kit and Report system in the

- Blue Drop System

will be assessed by estimating possible contributions to its various criteria. Discussions will continuously ongoing with the researchers in the ICOMMS group at University of Cape Town and interviews will be carried out with municipal workers at Water Service Authorities in Hantam Municipality.

2.1.1 Data Collection

The monthly drinking water quality reports of Hantam municipality, containing information about submitted water quality data, were obtained from staff in the iCOMMS group, at University of Cape Town on 19 May and 9 June 2011.

Statistical data about Hantam municipality was obtained on the Statistical South African web page where statistical tables can be created on municipal level.

2.1.2 Interview design

The framing of the interviews performed with municipal workers were of both informative and responsive characteristic. The informative part had the objective to obtain qualitative data about roles and responsibilities of actors within the drinking water quality monitoring and communication. Furthermore, it was to comprehend the changes in monitoring and communication between consumers and different levels of government, due to the implementation of the H_2S and Reporting system. Hence, the interviews were designed with the intention to clarify how these processes were handled before as well as after implementation.

The part of the interviews with responsive characteristic had the objective to examine the experience of the municipal workers in using the H_2S field kit and Report system. Important variables examined were the perceived ease of use, perceived usefulness and whether or not the system was experienced as time-consuming.

A semi-structured approach was used during these interviews. However, since the interviews with the Supply Testers were performed with a translator and since the time was limited, the interviews was partly of semi-structured characteristic and partly of survey characteristic to obtain the information needed.

2.1.3 Interviewees

Riaan Van Wyk is the Water Service Manager for the research project in Hantam municipality, e.g. he has the overall responsibility for the sampling programme in Hantam Municipality. He has worked with the H_2S test and reporting system with UCT since it was implemented in 2009. Riaan Van Wyk works within the local government and is the head of the Social Department of Hantam municipality. He runs the Department of Traffic, the Department of Sanitation, and the Department of Library and is also involved in Environmental Health. His office is in the municipal office situated in Calvinia.

Patrick Farmer is the Supply Tester in Loeriesfontein. It is one of the bigger towns in the area with about 3000 residents. He works as the Forman in Loeriesfontein where he has the responsibility for basic services such as water, sanitation, electricity, roads etc. He has 16 workers under him. Patrick Farmer has his office in Loeriesfontein, but we meet with him at the municipal office in Calvinia.

Sauul Maans is the Supply Tester in Middelpos. It is one of the smallest towns in the area with about 300 residents. He works as the Forman in Middelpos, where he is the only municipal worker. He is responsible for everything related to running the town such as water and waste management, money collection, cleaning streets etc, but since he sometimes cannot do everything himself he has some casual workers. Sauul Maans has his office in Loeriesfontein, where we meet.

Corrie Majied is the Supply Tester in Calvinia. It is the biggest town in the area. He works as the foreman in Calvinia. He is involved in everything related to water in the municipality. Aside from the tests he performs, he also deals with pipes breakage or new water connections etc. Corrie Majied has his office in Calvinia, in the municipal building, where we meet.

Ulrike Rivett is the head of the iCOMMS team, leading the investigation of the role of mobile phones in drinking water quality monitoring. The development of such tool is part of the Aquatest project. Ulrike Rivett is an Associate Professor in the Department of Civil Engineering at the University of Cape Town.

2.2 Limitations

The study will be based on the institutional framework of South Africa and the case study of one municipality. Thus, it is not feasible to make general statements representative for all types of rural areas, but rather comprehend this study as a specific evaluation of Hantam municipality, which hopefully can attribute to the understanding and successfully results in similar projects.

The extensions of field trips will be limited to why confounding factors external to the intervention under evaluation will be present and cannot be totally controlled. The effect of droughts, political/social instability or economic crisis that may very well vary in time will affect the study but is tried to make explicit.

In the municipal where the case study was performed, Afrikaans is the main language. One of the interviews was performed in English, and the others with a translator which might bring misinterpretations. The formation of the interview schemes and following discussions of the interviews were done in the attempt to limit those faults. It should also be considered that my appearance together with the iCOMMS group, probably resulted in the interviewees recognized me as one of the project team which may have affected their answers.

3 Water Service Delivery in South Africa

"Governments, in partnership with stakeholders, have a primary role in creating an environment that enables progressive and equitable improvements in sanitation and drinking-water services" World Health Organization (2010), page 37. An enabling framework for progress in drinking water services requires coordination among government agencies, agreements on objectives, development of policies or strategies and clearly defines roles of different actors. If those guidelines do not exist it is particularly difficult to achieve effective and efficient water service delivery *World Health Organization (2010).* The water sector in South Africa has experienced an impressive restructure in the last decades, including updated water acts, developed water policies, and restructured water resource management resulting in significant institutional changes *Turton A.R. el al (2007).* This chapter aims at offering an overview of those legislations and policies, the responsibilities of actors, and its implementation. It will be continued in Chapter 4 where the main national drinking water quality management framework, the DWQM, is presented.

3.1 Legislations and Policies

Prior to the end of Apartheid era government policies were supporting the wealth of a few, mostly whites, while leaving the big part of the population with very limited resources. Water resources were used supporting progress in the agricultural and mining sector, stimulating the county´s wealthy sector and water supplies and water-borne sewage services were distributed to the wealthy municipalities and towns. Black local authorities, on the other hand, suffered from inefficient management and lack of funding *Schreiner B., Van Koppen B. (2001).* Consequently, in 1994, when the democratic government succeeded the power, inequalities were remarkable and big areas of the country were in great need of rapid provision improvements. The political environment has changed dramatically since. In the White Paper (1994) the Government outlines the goal of Department of Water Affairs and Forestry as to end the inequity in access to basic water supply and sanitation service. The central concepts of social equity and the right to a healthy environment are now entrenched in the Constitution, adopted in 1996. It has been referred to as the model social rights constitution as it imposes responsibility on the State to make sure the rights to dignity and life is respected, including the right to access water.

The Constitution guarantees that *"Everyone has the right to have access to sufficient food and water*" (Section 27(1) (b)) and require the Government to *"take reasonable legislative and other measures, within its available resources, to achieve the progressive realization of each of these rights"* (Section 27(2)) making the Government responsible to put in place arrangement to secure access to sufficient water to meet the domestic needs of all South Africans *McDonald D.A., Pape J. (2002); Constitution of the Republic of South Africa (1996).* Several new laws and policies such as the National Water Act and White Paper on National Water Policy support these concepts.

However, while legislation and policies where updated it soon became obvious that many people were too poor to take advantage of new services. The new free basic water policy was developed as a response to this. It was introduced in 2001 and guarantees all citizens a basic amount of water free of charge *Muller M. (2008).* The Free Basic Water Provision makes the first 6000 liters per month free for all households. This amount is calculated based on a household of eight people consuming 25 liters per person and day. The water should be accessible at a maximum distance of 200 meters from each dwelling, with 98% assurance of supply at a flow rate of 10 liters per second of potable quality. *Department of Water Affairs and Forestry (2003)*

Recently, the Blue Drop System was introduced, to directly improve drinking water quality through improved performance of Water Service Authorities. It is further presented in Section 6.2 and has the objective to ensure improvements of tap water quality. *de Souza PF. et al (2009)*

3.1.1 Roles and Responsibilities

The Government of South Africa constitutes national, provincial and municipal spheres. Water management is constitutionally a national function within the Department of Water Affairs but environmental and pollution issue are partly also of provincial concern. The national and provincial governments have responsibility to assure that Water Service Authorities, located within the local government, are performing their function in providing water and support and assist them in order to doing so, see Figure 2.

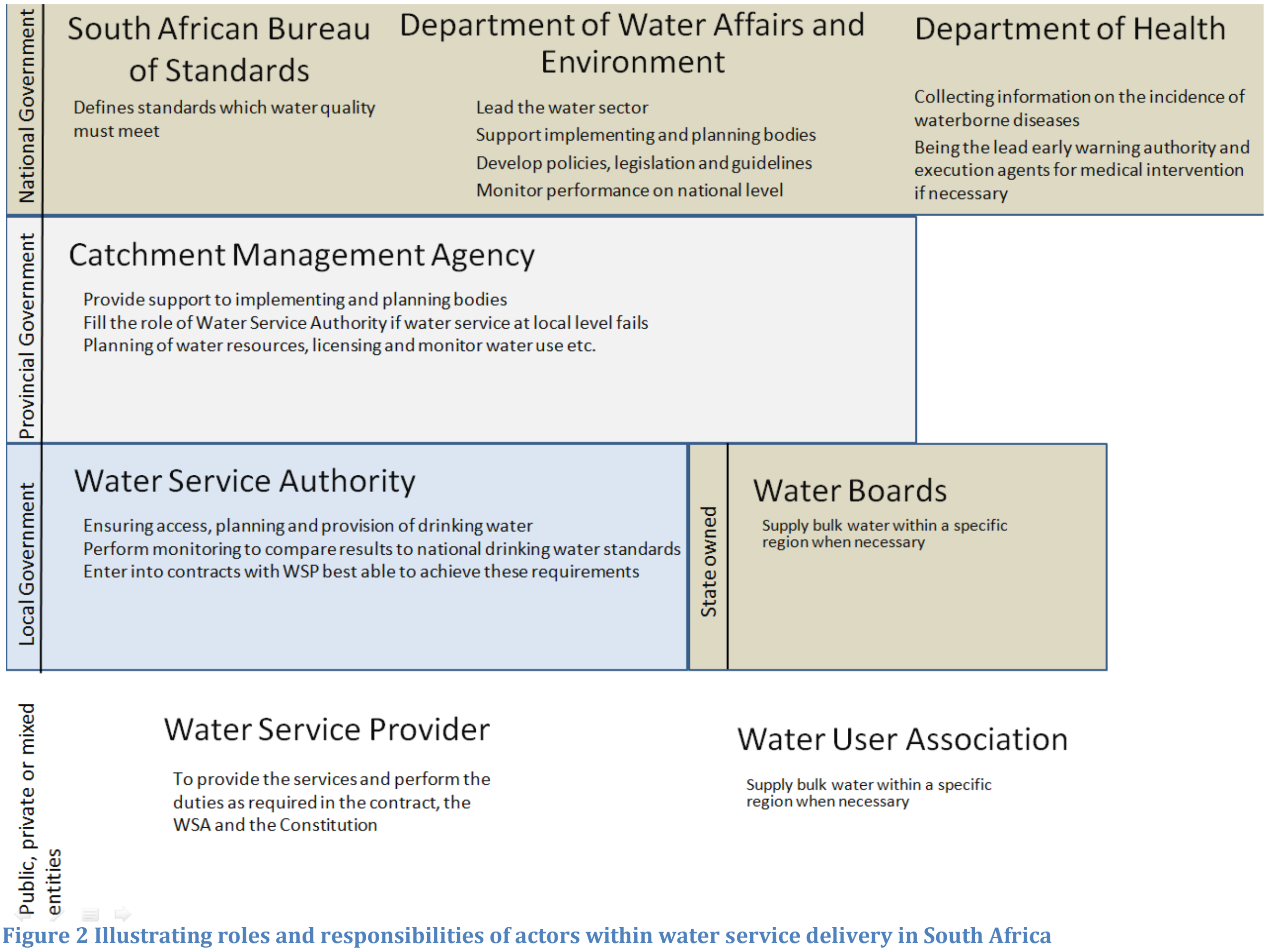


Figure 2 Illustrating roles and responsibilities of actors within water service delivery in South Africa

The Water Service Authority delegates the water service delivery to a Water Service Provider, which may be a government body, a private company or a community based organization. Those are some of the actors involved in the distinctive, interdependent and interrelated structure of water service delivery. Their respective responsibilities are further presented below, together with Department of Health, South African Bureau of Standards, Water Boards and Water User Association, all of those forming part of the institutional framework in the water sector of South Africa.

3.1.1.1 Department of Water Affairs (and SABS)

The Department of Water Affairs (DWA) is the national department with overall responsibility of water resource management and water service provision. As the leader of the water sector it aims at support and strengthens Water Service Authorities. This includes offering guidance toward effective management, monitoring performance and enable capacity building. Moreover, the DWA has a central role in regulation by monitoring the sectors performance and ensuring its effectiveness of duties. If the Water Service Authority is incapacitated to meet their standards the DWA has the right and responsibility to intervene *Department of Water Affairs and Forestry (2003).* DWAE is also responsible to update legislation and develop standards and national water policies while South African Bureau of Standards (SABS) actually defines the standards which water quality must meet *Department of Water Affairs and Forestry (1994).* Furthermore, DWAF manage information to be used for support, monitoring, regulation and planning *Department of Water Affairs and Forestry (2003).* As the leader of regulation of drinking water quality it is required to interact with all stakeholders to ensure development and effective delivery *Department of Water Affairs and Forestry (2005).*

3.1.1.2 Department of Health

The Department of Health (DoH) supports drinking water quality management by collecting information on the incidences of waterborne diseases and by being the early warning authority *Department of Water Affairs and Forestry (2005); Hodgson K., Manus L. (2006).* At district municipality and metropolitan level, it is the environmental health officers who carry out drinking water quality monitoring and assumes primary responsibility for health and hygiene education related to water and sanitation issues. In case of emergency drinking water quality conditions DoH is the execution agency for medical interventions *Hodgson K., Manus L. (2006).*

3.1.1.3 Catchment Management Agency

There are 19 Catchment Management Agencies (CMA) acting on the provincial level with shared responsibility (together with DWA) to support and strengthen local governments and regulate those to ensure effectiveness *Department of Water Affairs and Forestry (1994); Department of Water Affairs and Forestry (2003*). While the DWA has responsibility for water resource planning at international and national level, the CMA is responsible for water resource planning at catchment level, i.e. within its catchment area *National Water Act (1998).* It includes licensing and monitoring water use and discharges together with other environmental issues of significant importance in water provision since water quality and accessibility is essential factors, especially in areas where people rely on untreated water *Department of Water Affairs and Forestry (2003*). The establishment of CMAs is still very recent in most places and in areas where they have jet not been established DWA is carrying out their function *Schreiner B., Van Koppen B. (2001).*

3.1.1.4 Water Service Authorities

Provision of water is the constitutional responsibility of local governments, i.e. the Water Service Authorities (WSA) *National Water Act (1998).* The WSA operate within their area of jurisdiction that may consist of metropolitan municipalities, district municipalities or authorized local municipalities *Department of Water Affairs and Forestry (2003).* This system adopted in 2002, reduced the number of local governments from 843 to 284 whereof 6 metropolitan municipalities and 47 district municipalities (typically containing three to six local municipalities) covering the whole county. There are 231 local municipalities located within the areas of district municipalities. The local municipalities usually include two to three towns as well as surrounding rural areas. *Mackintosh GS. et al (2004)*

Beyond the responsibility of ensuring access to safe drinking water the WSA must prepare water service development plans and undertake operational monitoring. Monitoring is used to trigger immediate corrective actions to operational procedures as required and as verification monitoring to ensure that barriers and preventative measures are working effectively, see further Section 4.2 *Department of Water Affairs and Forestry (2005).* The WSAs are committed to compare results to national drinking water standards and inform consumers and appropriate authorities about health risks *Hodgson K., Manus L. (2006).* Even though the WSAs are responsible for water provision, they may not be the provider but can also contract external Water Service Providers *Department of Water Affairs and Forestry (2003).*

3.1.1.5 Water Service Providers

A Water Service Provider (WSP) is the organization that assumes operational responsibility of water provision in accordance with the Constitution, the Water Service Act and the by-laws of Water Service. The WSP may be either the WSA, a private company, a non-profit company, or a community based organization *Department of Water Affairs and Forestry (2003).* Whoever is the Water Service Provider, separation of responsibilities between the WSA and the WSP must exist *Water Service Act (1998).* The responsibility includes providing water services to or on behalf of WSAs. There are several ways of distributing the responsibility, whereof South Africa has experienced a considerable amount of outsourcing and public-private partnership *McDonald D.A., Pape J. (2002).*

3.1.1.6 Water User Associations and Water Boards

Water User Associations are an extension of the concept of self selected irrigation boards, who managed large scale irrigation schemes under the previous regime *Schreiner B., Van Koppen B. (2001).* Any user-group may form a Water User Association group with approval from the DWA. A Water Board is a state owned regional bulk supplier to more than one WSA area and retail service on behalf of WSAs *Department of Water Affairs and Forestry (2003).*

3.2 Implementation and Current Situation

While policies and legislation are fundamental to reach development, so is the capacity of the state to manage the tasks assigned by those. The politics of ANC is based on a people centered society, where participation and empowerment is encouraged *Human Science Research Council (2009).* This is valid also for water service policies and guidelines where the importance of people driven processes are claimed to be fundamental, and provision of supply in poor communities is considered likely to fail if the people themselves are not involved *Department of Water Affairs and Forestry (1994).* With this in mind, local government is viewed as the most appropriate sphere of government to carry out delivery and Water Services Authorities has been imposed a great responsibility, as they have the primary responsibility for ensuring the provision of safe drinking water *Department of Water Affairs and Forestry (2005*).

Improvements have been achieved, as discussed earlier, with an increased population served with piped water but still service delivery backlogs exist in the provision of drinking water. In Prior to 1994 it has been estimated that 30 - 40 % of the population in South Africa was without adequate water supply services. In 2008 improvements had been achieved but still 9% of the population of South Africa did lack access to improved drinking water services *United Nations Development Programme (2010).* In addition, too often the quality of drinking water actually provided is of unacceptable poor standard in many parts of non metro South Africa *Mackintosh GS. et al (2004).* The difficulty to deliver is partly caused by lack of capacity in public sector which cannot live up to the developmental challenge *Human Science Research Council (2009)*The introduction of the new municipal system and the division of powers and functions between district and local municipalities has been a major issue. *"Water challenges in South Africa are symptomatic of an emerging gap between national policies and implementation of such policies. For instance, recently the reliability and quality of water supply by municipalities has been receiving attention, with some experts warning that South Africa has serious water challenges. Some of these challenges include a lack of qualified staff and insufficient investments in water infrastructure for both capital and maintenance".* Financial and Fiscal Commission (2009)

Furthermore the management of rural areas and former homelands remains a challenge in many areas as municipalities possess enormous differences within areas essential in water delivery such as geographic, economic and human resources and capacity *Mackintosh GS. et al (2004).* According to *Hodgson K., Manus L. (2006),* reasons for failure of drinking water standards include:

- A lack of understanding by Water Services Authorities (WSAs) regarding requirements for Drinking Water Quality Management;
- Inadequate management including monitoring of drinking water services;
- Inadequate infrastructure management;
- Inadequate WSA institutional capacity (staffing, funding expertise, education), and
- Lack of interventions to address poor drinking water quality when detected.

It was with this in mind, the DWA (in December 2005) developed the Drinking Water Quality Management framework for South Africa, which is further described in Section 4.2. It confirms the requirement of commitment of all sector stakeholders and the interaction between those, to achieve successful implementation as well as the requirement of WSAs to undertake operational and compliance monitoring *Department of Water Affairs and Forestry (2005). United Nations Environment Programme (2010)* confirms that many WSAs have had troubles in undertaking the drinking water quality monitoring, management and communication. It refers to data from 2004, illustrating that less than 50 percent of WSPs in South Africa had drinking water quality monitoring programmes in place and did fail to comply with the compulsory national standards for the quality of potable water, see Section 4.3.

It is of major concern in the rural areas where the difficulty to monitor water quality and manage supply for sparse populations living over large, remote areas is limiting the delivery of safe water. Long distances to laboratories increase the costs and are time consuming for the limited number of trained staff. *Rivett U. et al (2009)* argues that tests are taken but the long intervals between testing occasions make, especially the microbiological testing inefficient. Microbiological testing requires the use of instrumentation and/or laboratories and consequently the samples needs to be collected and transported to a laboratory within 24 hours. Even where samples are taken on the basis of one month, which is the minimum requirements basis for compliance monitoring, the time between the first occurrence of contamination and the time the sample is taken and results analyzed can be long and short term peaks in pathogen concentration are impossible to note. If contamination would be detected in the sample, users have to be informed and action has to be taken, but sadly this is rarely prioritized. Results may delay weeks or even months, and in some cases contamination is only identified when an increase in water related diseases is identified. *Rivett U. et al (2009)*

Due to programmes introduces by government, *United Nations Environment Programme (2010)* states that in 2009, 100 percent of the municipal authorities had water quality monitoring programmes in place though only 18 out of over 150 municipalities were awarded the Blue Drop status *United Nations Environment Programme (2010)*. In contrary according to the DWA´s estimations, as much as 30% of the consumers served by water supplies are not covered by the sampling programme. Reasons for the exclusion of these supplies include:

- Resource constraints at municipality level;
- Remoteness of communities;
- Cost of the sampling programme, and
- Distance from laboratories. *Rivett U. et al (2009)*

4 Institutional Framework for Drinking Water Quality

An enabling framework for progress in drinking water services requires coordination among government agencies, agreements on objectives, development of policies or strategies and clearly defines roles of different actors. If those guidelines do not exist it is difficult to achieve effective and efficient water service delivery *World Health Organization (2008).* The main international guideline for safe drinking water quality is the Guidelines for Drinking Water Quality (GDWQ), which most countries consider together with standards, set in other countries *United Nations Children´s Fund (2008).* The key policy in South Africa, with regard to drinking water quality, is the Drinking Water Quality Management framework.

4.1 International Guidelines for Drinking Water Quality

The GDWQ states that "*The basic and essential requirements to ensure the safety of drinking-water are a "framework " for safe drinking –water, comprising health-based targets established by a competent health authority; adequate and properly managed systems (adequate infrastructure, proper monitoring and effective planning and management); and a system of independent surveillance" World Health Organization (2008).* The GDWQ refers to the Water Safety Plans as the most effective mean to create the framework ensuring the safety of a drinking water. *World Health Organization (2008)*

4.1.1 Water Safety Plans

The Water Safety Plans (WSP) for a specific supply should be developed as appropriate for the situation to obtain its primary objectives:

- Minimize contamination of source waters;
- Reduce contamination concentration through treatment processes, and
- Prevent contamination during storage distribution and handling of drinking water.

The best way to achieve these goals are to evaluate all steps from catchment to consumer by using three main components; system assessment to develop a comprehensive understanding of the drinking water supply system involved, the risk of hazards that may be present, the ability of the processes and the infrastructure available to manage this risk; operational monitoring to ensure health based target to be met and to enable effective system; and management in order to ensure efficient water delivery *World Health Organization (2008)*. The GDWQ offers a scientific approach on how safe drinking water is provided with the aim to support national authorities to develop drinking water regulations and standards. It should not be interpreted as mandatory universal standards, rather as an aid in developing risk management strategies in the context of local or national environmental, social, economical and cultural conditions *United Nations Children´s Fund (2008).* It is up to each country to review its needs and capacities of the government, the technology available and the society when developing the regulatory framework *World Health Organization (2008).*

4.2 Drinking Water Quality Management Framework for South Africa

The Drinking water quality management framework (DWQM) is the lead policy of drinking water quality in South Africa. It does as well include the three components from the WSP but is more adapted to the national situation. The South African DWQM also stresses the importance of understanding the entire water supply system, the assessment of hazardous evens, implementation of preventative measures and operational controls, as do the GDWQ. The key components in the Drinking Water Quality Framework for South Africa are;

- Commitment to Drinking water quality management and multi-stakeholder involvement
- System analysis and management
- Supporting programmes
- Review and audit

Commitment by relevant all stakeholders and a well-developed collaboration between those is prerequisite to achieve successful implementation of DWQM. Awareness and understanding of the importance of the framework and how associated decisions and actions affect public health should built this commitment. The lead institution, Department of Water Affairs, should provide sector leadership, interact with all key stakeholders and ensure clear definitions of their roles and responsibilities. *Department of Water Affairs and Forestry (2005)*

System analysis and management includes the supply system analysis which aims at developing a comprehensive understanding of the drinking water supply system involved, the risk of hazards that may be present, the ability of the processes and the infrastructure available to manage this risk, as do the guidelines of GDWQ. The collection and evaluation of relevant water quality data will assist in understanding the source. It requires data concerning pathogen and chemicals occurrences in the source water as well as effectiveness of existing controls. Information which, if monitoring is performed and assessed, would assist in the understanding of source water characteristics and drinking water system performance both over time and following specific events such as flooding. *Department of Water Affairs and Forestry (2005); World Health Organization (2008)*

Preventative strategies are highlighted and defined as actions and activities required to eliminating or reducing likelihood or level of hazards and impacts, usually by using multiple protection barriers. An essential part to ensure good water quality is proper maintenance and operation of water supply. It includes operational monitoring to assess the performance of each control measure at appropriate time intervals to ensure health based target to be met and to enable effective system management. The operational monitoring is used as a trigger for immediate corrective actions and verification to ensure that the implemented barriers function effectively. *Department of Water Affairs and Forestry (2005)*

In addition to the operational monitoring, verification or compliance monitoring is performed to ensure the operating safety of the system as a whole. It includes testing for faecal indicator organisms and hazardous chemicals in treated water or water in distribution (Indicator organisms are used in order to reflect the likelihood of having pathogens present and should be relatively easy to detect and should be present whenever pathogens are present). The samples are transferred to an accredited laboratory where they are analyzed. The frequency is usually based on population served or volume of water supply but should also reflect the benefits and costs of obtaining information, see further Section 4.3. *Department of Water Affairs and Forestry (2005)*

Supporting programmes are referred to as the actions that are important in ensuring drinking water safety, but do not directly affect drinking water quality, as stakeholder's awareness and training. Personnel must be appropriate trained and skilled to make informed decisions and community's involvement and awareness have major impact on public confidence in water service. Documentation and reporting provides the foundation for the establishment and maintenance of an effective DWQM system and is required for effective communication between stakeholders and within organizations. Both the internal and external communication is important to ensure information is available when informed decisions are taken about the management or regulation of drinking water quality. *Department of Water Affairs and Forestry (2005)*

Review and audit of drinking water quality data and management is necessary to identify emerging problems and trends, in order to take effective decisions and implement appropriate preventative strategies. Systematic audits such as drinking water quality compliance audits or customer services audits should be undertaken and followed by evaluation of those. It enables assessment of overall performance to compare with numerical guideline values, regulatory requirements and agreed levels of service. This surveillance of the water systems and water providers, ensure the consistent safety and acceptability of national drinking water supplies. *Department of Water Affairs and Forestry (2005)*

4.2.1 Roles and Responsibilities in Monitoring and Reporting

As presented in Chapter 3 several policies and legislations have been created to direct the efforts in water service delivery and to define the roles of different actors. In the context of monitoring and reporting, the DWA is the lead institution for the regulation of drinking water quality and has the responsibility to ensure that monitoring and surveillance is performed *National water Act (1998)*. The DWAF is also required to manage information, including a database and information sharing system covering water quality data and ensure the availability of technical, economical and human resources to enable proper usage *Department of Water Affairs and Forestry (2005)*.

The responsibilities of the Department of Health regarding monitoring include the development of national health-related key performance indicators and targets on the national level. On provincial level its role includes drinking water quality monitoring and reporting, collection of information on the incidence of waterborne diseases and being the lead agency in drinking water quality emergencies. DoH also acts at the District Municipality and Metropolian level to perform drinking water quality monitoring at point-of-use, with focus on health risk related constituents, both where communities are served with potable water and where they are not. *Department of Water Affairs and Forestry (2005)*

The CMAs provide the DWA with the information regarding water usage and water resource quality while the WSAs provide the department with information regarding water service delivery. Thus, the overall responsibility of monitoring water service delivery and ensure that drinking water quality standards and norms are met, is the WSAs. They are legally required to carry out compliance monitoring of drinking-water quality on a monthly basis *Mackintosh GS. et al (2004).* As described in Compulsory National Standards for the quality of potable water published in Government Gazette No 22355 in 2001, WSAs have a defined responsibility to:

1) *Within two years of the promulgation of these Regulations, a water services authority must include a suitable programme for sampling the quality of potable water provided to consumers in its water services development plan.*

2) *The water quality sampling programme contemplated in subregulation (1) must specify the points at which potable water provided to consumers will be sampled, the frequency of sampling and for which substances and determinants the water will be tested.*

3) *A water services institution must compare the results obtained from the testing of the samples with SABS 241: Specification for Drinking Water, or the South African Water Quality Guidelines published by DWAF.*

4) *Should the comparison of the results as contemplated in subregulation (3) indicate that the water supplied poses a health risk, the water services institution must inform the Director-General of the Department of Water Affairs and Forestry and the head of the relevant Provincial Department of Health and it must take steps to inform its consumers:*

   a) that the quality of the water that it supplies poses a health risk;
   b) of the reasons for the health risk;
   c) of any precautions to be taken by the consumers; and
   d) of the time frame, if any, within which it may be expected that water of a safe quality will be provided.

In areas where communities are yet not served with potable water it is within the responsibility, to provide services to all consumers, of the WSAs to identify and classify communities, assess fitness of available raw water sources and implement required interventions *Department of Water Affairs and Forestry (2005).* While non-compliance is not criminalized, it is an offence under the act to refuse to provide information about water quality to consumers or regulator, or to provide misleading information *Mackintosh GS. et al (2004).*

4.3 South African National Standards (SANS) 241

In South Africa the acceptable limit for drinking water quality parameters is specified in the South African National Standards 241 Drinking Water Specification. SANS 241 provides guideline levels for a range of water quality characteristics and summarizes the suitability of drinking water as two different classes. Class I is the objective of most WSAs and WSPs. It corresponds to water quality characteristics of acceptable levels for lifetime consumption and does not pose significant risks to health either for babies and infants, the immune-compromised or the elderly. Class II refers to water quality characteristics of maximum allowable levels for short term consumption *Department of Water Affairs and Forestry (2005; Standards South*

Africa (2006). SANS 241 includes microbiological safety requirements as well as physical, organoleptic and chemical requirements. *Standards South Africa (2006)*

These constituents are typically tested for during compliance monitoring in the treated water or water in distribution, as discussed in Section 4.2. The samples are collected at predefined spots and transferred to an accredited laboratory where they are analyzed. Table 1 specifies the recommended minimum frequency of sampling.

Table 1 Suggested minimum frequency of sampling depending on population size supplied. *Standards South Africa (2006)*

Suggested minimum frequency of sampling according to SANS 241	
Population	**Frequency**
Less than 2 500	1 every month
2 500 - 10 000	2 every month
10 001 - 25 000	3 every month
25 001 - 100 000	10 every month
More than 100 000	10 every month per 10 000 of population served

However, it is also stated that on SANS 241 that it is not practicable to prescribe a frequency without taking into consideration all the variables associated with a water supply, such as climatic, human and industrial activities, population served or volume of water supply, benefits and costs of obtaining information etc. *Standards South Africa (2006)*. Thus the absolute minimum of compliance monitoring is determined to once a month *Rivett U. et al (2009).*

5 Monitoring

Water quality monitoring is the routine and systematic inspection and testing of water supply systems *United Nations Children´s Fund (2008).* The data collected provides information about water as essential as water itself according to the United Nations World Water Assessment Programme. The data is used in the daily operations of water supplies and informs about failures. It is the basis of water democracy as it enables citizens to access this vital information for public health and safety and because it reduces ignorance and uncertainty, creating a transparency making institutions more accountable for their actions *United Nations Educational, Scientific and Cultural Organization (2009).* Drinking water quality monitoring is also necessary in that poor drinking water quality has a direct impact on the health of the community as it entails an assessment of the safety of the source including chemical and microbiological quality as well as risk assessment and risk management information *World Health Organization (2008).*

It is essential to transfer those data into national accounts in order to attribute to development of relevant policies and appropriate decision-making regarding resource allocation and supply improvements such as where efforts should be directed or what type of infrastructure is more appropriate. As important is that information of the performance of national water sector and services is evaluated and progress, towards for example the MDGs, is estimated. *United Nations Educational, Scientific and Cultural Organization (2009)* At national level the DWQM framework and SANS 241 defines targets and develop plans to achieve these targets by the means of implementing actions, monitoring actions and evaluation of progress. In this framework, monitoring is the verification that goals are met or progress is being done. This data attributes the evaluation of actions taken and should be used in future processes towards safe drinking water. *World Health Organization (2010)*

The capacity of governments to monitor and evaluate performance differs widely among countries in the developing world, with several countries missing even annual reviews *United Nations Educational, Scientific and Cultural Organization (2009)*. It is in this context an easy accessed monitoring technical advice and an enabling communication tool would be necessary. Reaching the government and the society as well as it would offer information that society and government can communicate with each other. In this chapter the importance and potential of water quality monitoring, with the focus on operational monitoring will be discussed.

5.1 Water Quality Monitoring at Community Level

Water supplies in poor and rural communities worldwide are not only more frequently contaminated than larger drinking-water supplies but the residents also tend to have low awareness levels of the importance of water quality *World Health Organization (2008); United Nations Children´s Fund (2008).* A test device and report system may attribute to improved safety, in having the role of extending the reach of operational monitoring systems to poor and rural areas and increasing the awareness in those areas.

In piped systems water quality monitoring involves analysis of parameters related to both the quality of the water, including the quality of water in the intake and the efficiency of the system by measuring for example levels of chlorine in the water. The key purpose is to create awareness of existing problems, and correct them by appropriate measures before unsafe water is delivered to consumers.

In point sources, on the other hand (including both community and household system) monitoring is often limited to sanitary inspections of water quality control measures such as rooftop rainwater harvesting filters. *United Nations Children´s Fund (2008).* GDWQ confirms that in the case of non-piped, community and household system where community sources such as boreholes, wells and springs are used, treatment is rarely practiced and that monitoring of water sources would typically involve periodic sanitary inspections in the form of pictorial inspections performed by community operators or households. The GDWQ states that also physical assessment of water should be performed, especially in case of heavy rains in order to detect obvious changes such as changes in colour or turbidity. Efforts should be directed to hygiene education programmes since the households have to transfer and manage the water in a safe manner. Direct analysis of water quality is however recommended and may be performed by the use of field instruments. *World Health Organization (2008)*

Sampling and analysis are required more frequently for microbial constituents than for chemical constituents since brief episodes of microbial occurrence can cause illness in consumer, while variations in chemical concentration on the other hand are very rare and would normally not occur in the absence of a specific event *World Health Organization (2008).* Microbial constituents will be in focus in this section but it should not be forgotten that chemical contamination can be of major health concern. Physical quality of water (e.g. colour and taste) must also be considered as it affects the perceptions of consumers and may contribute to the use of a less safe source. Radioactivity may also be a threat in drinking water contaminated from natural sources or human-made nuclear materials. *United Nations Children´s Fund (2008)*

When verifying the microbial quality of drinking water, potential variations of locations and times of increased likelihood of occurrence should be taken into account. Since microbial contamination is likely to vary throughout the distribution system it can be difficult to detect its occurrence. Chances of detection of faecel bacteria, in a system reporting predominantly negative results, can be increased by using more frequent presens/absens (P/A) testing, further discussed in Section 5.2.1 regarding the H_2S test. *World Health Organization (2008)*

5.1.1 Microorganisms

The most serious public health risk associated with drinking-water supplies is microbial contamination. The microbial constituents, pathogens, which cause diseases in humans may be classified in three major groups; Bacteria, Viruses and Parasites. Bacteria are single-celled organisms, viruses are much smaller than bacteria and constitutes protein-coated genetic material lacking many cell structures. Parasites are single-celled organisms that exist in two main types, protozoa and helminthes. Parasites invade the intestinal of their hosts. *United Nations Children´s Fund (2008)*

Because it is impossible to test for all possible pathogens these test normally use indicator organisms to test for the likelihood of having pathogens present *World Health Organization (2008).* Of special concern is human and animal faeces which is the major contributor to diarrheal diseases, causing the deaths of millions of children every day. It is thus more practical to test for indicator species present in faecal matter. The one most commonly used are thermotolerant coliforms or faecal coliforms, which are the types of coliform bacteria most closely associated with faecal pollution. The most specific indicator of faecal contamination is Escherichia coli (*E.coli*), which is a subset of the total coliform group, almost always of fecal origin and which never multiplies in the aquatic environment *United Nations Children´s Fund (2008).*

In DWQM it is recommended to test for *E.coli* but also for total colifoms as an evaluation of the treatment process, microbial growth in the distribution system or post-treatment contamination of drinking water. Turbidity should be measured along with coliforms, since pathogens can adsorb onto suspended particles, and to some extent be shielded from disinfection. The water treatment residual chemicals and disinfectants are as well important to measure after the treatment. If for example chlorination is used as disinfectant, free chlorine residual should be tested for or if aluminium sulphate dosing is used, aluminium should be tested for *Department of Water Affairs and Forestry (2005).* These four parameters

- *E.coli*/faecal coliforms (and total coliform, according to DWQM);
- Turbidity;
- Disinfectant residual, and
- pH

are considered the minimum set of "essential parameters" which are required to assess microbiological quality of drinking water *World Health Organization (2008); Department of Water Affairs and Forestry (2005).* (SANS 241 refers to *E.coli* as the preferred faecal indicator, and to Thermotolerant (faecal) coliform bacteria as an indicator of unacceptable microbial water quality that can be used instead of *E.coli*, but is not the preferred indicator of faecal pollution). As discussed in Section 4.1 operational monitoring is used to assess the performance of each control measure but in communities without water treatment works, the control measures normally constitute chlorination if anything at all. Operational monitoring then constitutes the testing of those four parameters. Normally the water is then analyzed before and after chlorination[1]

5.2 Field kits for Monitoring Drinking Water Quality

In most developing countries the water quality monitoring and surveillance is inadequate to test all drinking water resources regularly as a results of limited or no access to laboratory facilities, widely spread water sources and lack of trained personnel. But microbial and chemical testing can be done on-site using field kits. While laboratory analysis normally is required for identification of specific pathogens (e.g. *E.coli*, viruses, protozoa) or non-coliform indicator species (e.g. faecal streptococci), total and feacal coliforms can be measured in field using a field kit. Field kits are simpler, but however very useful, as stated in the *World Health Organization (2008) (page 72)*; *"more frequent examination by simpler method is more valuable than less frequent examination by a complex test or series of tests".* Field kits are the preferred method according to *United Nations Children´s Fund (2008)* as it is *"logistically much easier, and in most cases significantly more cost*

[1] Ulrike Rivett, ICOMMS, University of Cape Town, 2011

effective. In addition, errors introduces from the preservation, transport and storage of samples for laboratory testing are eliminated". When testing rural water supply systems routine field-testing may also very well be the only practical option.

In recent years technological innovations within the field have improved the quality of tests and costs has decreased. This is done along with the trend many countries, including South Africa, do experience towards decentralization of government services and of water system management. To success with the implementation and to reach sustainability these technologies must be technically effective and applicable, affordable, easy to use and socially acceptable. The H_2S is already in use in many parts of the world while the Aquatest device is developed in this time of writing and estimated to be ready for use in September 2011 *University of Bristol (2011).*

5.2.1 Hydrogen Sulfide (H_2S) testing

The H_2S test is a test detecting microbial activity in drinking water. While not as accurate as laboratory tests, it provides qualitative information indicating whether or not sources are likely to be contaminated with faecal bacteria. It can be used in the field without skilled personnel in place and is less expensive than conventional bacteriological tests. The H_2S rapid field test was developed in 1982 and has been modified in attempt to improve its performance. Prepared vials are filled with sample water and a powder medium is added to detect the presence of H_2S producing bacteria. It is placed in a location with a constant temperature of 25-35 °C for 24-48 hours, and if an incubator is available the sample should be incubated at about 30 °C for 24-48 hours. *Hach Company (2007)*

If the sample does contain H_2S-producing bacteria a black precipitate, iron sulfide, is produced as a result of the reaction between the H_2S gas and iron in the media *Tambekar D.H. et al (2007).* A large number of bacteria can cause H_2S production, e.g. Citrobacter, Enterobacter, Salmonella, Clostridium perfringens, most of which are faecal in origin *United Nations Children´s Fund (2008).* Thus, it indicates the presence of faecal contamination, without specifically test for the standard indicators. However, since several kinds of non-pathogenic bacteria also may create hydrogen sulfide it can lead to false-positives.

The method has been applied as in present/absence (P/A), most probable number, and membrane filter formats. Most common is, that result takes the form of present/absence e.g. whether or not any H_2S -producing bacteria does exist in the sample, but giving no quantitative result indicating the concentration of bacteria. P/A tests can be simpler, faster and less expensive than quantitative methods *World Health Organization (2008).*

5.2.2 Aquatest device

The Aquatest field kit is under development and expected to be ready for use in September 2011. It is easy to use, it accurately measures key water quality parameters to detect microbiological contamination without the need for laboratory or special training and it is supposed to be available at a relatively cheap price. It is a single-use kit containing a device where 100 ml of water is collected, see Figure 3. A growth medium is released into the water when rotating the device. As it is mixed the sample segregates into district chambers of the device. It is placed in an incubator for 24 hours with ideal condition of *E.coli* growth. The temperature is 37 degrees, if higher; the bacteria might die and if too low; the growth will be slow. The colour of chambers will change depending on the level of *E.coli* contamination. This colour change happens by the use of an industry standard MUG reagent (4-methylumbelliferyl-β-D-glucuronide *Hach Company (1993)*), which fluoresces under UV light in the presence of *E. coli*. *University of Bristol (2011)*

Figure 3 Showing the Aquatest device. ***Adopted from University of Bristol (2011).***

The incubator, also developed within the project, works without electricity, which makes it accessible for a larger user group, especially in rural areas where reliable electricity supplies are rarely available. By addition of boiling water a phase change material (PCM) melts, and as it solidifies it releases energy at a constant temperature just above body temperature. The temperature is remained in the well-insulated container throughout an incubation cycle. Thus, it prevents the sample from being overheated even though the ambient temperature would be above 37C, which very few conventional incubators can do. It is potable and reusable device with a cost around $20. Conventional incubators may however also be used where available. *University of Bristol (2010)*

After incubation, the quality of the water can be estimated by the presence of fluorescence in the chambers. The more chambers that fluoresce indicate greater *E.coli* contamination. Thus the test will go beyond the P/A testing to provide basic enumeration. It can be important as the knowledge of relative contamination of different sources may improve water management. Once the result has been recorded a disinfectant will be released in the sample to eradicate any microorganisms, thus enabling safe disposal of the device. *University of Bristol (2011)*

6 Communication

Information and communication technologies in developing countries have big importance in monitoring and facilitating progress towards developments goals. It has the potential of improving communication between water supply caretakers based in communities and the responsible WSA, supporting water supply caretakers so that they are able to carry out operational monitoring themselves. It enables the collection of reliable and up to date information about the water quality supplied to consumers keeping WSAs better informed about the current water quality in the area they serve. Efficiency of existing monitoring can be improved while also extending the reach of the monitoring programme. Furthermore, information may also be made available for the communities requiring information about the safety of their drinking water. *Rivett U. et al (2009)*

Making monitoring information more easily available for stakeholders, may attribute both internally in daily operation and maintenance of water supply projects, and externally by organizations that regulate, support and evaluate the supply. There are several ways this communication may take form. The Reporting system presented in Section 6.3 is a cell phone based communication system that has the purpose of acting internally, within the daily operation. By doing so it may as well affect the externally communication. In South Africa the eWQMS and the Blue Drop System are widely used in the communication on the national level. Those systems are based on making the WSAs submit information on a data server.

6.1 Electronic Water Quality Management System

The electronic Water Quality Management System (eWQMS) is a water quality information system developed by Emanti Management in collaboration with DWAF and South African Local Government Association (SALGA). The eWQMS is a novel open source software based system, which is accessible via the internet and allows participating parties to guide the tracking, reviewing and improving water quality. The eWQMS has been established at all WSAs in South Africa, and is provided continuously with water quality data. It is used to improve water quality management, as it provides information to support Water Service Authorities as well as it meets the needs of the DWA to monitor and regulate the operation of WSAs. Data can also be transferred through eWQMS to the Blue Drop System. *de Souza PF. et al (2009)*

6.2 The Blue Drop System

In 2005, the Drinking Water Quality Regulation programme was initiated by the DWA. It required microbial and chemical water quality testing to compare with the standards. This programme, later developed to become the Blue Drop System, had the objective to ensure improvements of tap water quality through improved performance of Water Service Authorities. *de Souza PF. et al (2009)*

Since the introduction of this regulation the monitoring performance per legislative requirements increased from 50% in 2006 to 100% in 2008 but still the public confidence in water quality didn't increase. As a way to increase the awareness of the public about drinking water quality the Blue Drop Certification programme was commenced in 2008. It aims at creating a transparency in drinking water quality management by awarding Water Service Authorities with Blue Drop Status if they are compliant with drinking water legislative and best practices requirements *Department of Water Affairs and Forestry (2010).* In that way it allows consumers to drink the water with confidence.

The system is built on an incentive-based regulation stimulating a process of sustainable improvements. The specific criteria taken into account when evaluating the Water Service Authorities concerns; water safety plans, process control, efficiency of monitoring programme, credibility of sample analysis, submission of results to DWA, compliance with SANS 241, failure response management, responsible publication of performance and efficacy of basic DWQ asset management. The criteria and the related requirements for each of them are listed in Table 2. The criteria as well as the requirements are weighted differently depending on their relevance or importance.

Table 2 Requirements for the Blue Drop System used in National Water Service Management *(De Department of Water Affairs and Forestry (2010)*

Criteria (& weighting)	Requirements (& secondary weighting)
Water Safety Plan (5%)	1. A Risk Assessment (on the basis of Water Safety Plan concept) must have been done, covering all areas of responsibility (from catchment to consumer) (30%) 2. The water Safety Plan must detail roles and responsibilities, deadlines for management activities, and 3. Management´s commitment to fund implementation (30%) 4. Proof had to be presented on how findings of the Risk Assessment influenced the monitoring programme. 5. It must also indicate plans for security improvement (40%)
Process Control and Maintenance Competency (10%)	1. Treatment works complying with Regulation 2834 of water Act. In terms of Classification and Registration (20%) 2. Process Controllers complies with skills requirements of Regulation 2834 of Water Act (40%) 3. Availability of skilled maintenance skills (10%) 4. Operations and Maintenance manual is in place (30%)
Efficiency of Drinking Water Quality Monitoring Programme (15%)	1. Operational monitoring efficiency (20%) 2. Compliance monitoring efficiency (40%) 3. Adequate monitoring coverage or distribution network (20%) 4. Number of key analyses (e.g. *E.coli*) per population served (regulatory yardstick is a minimum of 1:10 000) (20%)
Credibility of Drinking Water Sample Analysis (5%)	1. Proof to be provided of the laboratory used (10%) 2. Laboratory is either accredited or participates in an accredited Proficiency Scheme (obtaining an acceptable Z-score) (50%) 3. Proof that analysis result are used to improve process controlling (30%) 4. DWQ Data is fully verifiable on the Blue Drop System (BDS) (10%)
Regular Submission of Drinking Water Quality Results to DWA (5%)	1. Results must be submitted 12 months a year (100%)
Drinking Water Compliance with the South African National Standard (SANS 241) (30%)	1. Provide adequate figures/information on monitoring data for compliance calculation (20%) 2. Complies with more than 99% of key micro bacteriological limits and more than 95% of key chemical limits (80%)
Drinking Water Quality Failure Response Management (15%)	1. Proof provided of a Drinking Water Incident Management Protocol (45%) 2. Proof of Implementation - DWQ Failure Incident register (55%)
Responsible Publication of DWQ Management Performance	1. Annual Publication of DWQ Management performance (50%) 2. Evidence to be provided that wider audiences reached through the communication means (50%)
Efficacy of basic DWQ Asset Management (10%)	1. An annual Process Audit done on treatment works (20%) 2. An update Asset Register to be in place (30%) 3. Treatment works operations should not exceed design capacity (20%) 4. Operations budget should make provision for Maintenance (30%)

Depending on how well a certain Water Service Authority fulfill each of the requirements of a specific criteria they are classified in groups represented by a letter and a percentage, as is shown in Table 3, Chapter 7, Section 7.1. Water Service Providers who are at or above 95 percent compliance with standards get awarded a Blue Drop Status, which ensures that the municipality is *"Managing Drinking Water Quality with Excellence: Compliance with this scoring category implies that the specific water supply system qualifies for Blue Drop Certification. If sufficient information is available to support the scoring, Blue Drop acknowledgement will be issued. This would imply that DWA has confidence that the water services institutions (municipality) is capable of sustaining safe quality of water supply and will act responsibly when deviation in tap water quality is detected (which might pose a health risk) through continuous efficient operational and compliance monitoring."*. Department of Water Affairs and Forestry (2010)

6.3 The Reporting System

The development of a report system, as part of the Aquatest programme, is taking place in South Africa. It aims at supporting management of resources within water quality monitoring. In South Africa, the H_2S test along with the reporting system has been implemented in four different areas of diverse characteristics. By doing so the iCOMMS team at UCT has enabled a user-based development of the reporting system, a system aimed to function in the major parts of rural South Africa. Due to the diverse nature, the many cultures and the dissimilarity that often exist between communities the system had to be adaptable in all those different occasions. The result came to be, a cell phone based system where a Supply Tester report water quality by complete a form on his cell phone. The form is sent to a data server where information is stored and an alert SMS is sent to the manager if a sample turns out to be non-compliant *Rivett U. et al (2009.)* See Figure 4 for an illustrative explanation of the process.

The Supply Tester is equipped with a cell phone application on his/her phone where data input is entered regarding the water quality. The application forms are designed depending on each municipality thus requiring data the municipal Water Service Manager considers necessarily. They normally include electrical conductivity, turbidity, pH, free chlorine and the H_2S result[2]. After samples are taken and analyzed the Supply Tester transfer the results to the reporter form by answering questions like "what was the reading for turbidity?" and "Where was the sample taken?". *University of Cape Town (n.d.)*

In the initial stadium of the project the data was sent via GPRS or SMS to a Message Manager who performed basic verification and data integrity checking before storing it in the database. Both the Supply Tester and the person responsible for water quality monitoring in the WSA, the Water Service Manager, receives confirmation SMSs. If the result turns out to be outside of acceptable operational parameters an alert SMS was sent to both the Supply Tester and the Water Service Manager. *University of Cape Town (n.d.)*

Recent development of the system has included a Water Quality Manager-application to clarify results from Supply Testers and simplify the role of managers. Data is sent

[2] Ulrike Rivett, iCOMMS team, University of Cape Town

from the Supply Testers and automaticity transferred to a server which the Water Quality Managers access via their phones. All managers will be provided with an android, touch screen, cell phone required for the application at latest in May 2011. Android phones are unique as they have an operating system allowing open source development, which means that basically anyone can create applications. The application developed by the iCOMMS team at UCT is now used by the Water Quality Managers and available at the Android Market for anyone to download to her phone.[3,4]

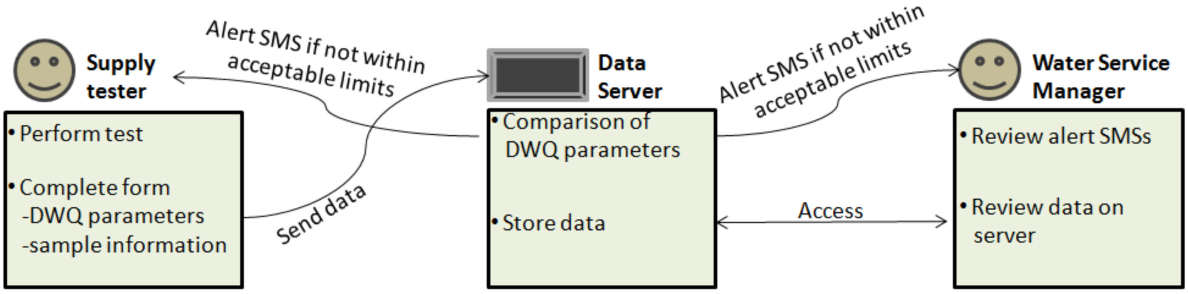


Figure 4 Illustrating the communication between the Supply Testers and the Water Service Manager enabled by the use of the Report system.

The Water Service Managers will then not receive SMSs every time a sample is recorded but only when water quality parameters are not within the acceptable range. Water quality parameters are automatically compared with the levels in SANS 241, to assure that they stay within the acceptable interval. The quality of the water is presented to the manager as the level of each parameter, the altogether compliance as well as a representative colour showing the status of the water quality. All data is stored in the server and historical data is easily accessed in form of a calendar or on a map showing the location and status of sampling points. The server is accessible on the phone as well as on computers.[5]

The UCT iCOMMS team provides the municipalities with monthly reports. The monthly report contains the results over an entire month and offers an overview of the drinking water quality during that time. The monthly report is accessed on Internet but will now also be available using the phone.[6]

[3] Ulrike Rivett, iCOMMS team, University of Cape Town
[4] Michael Champanis, iCOMMS team, University of Cape Town
[5] Ulrike Rivett, iCOMMS team, University of Cape Town
[6] Ulrike Rivett, iCOMMS team, University of Cape Town

7 Case Study in Hantam Municipality – South Africa

The first municipality to participate as research site for the Aquatest programme in South Africa was Hantam Municipality. Hantam Municipality is also where the field study for this thesis takes place. The methodology used in the case study was presented in Chapter 2. In Section 7.1 the situation in Hantam Municipality and it surrounding will be presented, before studying the water service delivery in Hantam Municipality more closely.

7.1 Area Specific Information

Hantam Municipality is situated the Northern Cape (see Figure 5), the largest and most sparsely populated province in South Africa. The Northern Cape covers an area of 372 889 sq kilometer and has a population of 1 104 000 citizens (in 2010), responding to only 2.2 percent of the South African population. The population density is about 3 persons per sq kilometer. The unemployment rate in Northern Cape is high, 24.3%, which is similar to the National unemployment. *Statistics South Africa (2010a); Statistics South Africa (2010b)*

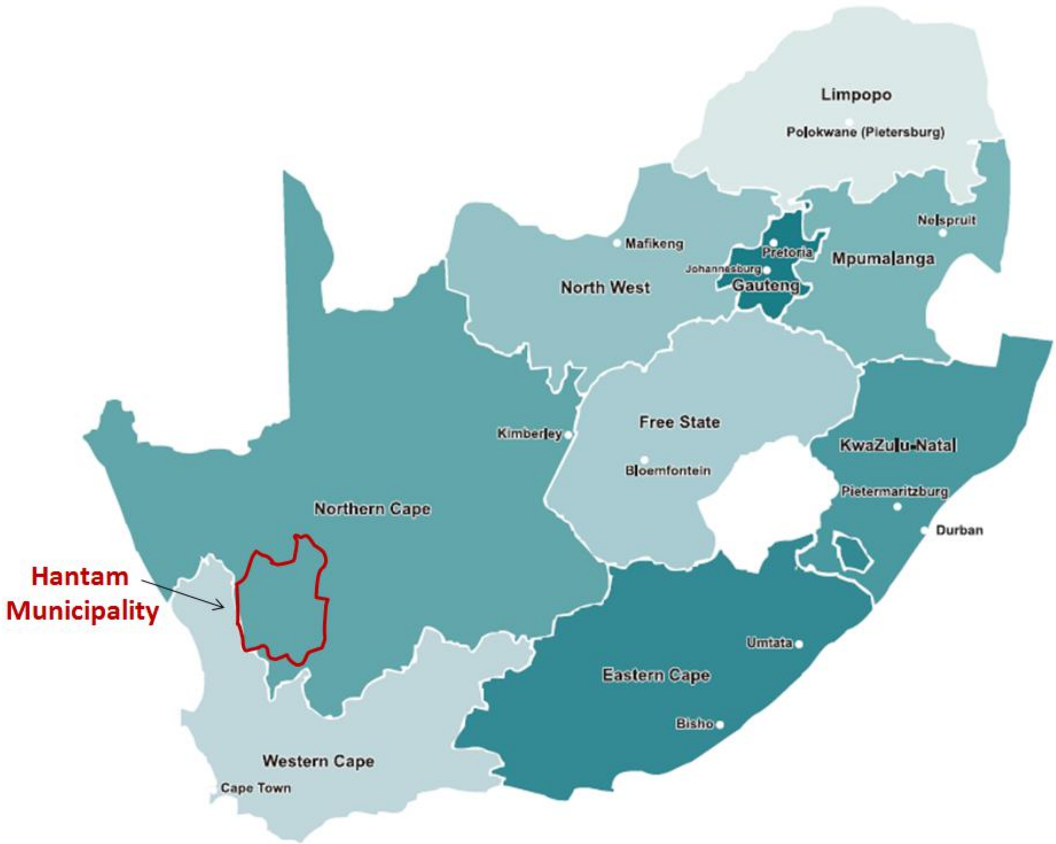


Figure 5 A map of South Africa showing the location of provinces

A closer look on the Hantam Municipality shows that the population density in that area is even lower than the Northern Cape average. Hantam municipality covers an area of 26443 sq kilometers and has a population of 21 234 persons, thus, has a population density less than 1 person per sq kilometer. Hantam Local municipality includes 5819 households, that is, with its current population an average household size of 3.6 persons. *Statistics South Africa (2007)* The municipality includes the towns Brandvlei, Loeriesfontien, Nieuwoudtville and Middelpos and Calvinia. They are all situated far apart with very limited connections, causing long travel times, see Figure 6.

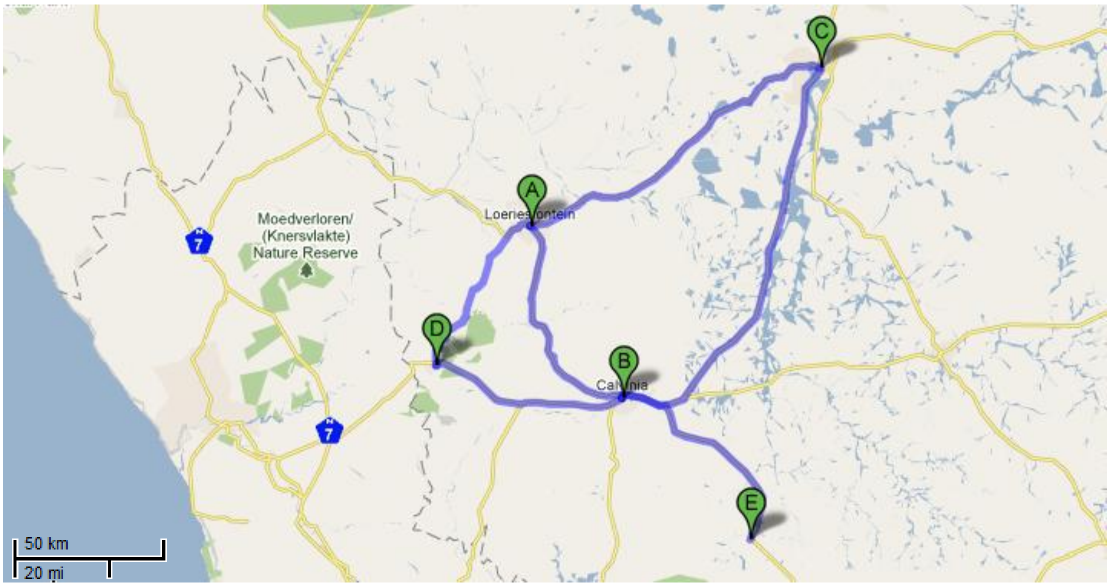


Figure 6 Map showing the distance between Loeriesfontein (A), Calvinia (B), Brandvlei (C), Nieuwoudtville (D), Middelpos (E). ***Modified picture from Google maps (20 March 2011)***

The fact that everything is very far away, along with limited resources and financial support limits the possibilities of the municipality. There are few highly educated people and the migration of people is very high.

The municipal headquarters are located in Calvinia. It is the biggest town in the area with about 10 000 residents. The Calvinia district is situated in the Great Karoo. The area is renowned of its spring wildflowers but is most of the year as dry as it surroundings.

The Blue Drop Score of Hantam municipality is 68.5. It is within the range for 'Good DWQM', explained in the Drinking water Quality Report, 2010 as: '*There is sufficient proof that the municipality/institution has adequate processes in place to ensure safe water supply. However there is room for improvement towards Blue Drop certification, since portions of the requirements are not complied with as yet'*. The score is quite close to the national average Blue Drop Score of 70.75, but significantly higher than the Northern Cape Provincial score of 46.87. The Report notes the concern of rural systems to fail in recording acceptable compliance levels which could be accounted to inconsistent disinfection processes. *Department of Water Affairs and Forestry (2010)* In Table 3 the Blue Drop the Blue Drop score for each town is presented.

Table 3 Showing the Blue Drop evaluation of each criteria for the different towns of Hantam municipality as well as the total Blue Drop Score for each. ***Adopted from Depatment of Water Affairs and Forestry (2010)***

Performance Area	Systems	Calvinia	Brandvlei (Boreholes)	Loerisfon-tein (Boreholes)	Middelspos (Boreholes)	Nieuwoudt-ville (Boreholes)
Water Safety Plan		C	B	C	E	C
Process Control & Maintenance Competency		E	A	C	D	C
Efficiency of Monitoring Programme		B	B	E	C	C
Credibility of Sample Analyses		A	B	B	B	B
Data Submission to DWA		A	A	A	A	A
Compliance with National Standard		C	C	C	G	C
Failure Response Management		C	C	C	C	C
Responsible Publication of Performance		G	G	G	G	G
Efficacy of Asset Management		E	D	E	D	D
Microbial DWQ Compliance with National Standard		99.99% 12 months data	99.99% 12 months data	99.99% 12 months data	75.00% 12 months data	99.99% 12 months data
Chemical DWQ Compliance with National Standard		No data	No data	No data	No data	No data
Blue Drop Score (2010) + Trend		69.81% ↑	76.25% ↑	64.88% ↑	48.60% ↑	68.10% ↑
Blue Drop Score (2009)		*Not Assessed*	*Not Assessed*	*Not Assessed*	*Not Assessed*	*Not Assessed*

´Regulatory impression:

Hantam municipality did very well in their first year of being assessed according to the stringent criteria set by the Blue Drop Certification programme. It is laudable that water safety planning processes were initiated over the vast area under municipal jurisdiction. It implies that drinking water management is based upon globally accepted best principles. It is however trusted that the implementation thereof will be sustained by means of management's support and commitment to the process. It is however required that the monitoring of chemical determinands be included in the monitoring programme as well as the improvement of Middelpos water quality.' Department of Water Affairs and Forestry (2010)

7.1.1 Water Quantity and Quality

Normally the water quality is good in the Northern Cape, while water scarcity is a hurdle as it varies a lot over time. South Africa´s average rainfall of about 450 mm per year is much lower than the world average of about 860 mm/a. Furthermore, the poor spatial distribution of the rainfall results in highly uneven availability throughout the country. The Northern Cape is situated in an area of comparatively low rainfall resulting in its semi arid nature. Furthermore, the seasonality of the rainfall, as well as high within-season variability, worsens the situation remarkably in the Northern Cape. *Department of Water Affairs and Forestry (2004)*

In the main town, Calvinia, groundwater is pumped to a water treatment work, where the water is treated before distribution. The treatment work is not a proper one, according to the Riaan, but chlorination is performed as well as fluorination when it is considered necessary.

In the smaller towns, Brandvlei, Loeriesfontien, Nieuwoudtville and Middelpos, groundwater is pumped from boreholes to reservoirs where chlorine is added before distribution. As the rainfall differ so do the availability of groundwater for the drinking water provision of the towns. *"Hantam Municipality is situated in the Karoo, so water is a scarce item for the municipality"*[7] According to Riaan Van Wyk the main challenge of drinking water supply in Hantam Municipallity is the scarceness of water resources during dry seasons *"when you are going into high seasons the underground water starts to get scarce, so you have to maintain and operate the boreholes in a way that they do not dry up. So the challenge is to give enough water to the people and to maintain your boreholes."*

Using groundwater is coherent with the recommendations given in for example *World Health Organization (2008)*, that surface water or shallow groundwater should not be used as a source of drinking water without sanitary protection or treatment. However, since the resources of Hantam municipality are limited alternatives do not always exist and some households use water from springs or rivers/streams etc, see Table 4 *Statistics South Africa (2011)*. This might especially be the case for the households not situated within those small towns but outside and thus very far apart. Water scarcity may also cause dehydration of water sources forcing people to get water from other, non-protected sources. People getting water from those sources might occasionally be the result of pump breakages or such as bad smell of water.

Table 4 Type of access to water *Statistics South Africa (2011)*

Access to water by household in Hantam Local Municipality									
Piped water inside the dwelling	Piped water inside the yard	Piped water from access point outside the yard	Borehole	Spring	Dam/pool	River/stream	Water vendor	Rain water tank	Other
3324	2084	57	247	22	0	22	0	11	52

Although the drinking water quality is normally good, Riaan note the challenge to assure good drinking water quality at all times. *"The quality of the water have to be all the time up on standard and when you take samples and if it's not up to standard you must make sure that the water goes back up to standard, add more chlorine or do proper things you have to do"*. The fact that water quality is normally good and therefore does not get monitored can be dangerous if for example raw sewer is leaking into the drinking water.

[7] Riaan Van Wyk, Hantam municipality

7.1.2 HIV/AIDS

Even small fluctuations in the water quality may have severe consequences in a country, such as South Africa, where HIV/AIDS is an important public health challenge. In South Africa the HIV trends and prevalence in the general population is estimated mainly based on surveillance among pregnant women attending sentinel antenatal clinics. In 2006 the national HIV prevalence trends among antenatal clinic attendees was 29.1 %. The estimated percentage of the total population living with HIV was 10.1 %. In 2010 this percentage had increased to 10.5 % *Statistics South Africa (2010b).* HIV prevalence at provincial level shows that the epidemic has progressed at different pace in different provinces, where Northern Cape with a prevalence of about 15.6% in antenatal clinics, is one of the districts with lowest HIV rates in South Africa. *Department of Health (2007)*

HIV prevalence and water quality are closely connected and affect each other in many ways. The impact of HIV epidemic has negative impact on the quantity and quality of services provided by the water sector since funds are reduced and sector staff performance decline. This has been and still is a huge challenge in South Africa *Kamminga E. et al (2003).* In this chart, Figure 7, the percentage of the population in different ages of South Africa as compared to Sweden. Remarkable differences are shown and it is obvious that South Africa loses important parts of its population around their 20-30th affecting the productivity of the county, including the service delivery.

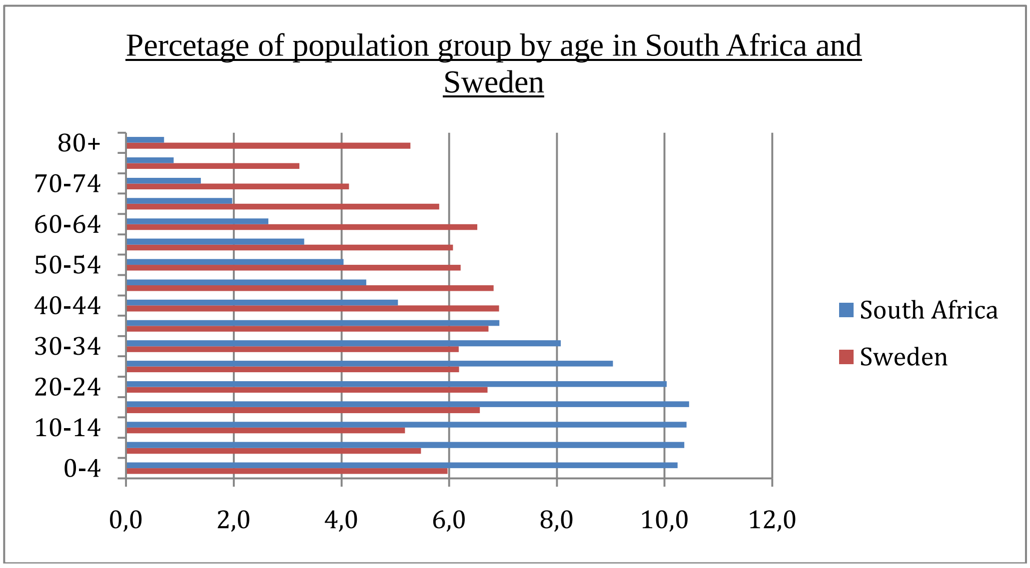


Figure 7 Illustrating differences in percentage of population group by age in South Africa and Sweden respectively.

Also, the water availability and quality plays an important role in the prevention and mitigation of the effects of the epidemic. Clean water is indispensable for people living with HIV/AIDS. Water is needed for bathing, washing, taking medicines and keeping everything clean in order to minimize the risk of opportunistic infection. *Kamminga E. et al (2003)*

8 Findings

This chapter constitutes the examination of several areas in order to evaluate the feasibility of the H_2S field test kit along with the Report system. To start with the identified roles and responsibilities of safe drinking water delivery in Hantam Municipality are explained. The implementation of the system will be described and used in the following section regarding ease of use, important for the management of the system and depending on the capacity of staff, their management skills and the organizations overall capacity (existence of processes, equipment etc.). The perceived usefulness of the system will be evaluated, as it is important for the sustainability of the system.

In the following part the integration and efficiency of the H_2S field test kit along with the Report system will be assessed, by evaluating their coherence with the policies leading the country. This includes their contribution to extension of monitoring, increase of stakeholder participation and improved Blue Drop Score.

8.1 Roles and Responsibilities in Drinking Water Service Delivery

The roles and responsibilities are based on the national institutional framework described in Section 3.1.1 but adjusted to the local context. The users of the H_2S field test kit and the Report system works within the local government. This chapter will describe their roles regarding drinking water and drinking water quality, as well as the role of the national government (illustrated in Figure 8).

Hantam Municipality is an authorized local municipality where the Water Service Authority is also the Water Service Provider in the whole area as explained in Chapter 3, Section 3.1.1. The WSA has the responsibility to assure safe water supply. Riaan Van Wyk is the head of the Social Department of Hantam municipality. He runs the Department of Traffic, the Department of Sanitation, and the Department of Library and is also involved in Environmental Health.

Operational monitoring is as well the responsibility of the WSA (Section 3.1.1). In Hantam, Riaan Van Wyk is responsible for assuring that the operational testing is being done and the one to blame if it is not done appropriately. He has the overall responsibility for the sampling programme in Hantam Municipality, and he is the one referred to in this report as the Water Service Manager. The Supply Testers, or foremen, working for Riaan Van Wyk, are those actually performing the sampling. If non-compliant, a resample is normally taken and if this again shows non-compliance, Riaan Van Wyk has the responsibility to take remedial action.

Riaan Van Wyk is also the one performing compliance monitoring once a month. He has the responsibility of assuring that test results are compared with the national drinking water standards and inform consumers and appropriate authorities about health risks. Since the implementation of the Blue Drop System in 2009 Riaan Van Wyk has the responsibility to assure that results are loaded on the BDS[1].

Riaan Van Wyk work in close cooperation with the Head of Infrastructure, responsible for operating the water systems. If remedial action has to be taken and flushing has to be performed, the infrastructural foremen are the one performing this operation.

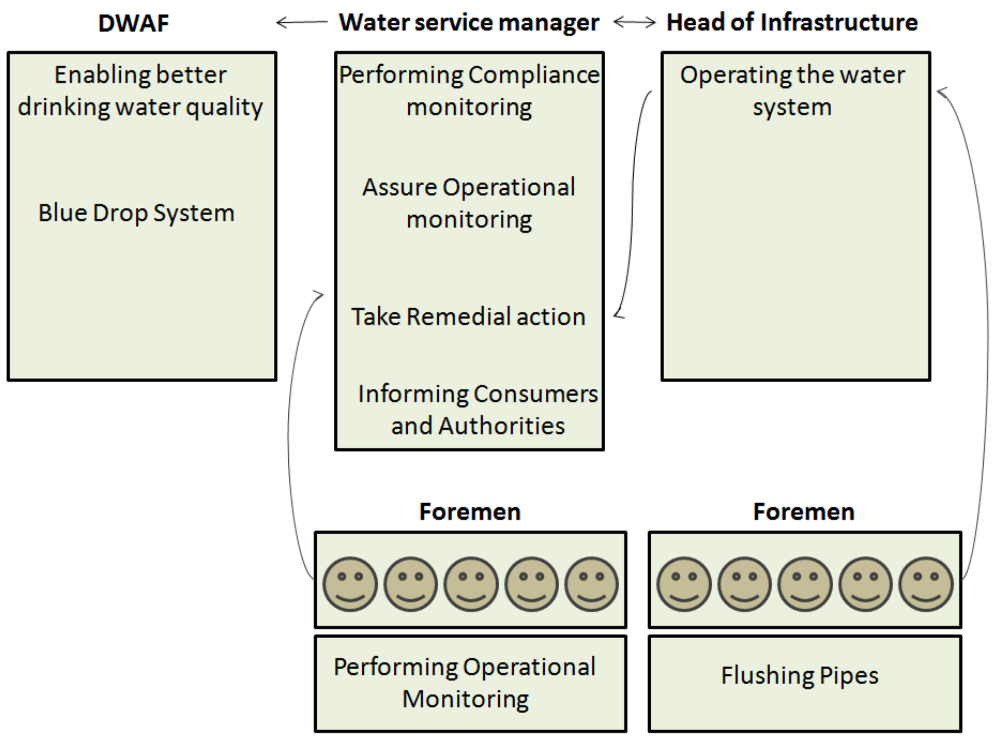


Figure 8 Illustrating responsibilities of actors, as well as communication (illustrated by arrows) between them

The municipal foremen of each town, working under Riaan Van Wyk, also act as the ones referred to as the Supply Testers in this report. Since there are five towns in Hantam Municipality there are also five foremen, responsible for the public services. The amount of municipal workers in the towns depends on the population it serves. In Middelpos for example, with about 300 residents, the foreman is the only municipal worker. He is responsible for everything related to running the town such as water and waste management, money collection, cleaning streets etc. Since he sometimes cannot do everything himself he has some casual workers cleaning the reservoirs or similar.

In Loeriesfontein, which is a bigger town with a population of about 3000 people, the foreman is responsible for the basic services such as water, sanitation, electricity, roads etc. but he also have 16 workers under him. The responsibility as Supply Tester contains measuring basic operational parameters on a daily basis. This includes electrical conductivity, turbidity, pH and free chlorine. They are also the ones supposed to perform the H_2S test and report drinking water quality parameters and information about the samples, such as where it was taken etc.

8.2 Implementation Processes

The implementation of the Water Quality Reporter was undertaken in April 2009 but since the Aquatest kit is still under development the H_2S test kits is used as test method together with the cell phone application. The initial customization of the application for the municipality included preloading existing sampling points from the eWQMS and translation of the entire application into Afrikaans. The field kits, barcoded ‘sampling packs’ were distributed, containing a pair of gloves as well as an H_2S sample bottle. A training session was performed at the municipal headquarters in Calvinia, when the cell phone application was loaded on the phones of each person working as a field tester. This application was the water quality reporter, which allowed the Supply Testers to fill in the form, explained in Section 6.3, and send this to the Water Quality Manager. The reporting cost is the sms-costs of sending water quality information. It is covered by the UCT.

The Water Service Manager would then receive several SMSs from each and every Supply Tester to evaluate and transfer this information to a data server. Since the managers experienced these messages, to be too many to go through the Reporting system was further developed and the Water Service Managers will prior to April 2011 be provided android phones. The ICOMMS research team visited Hantam Municipality in April to provide them with android phones with the water quality management application. It will simplify water quality information accessibility and transferring.

8.2.1 Training and Support

Appropriate training of field test kit operator is essential. If they are properly trained a large number of water sources can be tested in a relatively short time which enables results to be obtained and shared with users within hours or days *United Nations Children´s Fund (2008).* In Hantam municipality the ICOMMS research team had a 2-3 hour training session at the initial stage of the implementation. After this first session, they visited the individual operator to check if they did everything right. Other than that the ICOMMS research team has the intention to interfere as little as possible. They give the support they agreed on with the municipality, which is sending SMSs, fixing broken phones and providing H_2S field test kits. It was not their intention to necessarily develop skills etc, since the municipal staff already knows what needs to get done. They rather they wanted to see if the cell phone application fits into their work.

Field kit Supply Testers can take advantage of their visit to support improved sanitation and hygiene as needed *United Nations Children´s Fund (2008).* They have not been offered additional training to support consumers in sanitation and hygiene issues. That is outside the study and the responsibility of the Department of Education. There have been a few technical queries but the research team normally easily fixes those. They support the municipal workers via the phone whenever there are any queries. If the problem is unmanageable by phone they handle it at the next visit.

8.3 Integration in the Municipal Structures

The monitoring technique and communication technology has to depend on the capacity of staff, their management skills and the organizations overall capacity depending on existence of processes, equipment, internal policies and finance to achieve its objectives. In many parts of the developing world lack of human resources is a threat to successful management, why a technical device that aims at improving the situation should be easy manageable *World Health Organization (2010).* If systems are perceived as expensive, complicated or requiring additional work they are unlikely to succeed, according to *Rivett U. et al (2009).* The intention is that the H_2S field test kit and the cell phone based report system should be easy to use, analyze and navigate.

8.3.1 Perceived ease of use

It is the overall impression that both the H_2S field test and Reporting system are easily understandable and manageable, both according to the Supply Testers and the Water Service Manager. Also the researcher team agrees that implementation did happen smoothly and that no restructuring have been needed and are not either allowed since it is a research project. However it shows that the system can be easily integrated in the municipal structures.

The complications that have occurred have rather been within the technical side of application. At the moment of our visit in Hantam municipality there had been a bug preventing the Supply Testers from changing a certain input in the form.

When talking to the Water Service Manager and the Supply Testers they all agree that the report application on their cell phone is easy to understand and navigate. The Water Service Manager and the Supply Testers experience the system as easy integrated in their daily work. They also experience cell phones as a good communication media, feasible in their work. Cell phones are always carried on the person and can provide and collect information without intruding on the workflow of the user. Despite this perceived ease of use it seems not to be uncommon that the reporting of sample results is not followed through, see Section 8.4.1.1.

The Supply Testers have no problem with performing the field test. Their experience is that it is an easy performed test that can be done quickly, while the hurdle is getting to the sample points, which is discussed in Section 8.3.3 below.

8.3.2 Perceived Usefulness

For the Water Service Manager it is a very useful tool helping him to improve the water quality management. He now gets additional information about microbiological constituents in the drinking water and he gets the sample results on a daily basis in contrast to once a month. It enables timely response if contamination is detected, even though, this rarely happens. Riaan Van Wyk declares that failure almost never happens, it have occurred only a few times in Middelpos.

The Supply Testers agree that it is useful as they get timely response. By the use of the H_2S field test kit and the Report system they are more confident in the quality of the water they provide their citizens, and thy feel supported in their decision-making, Nonetheless, something seems to prevent the Supply Testers from reporting drinking water quality on a daily basis, as discussed in Section 8.3.1.

The challenge brought up by the Supply Testers concern the time-consuming procedure of performing the H_2S test. The H_2S field test has to be performed on specific sample points while the other parameters (pH, electric conductivity, turbidity, chlorine) may as well be analyzed from a sample in the offices tap water.

The municipal workers state that the H_2S field test is only tested for once a week, in contrast to every day as for the other parameters. This is according to Ulrike Rivett the recommended frequency of performance. According to the monthly report though, it is reported much less. It may thus also be limited because of time strains, which is one of the challenges for the Supply Testers.

8.4 Integration in the Institutional Framework

Legislations and policies discussed in Section 3.1 supports and stress the empowerment of community and local governments. The H_2S field test and the Reporting system act within this trend, both being applicable on the local level and aiming at improving the conditions for the local WSA to success in ensuring drinking water quality. This is a well-directed investment as it supports the governmental body imposed a great responsibility but possessing very limited resources.

It responds to several of the reasons for failure in drinking water quality provision discussed in Section 3.2, such inadequate monitoring of drinking water services and lack of interventions to address poor drinking water quality. As a consequence of its ease of use and relative good price it also responds to the claimed lack of institutional capacity within the WSAs. It supports the WSAs in undertaking the drinking water quality monitoring, management and communication which is stated as problematic for them in the *United Nations Environment Programme (2010)*, see Section 3.2. It also affects the interaction between stakeholders and the requirement of WSAs to undertake operational monitoring as stated in the DWQM. How the monitoring has been extended and to which degree the stakeholder participation has been affected are evaluated in the following section. Furthermore, it is evaluated how the system affect or support the submission of information to national government and the information provided consumers regarding drinking water quality.

8.4.1 Monitoring

The best way to achieve the goals outlined in the Water Safety Plans as well as in the DWQM is to evaluate all steps from catchment to consumer by using several components, see Section 4.1 and 4.2. One of those components is the operational monitoring, to ensure health-based target to be met and to enable effective system. Nevertheless, as stated in Section 3.2, as many as 30% of the consumers served by water supplies are not covered by any sampling programme. The H_2S field test kit and the Reporting system aims at including those supplies by mitigate the limitations caused by resource constraints at municipality level, remoteness of communities, cost of the sampling programme and the distance from laboratories.

8.4.1.1 Operational Monitoring in Hantam Municipality

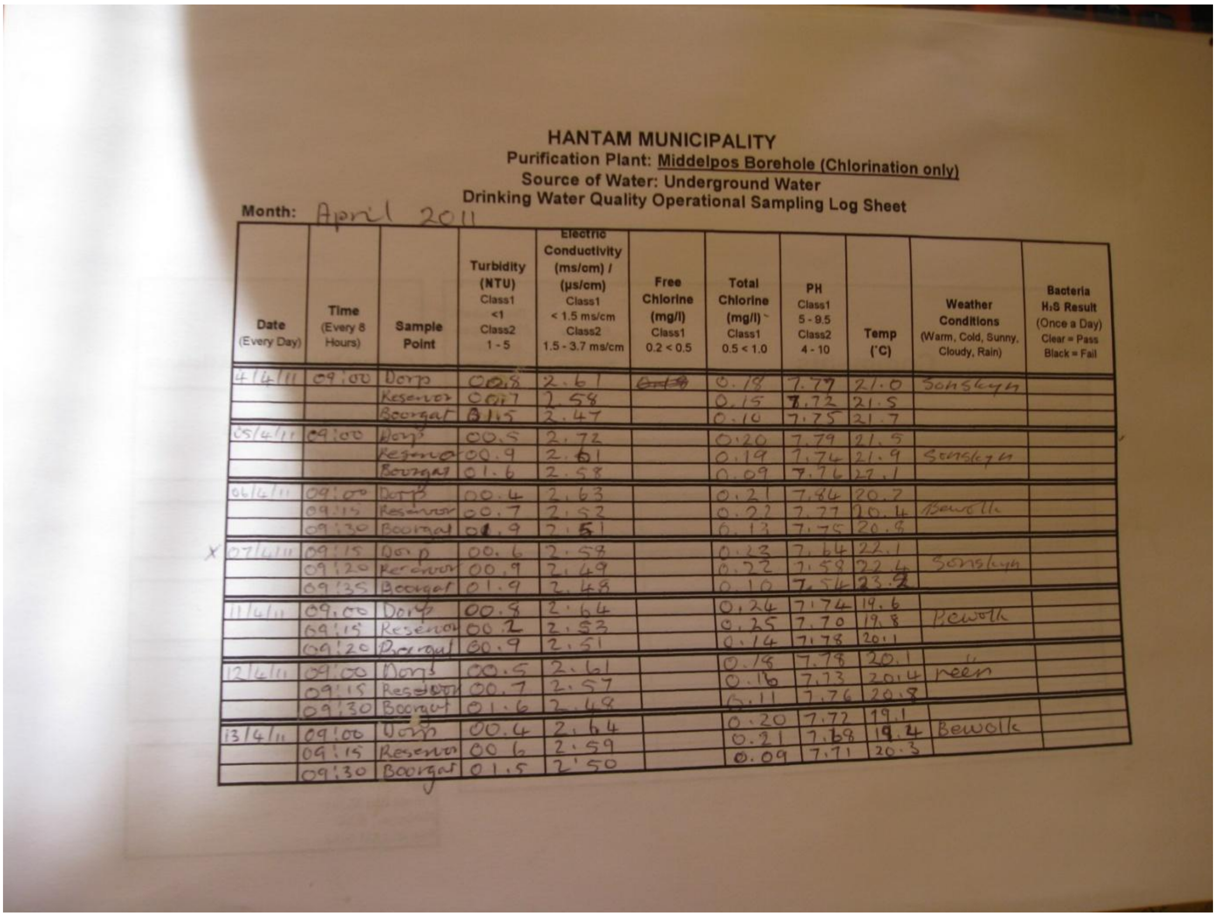
Prior to 2009 the operational monitoring in Hantam municipality did not constitute any microbiological testing. The tests covered three of the parameters considered the minimum set of “essential parameters” which are required to assess microbiological quality of drinking water, namely; turbidity, disinfectant residual and pH (see Section 5.1.1). The disinfectant in Hantam municipality is chlorine, why total chlorine is measured. Additionally conductivity is measured as required in SANS 241. These parameters are supposed to be analyzed on a daily basis.

The fourth “essential parameter”, *E.coli* (or faecal coliform bacteria) (see Section 5.1.1) was only analyzed in connection with the occasional compliance monitoring. The H_2S field test kit was provided by the ICOMMS research team in 2009 and is used today in the five towns of Hantam municipality. H_2S test is not performed as often as the other essential parameters, but rather once a week. According to Ulrike Rivett it is not necessarily to sample more frequently.

The field test kit has contributed to increased knowledge about microbiological water quality in Hantam municipality. They may now test for microbiological constituents weekly in addition to the monthly compliance monitoring. Since the field test kit offers results within 24 hours, in contrary to about three weeks (which it often takes to get results from the laboratory) remedial action can be taken much sooner and informed decision making is possible. Nevertheless, in South Africa the H_2S field kit is not recognized as a proper and reliable test for operational monitoring. This is to say it not accepted as an additional indicator of water quality and will therefore not theoretically improve the operational monitoring in Hantam municipality. The ICOMMS research team research team claims it should be accepted as an additional indicator, as it is in several other countries, and they are trying to convince the DWAF of their opinion.

The operational monitoring should preferably include any other health-related constituent that could be occasionally expected or any potential contaminant identified in the specific case, as suggested in the *Department of Water Affairs and Forestry (2005).* In Hantam municipality though, no further constituents are tested for, and no adjustments are done depending on what is expected.

Before the introduction of the Reporting system in Hantam municipality water quality parameters were communicated in paper form. Sample results were registered in a book along with information about the sample. Information to be reported was the date, time and location where the sample was taken as well as the results regarding turbidity, conductivity, total chlorine and pH. Furthermore the temperature and weather conditions were reported since these may affect the results. Figure 9 shows this book for Middelpos in Hantam municipality. Once a month the Water Service Manager, Riaan Van Wyk, would collect those books from each town and bring them back to Calvinia to compare the results with accepted values and transfer it to the Blue Drop System.



HANTAM MUNICIPALITY
Purification Plant: Middelpos Borehole (Chlorination only)
Source of Water: Underground Water
Drinking Water Quality Operational Sampling Log Sheet
Month: April 2011

Date (Every Day)	Time (Every 8 Hours)	Sample Point	Turbidity (NTU) Class1 <1 Class2 1 - 5	Electric Conductivity (ms/cm) / (µs/cm) Class1 < 1.5 ms/cm Class2 1.5 - 3.7 ms/cm	Free Chlorine (mg/l) Class1 0.2 < 0.5	Total Chlorine (mg/l) Class1 0.5 < 1.0	PH Class1 5 - 9.5 Class2 4 - 10	Temp (°C)	Weather Conditions (Warm, Cold, Sunny, Cloudy, Rain)	Bacteria H₂S Result (Once a Day) Clear = Pass Black = Fail
4/4/11	09:00	Dorp	00.8	2.61	[illegible]	0.18	7.77	21.0	Sonskyn	
		Reservor	00.7	2.58		0.15	7.72	21.5		
		Boorgat	01.5	2.47		0.10	7.75	21.7		
05/4/11	09:00	Dorp	00.5	2.72		0.20	7.79	21.5		
		Reservor	00.9	2.61		0.19	7.74	21.9	Sonskyn	
		Boorgat	01.6	2.58		0.09	7.76	22.1		
06/4/11	09:00	Dorp	00.4	2.63		0.21	7.84	20.7		
	09:15	Reservor	00.7	2.52		0.22	7.77	20.4	Bewolk	
	09:30	Boorgat	01.9	2.51		0.13	7.75	20.8		
x 07/4/11	09:15	Dorp	00.6	2.58		0.23	7.64	22.1		
	09:20	Reservor	00.9	2.49		0.22	7.58	22.4	Sonskyn	
	09:35	Boorgat	01.9	2.48		0.10	7.54	23.2		
11/4/11	09:00	Dorp	00.8	2.64		0.24	7.74	19.6		
	09:15	Reservor	00.2	2.53		0.25	7.70	19.8	Bewolk	
	09:20	Boorgat	00.9	2.51		0.14	7.78	20.1		
12/4/11	09:00	Dorp	00.5	2.61		0.18	7.78	20.1		
	09:15	Reservor	00.7	2.57		0.16	7.73	20.4	reën	
	09:30	Boorgat	01.6	2.48		0.11	7.76	20.8		
13/4/11	09:00	Dorp	00.4	2.64		0.20	7.72	19.1	Bewolk	
	09:15	Reservor	00.6	2.59		0.21	7.68	19.4		
	09:30	Boorgat	01.5	2.50		0.09	7.71	20.3		

Figure 9 Showing the book used to report drinking water quality in the towns of Hantam municipality (this one from Middelpos). ***Foto: Hanna Lindfors (20/04-2011)***

Still, those books are used as to support the foreman in his work. But results are as well sent as an SMS from the foremen as soon as they performed the test. The reported information is still the same, with the additional microbiological quality.

The Water Service Manager, Riaan Van Wyk, receives SMSs showing the drinking water quality and whether or not the parameters are within the acceptable ranges. Thus, drinking water quality information is now sent on a daily basis in contrast to once a month. The Supply Testers claim they do test and send results almost every day, with exception if something unexpected happens such as pipe break etc.

The Water Service Manager receives the same information in the monthly report provided by UCT. Those reports imply that results are in fact not sent every day. According to the monthly reports from the last six months samples are reported but not all Supply Tester report even every month, while others report weekly or more frequent. Non of them report results every day. According to the Supply Testers the samples are sometimes analyzed but not reported, since they were in some way interrupted.

Ulrike Rivett notes the changes in priorities as one of the challenges in the rural municipalities. If there is a fire for example, all the resources will be directed to fire fighting and everybody will work to stop the fire. Ulrike Rivett also claims that some of the Supply Testers do not see it as a priority to report results if they are all compliant. Further she says there have been problems with one of the phones. Also according to the Water Service Manager, the water is tested even when it is not reported.

At the visit in Hantam municipality in April 2010, android phones were provided. This system enables Riaan to always access the monthly reports on his phone at all times. He will then not receive SMSs, if the samples show compliance, but only if not compliant.

8.4.1.2 Compliance Monitoring

Prior to 2009 it was also very rare that compliance monitoring was conducted. Riaan Van Wyk states compliance monitoring could be conducted about once in sixth month for microbiological constituents and once a year for chemical constituents.

Nowadays, Riaan Van Wyk conducts compliance monitoring each month. He collects two samples in Calvinia and one in each of the other towns of Hantam municipality, to comply with the standards, see Section 4.3. The samples have to be collected at specific points and then transported to a laboratory. Samples for microbiological compliance are taken to the local clinic from where it is transported to the NHLS (National Health Laboratory Service) in Cape Town, which is about 400 km from the headquarter in Calvinia. Samples for chemical analyze, are transported by Riaan Van Wyk[1] to CSIR (Council for Scientific and Industrial Research) in Stellenbosch. Both of those are accredited laboratories. The travel time is a challenge both within the municipality, where distances between the sample points in towns are long and the connections are very limited, as well as the transfer to laboratories situated far away. The time from sampling until the samples get to the laboratory has to be less than 24 hours. Thus, travel times are challenging, as are travel costs, and the costs for analyzing the results at the laboratory. Money and other resources are very scarce in Hantam municipality why compliance monitoring is only performed as often as legislative necessary.

The H_2S and Reporting system does not in any way function as a substitute for the compliance monitoring but rather as a complement. One of the aims of the H_2S and Reporting system, according to the ICOMMS research team, is that by using the results from field tests the compliance monitoring can be more timely and spatially directed. The purpose is to perform compliance monitoring where and when it is really needed, as when the water poses a risk for the consumers in a specific area. But the Water Service Manager declares that he always sample at the same points in each town and at the same frequency, since that is required in the Blue Drop System.

8.4.2 Stakeholder participation

Increased stakeholder participation is outlined in the DWQF as one of the main priorities within water service management. The stakeholders evaluated in this study are the Water Service Manager and Supply Testers within the WSA and the consumers in Hantam municipality. The introduction of the H_2S field test kit and Reporting system have caused increased information regarding water quality supporting the Water Service Manager and Supply Testers making them more confident in the job they are performing. Especially the Supply Testers are empowered, as they may now do more well-informed decisions.

Water quality should be communicated to consumers and to the national government in order to involve them in the management. The H_2S field test and the Reporting system does not directly involve the national government, since information is communicated only within the municipality. However, with gathered data on the data server, and in the Monthly reports, water quality information is more easily accessed and also more easily transferred to the Blue Drop System, which represents the main communication between local and national government. Riaan Van Wyk claims that earlier the eWQMS was used to load the data, but then something happened, and now they only use the Blue Drop System. Moreover drinking water quality should be communicated to the consumers to improve their awareness of the drinking water quality and its importance.

8.4.2.1 Consumer communication and Community awareness

A water quality communication, offering information to consumer, is an important part both in *World Health Organization (2008)* and *Department of Water Affairs and Forestry (2005).* It is the 'next step' envisaged in the legislation, to make appropriate information available to communities. However, this is problematic in practice and seldom prioritized *Rivett U. et al (2009).* Especially poor and rural communities would benefit easily accessed and understandable information as they tend to have low awareness levels of the importance of water quality and thus do not typically demand water quality surveillance services. A community-based surveillance/monitoring system is important, according to *United Nations Children´s Fund (2008)*, as it directly involve the primary stakeholders in communities, thus helping to raise awareness on water quality. The implementation of the H_2S test and report system is not community based in that sense but has the intention of empower communities by improved local awareness, which ultimately leads to safer water supplies.

The Supply Testers declare that consumers are aware of the tests they perform as well as of the project they are involved in together with the UCT. Especially, in the smaller towns the residents know each other well and are aware about things happening in the town. Some of the Supply Testers get asked questions while taking sample, and then they tell the residents what they are doing. In the initial stage of the project there was also an article published in the local newspaper explaining the research project and the cooperation with the UCT.

If the H_2S and reporting system increases the credibility of the Blue Drop Score for Hantam municipality is does also improve the ‘quality’ of the information provided through the Blue Drop, which aims at improving drinking water quality communication to consumers. Yet a prerequisite is that the Municipal Blue Drop Score is easily accessible for consumers. The Blue Drop Score is published in the annual Blue Drop Report, available for everybody on the DWAF web page. However, only very few people in Hantam municipality have access to internet, namely 6.1 percentage of the total number of households in Hantam municipality *Statistics South Africa (2007)*. Some of the Supply Tester knew about the Blue Drop score while others never heard it before. None of them was actually aware of the Blue Drop score of their town.

Riaan Van Wyk claims the consumers definitely know the quality of the water. He notes that it is available on the Internet on *My water*, which is a service offered on www.dwaf.gov.za where you can search for any municipality or even town. The information offered though is very poor and as mentioned, the access to Internet is very limited *Statistics South Africa (2007).* According to Riaan Van Wyk the water quality communicated with the consumers has not increased after implementation of the system. Although they have got a project running to start reporting drinking water quality through the newspaper every month and sending pamphlets to consumers.

Both Riaan Van Wyk and the Supply Testers call attention to that if there is a serious problem consumers always get alerted. It is then announce on the community radio in Calvinia, 83.6 percentage of the total number of households do have a radio *Statistics South Africa (2007).* The municipal workers also go out to the towns telling the people they must for example boil their water before drinking it.

8.4.3 Informing the National Government

To enable development of relevant policies and appropriate decision-making accurate data should be submitted to the national government. Data may then also be used to evaluate the performance and progresses of the national water sector and services. The Blue Drop system is the main tool in South Africa for this submission of drinking water quality management information, as well as the evaluation of such and the progresses accomplished over time.

8.4.3.1 Submit information through the Blue Drop System

The communication between local government and the national government is not directly affected by the reporting system but indirectly as a consequence of better and more accurate information. To evaluate the effect of H_2S field test kit and the reporting system on the national level the affect on the Blue Drop Score for the municipality is evaluated. The Blue Drop System is, as explained in Section 6.2, based on nine Criteria. The H_2S and Reporting system will affect some of them, might affect others and do not affect some at all.

The monthly summaries of results decrease the effort in collecting data, making it easier to report information. Riaan Van Wyk defines the difficulties in the submission as one of the main challenges of the community. Proof is basically required for everything in the Blue Drop System, which is a challenge in Hantam municipality. Riaan Van Wyk says their administration is not every time up to standard, which makes the reporting difficult. The administration in Hantam municipality is poor and it takes time to introduce a system were everything has to be documented. Riaan Van Wyk says he use the monthly reports in reporting to authorities. It simplifies this part of his work, even though it is still a challenge.

8.4.3.2 Evaluation and progress through the Blue Drop score

Criteria one ‘Water safety plans’ may very well be improved by the use of the system. To have historical data available on the data server offers information about drinking water quality over time. If used properly this information may be used in order to develop a comprehensive understanding of the drinking water supply system involved, the risk of hazards that may be present, the ability of the processes and the infrastructure available to manage this risk. It also affects operational monitoring as discussed above and makes up an important part of the management as it ensure efficient water delivery. Areas with higher concentration of contamination may be traced and resources more effectively used. More relevant and timely information helps in decision-making and hence in deciding what actions that to be taken in different situations.

The next criteria ‘Process control and maintenance competency’ will not be affected while the third ‘Efficiency of drinking water quality monitoring program’ might be, as compliance monitoring efficiency increases. Compliance monitoring could be more timely addressed and area specific by analyzing the sample results from operational monitoring. But since the Blue Drop system requires samples to be taken at specific points and intervals, Riaan Van Wyk performs sampling at the same points, and same frequency as before the implementation regardless the results. Concerning operational monitoring, the report application helps transfer and store data as well as it makes data available for relevant authorities, which may improve the score. Since H_2S is not yet accepted as an additional indicator of water quality, the efficiency of the operational monitoring in that sense would not increase. However, if the ICOMMS research team is successful in convincing the DWAF of their opinion, it will then increase operational monitoring efficiency.

‘Credibility of drinking water sample analysis’ is not affected, but ‘Regular submission of drinking water quality results to DWA’ is as discussed in the Section 8.4.3.2 above. ‘Drinking water compliance with the South African National Standard (SANS 241)’ might get a point. With better and timelier information about water, correct treatment can be performed and the tests will then be more likely to comply.

‘Drinking water quality failure response management’ may also be improved since the system helps inform about when there is a failure, which enables more timely response. It could also act to prove incident, but they still need additional proof of the action taken. Riaan Van Wyk takes an example of when there is a failure or similar, *“you phone and say ´quickly go and look this and this and this´, but you haven’t got it on paper. You have to put it on paper as well and you have to load that (on the BDS). Blue Drop is about proof, if you haven’t got proof there are no points that you can get.”*

‘Responsible Publication of DWQ Management Performance’ might be improved if the municipality use the information provided to communicate drinking water quality in the form of publications, radio or similar. As discussed above (Section 8.4.2.1) Riaan Van Wyk claims the consumers definitely know the quality of the water, but the water quality communicated with the consumers has not increased after implementation of the system. If there is a serious problem the consumers always get alerted. ‘Efficacy of basic DWQ Asset management’ is not affected.

9 Discussion

The national policies and legislations of South Africa have shown to emphasize every ones right to safe drinking water, regardless wealth or accessibility. Nonetheless, it has been found that there are substantial disparities throughout the country with urban areas providing enormous quantities of best quality water, while in other areas, mainly rural, people do not get water of the quantity nor the quality enough to stay healthy. In those areas one of the main challenges has turned out to be lack of maintenance and management. While the DWAF has the responsibility to support the local government, the WSAs are the ones actually responsible for the services in their area of jurisdiction. The WSAs in those rural areas are the ones the H_2S field test kit and Report system aims to support, thus the system is directed to actors enabled to do great improvements within the water service delivery of exposed area in South Africa.

The evaluation of the H_2S test device in conjunction with the cell phone-based report system in Hantam municipality has shown on its ability to integrate well in the local structures. It can be introduced without major restructuring, which increases the chances for sustainable use over time. All the municipal workers perceive the system as easy to use. They also experience it as useful in their work, especially the Water Service Manager as it simplifies several parts of his job without sparing his time. It empowers the Supply Testers as it supports their decision-making, but for them it has to be considered time consuming. Performing samples at predefined spots require additional travelling, which is problematic for some of the Supply Testers with time strains as the main challenge in performing their job.

There are several aspects affecting the integration and sustainability of the H_2S test device and report system. Perceived usefulness and perceived ease of use where the aspects analyzed in this report, since those were experienced as the most accurate parameters both in relation to the subject of this report but as well during the interviews when the challenges and priorities of the municipal workers became clear. Other parameters such as social norms, attitudes toward behavior and perceived control, were touched upon during interviews but not further analyzed in this report. However, those could preferably be analyzed to develop a deeper and more covering understanding in the field. The cost turned out to be of big importance, although the WSA should be provided sufficient support to secure drinking water quality by the DWA, financial and technical resources are challenging in the municipal drinking water service. Thus, since compliance monitoring is considered too cost and time demanding to perform more frequent than legislatively necessary, the H_2S field test device is a good complement.

In Hantam municipality the H_2S field test kit and the Reporting system are supporting the Water Service Authority in extending its drinking water quality monitoring and assuring its provision of safe drinking water supply. The H_2S test device offers additional information regarding microbiological constituents, which increases the knowledge about drinking water quality and consequently improves drinking water quality management. As long as the H_2S test device is not legally accepted as an additional parameter the operational monitoring is not theoretically extended. Although, if the research team succeeds in convincing the DWA of its credibility, or if the Aquatest device later replaces it, the operational monitoring performed will cover all the “essential parameters” referred to in both the international GDWQ and national DWQF.

The H_2S field test kit and Reporting system enable timely remedial actions to be taken as they now analyze results more frequently than once a month, as before the implementation. It makes the Supply Testers and the Water Service Manager more confident in the quality of the water they provide. It was difficult to ensure the actual sampling frequency in Hantam municipality. During interviews the municipal workers claimed that pH, turbidity, conductivity and free chlorine were analyzed almost every day, with the only exception when something unexpected happened, while the H_2S test were performed weekly. They also assured they report results as soon as those are obtained, with the same exception of any unexpected happening. However, the monthly reports, which summarize the received results, indicate a significantly lower frequency.

The one explanation might be, as the Water Service Manager argues, that tests are taken even when they are not reported. If the Supply Testers find results to be within accepted ranges they may not find it necessary to report. If that is true, and the Supply Testers do the proper judgment based on the water quality parameters it would still be as safe drinking water as if reported. However, the system then fails in storing historical data showing spatial and timely fluctuations and it cannot either be used as proof in the submission to national government. Other reasons to test but not send the results might be problems in understanding and using the system, or technical problems (such as the application bug when we visited) preventing Supply Testers from using the reporting tool properly. It is as well likely that tests are actually not conducted daily as a consequence of rapid changes of focus in small rural communities like Hantam Municipality.

Why the information from Supply Testers, Water Service Manager and the monthly report is not fully consistent is difficult to tell. It has to be taken into consideration that only three out of five Supply Testers were interviewed and therefore the opinions of the other two have not been accounted for. Furthermore, language barriers might be a source of error as the translation can cause simplified or distorted answers. It can neither be neglected that answers during interviews have been embellished with the attention to appear as better in any way. For example the interviewees might have claimed to understand the system better or reporting more frequently than they actually do. As I arrived in Hantam municipality together with the ICOMMS research team the interviewees probably recognized me as one in the project team and therefore wanted to give a good impression. It is as well possible that interpretations of the Supply Testes and the manager in how often results are reported, differ slightly from the actual frequency. Those potential sources of error have been included, as far as possible, in the evaluation of the interviews making up parts of the content in this report.

The introduction of the H_2S field test kit and Reporting system causes increased stakeholder participation, as it especially empowers the Supply Testers whom can now do better informed decisions. Nevertheless, it fails in involving and informing the consumers. The information available for consumers has not increased the last few years, other than through the Blue Drop System. Very few people though, have the possibility to get hold of the Blue Drop score or possess the ability to analyze the score obtained.

The Water Service Authority has the responsibility not only to inform consumers but also the DWAF of the drinking water quality in their municipality. They do so by loading documents onto the Blue Drop System, a process that is challenging in Hantam municipality with its lack of proper administration. The Water Service

Manager, responsible for assuring that results are uploaded, claims the monthly reports does simplify this processes even though it is still a challenge. The drinking water quality management for each municipality is evaluated in the Blue Drop System. The H_2S field test kit and Report system turned out to have the potential to impact a number of the criteria in a positive manner, while it actually only did impact a few of them.

Stored historical data should improve 'Water safety plans' and since data availability increases the submitted data and thus 'Efficiency of drinking water quality monitoring program' improves. It also has the potential to increase compliance monitoring efficiency, but since sampling is performed at the same points, and same frequency regardless the results, it does not. Since H_2S is not yet accepted as an additional indicator it does not either improve efficiency. Monthly reports simplifies 'Regular submission of drinking water quality results to DWA', and since possible failures are now more timely reported and may be proofed by the stored information 'Drinking water quality failure response management' improves. The system has the potential of affecting 'Responsible Publication of DWQ Management Performance' in a positive manner, but since the information has not been used with that attention this has not happened.

Those improvements in the stakeholder participation and in the Blue Drop Score proofs the suitability for the H_2S field test kit and Report system in the national drinking water quality management of South Africa. It also shows its ability to further improve this management if information is managed more wisely (used for consumer communication, water safety plans, responsible publication etc.) and if the system is recognized nationally (in the sense of acceptability as additional parameters, acceptability as proof). Adjustments could also be done in the BDS to encourage directed compliance monitoring towards timely sampling in sensitive areas, which would enable further use of the system and consequently better drinking water quality management.

10 Conclusion

Interventions towards safe drinking water provision are encouraged in both national and international up-to-date literature. In spite of the explicit right to safe drinking water in legislations and policies of South Africa, disparities are remarkable and challenging to cope with. Within this study, the potential of the H_2S field test kit in conjunction with the Report system to improve drinking water quality management has been confirmed. The system is addressed to support the WSA, responsible for ensuring safe drinking water to all residents in their area of jurisdiction.

The H_2S field test and the Report system has shown to be feasible within the drinking water quality management of Hantam municipality by its ability to integrate well in the local structures and to be managed in an accurate and sustainable way. The introduction of the system have improved microbiological monitoring and increased frequency of drinking water quality communication, enabling more effectively used resources and making the Water Service Manager and the Supply Testers more confident in the quality of the drinking water they provide. While communication between actors has increased and been simplified, further use of the system should preferably include increased communication to consumers. The use of the system has affected several of the Blue Drop criteria in a positive manner, but has the potential to affect even more of them, resulting in a higher Blue Drop Score, which indicates improved drinking water quality management.

Those optimistic results encourage continued use of the H_2S field test kit and the Report system in Hantam municipality, but also continued support offered at local level and new interventions at national level, in order to reach a drinking water quality management which takes advantage of the systems fully potential. Moreover I strongly recommend further evaluations of the system in more outstretched areas of rural South Africa.

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