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An Assessment of the Effectiveness of Water Quality Monitoring and Drinking Water Quality Compliance by Environmental Health Practitioners at Selected Metropolitan and District Municipalities in South Africa during 2013-2014.

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Abstract

Access to safe drinking water is a basic right accorded to all people, and their well-being is critically dependent on both the quality of water and its availability, and how well these are managed. Water quality monitoring is an important activity for ensuring water supplied to the community is safe for human consumption. The legislation safeguarding the delivery of safe water has been evolving and implementation varies. Demand by communities for improvement in services places more pressure on the municipalities. The aim of the study is to assess the water quality compliance and explore the effectiveness of water quality monitoring by Environmental Health Practitioners (EHPs) in South Africa.

The aim of the study is to assess the effectiveness of water quality monitoring and the water quality compliance rate in municipalities in the country. The specific objectives of the study:

- describe the water quality monitoring system by local municipalities in the country;
- assess the compliance rate of domestic water quality samples taken by EHPs per municipality;
- assess the staffing norm of EHPs per municipality in comparison to the population served; and
- establish the relationship between the results of water compliance rate and the number of EHPs per municipality.

A retrospective qualitative and quantitative study was conducted of the water quality compliance rate using the District Health Information System (DHIS) data for the period 2010-2014, with the focus on the period 2013-2014. Detailed analysis was conducted on water quality compliance rate per municipality per month, EHPs staffing norm in municipalities per province, and the compliance rate of domestic water samples taken by EHPs per municipality. The compliance rate was compared to the number of EHPs and also to the population served. Pearson's correlation coefficient (r) was used to test for association of the water quality compliance rate and number of EHPs per Municipality. Data was also analysed on health outcomes, specifically the reports of acute diarrhoea outbreaks during the same year in the North West, KwaZulu-Natal and Northern Cape provinces.

The results reveal that water quality monitoring is not implemented effectively by most municipalities. The national microbiological compliance rate for the selected municipalities in 2013 to 2014 was at 88.8%, which is below the acceptable compliance standard (100%) in

terms of SANS 241. It was also observed that the staffing status is not compliant with WHO norms: Mopani District Municipality in Limpopo has a shortage of 95%, and in Amajuba and Zululand District Municipalities in KwaZulu-Natal at 88%. Gaps in the routine data of the DHIS could not allow for a more comprehensive analysis of water quality compliance rate monitoring.

Whereas the study has shown a weak positive association between the water quality compliance rate and the environmental health practitioner staffing rate in the municipalities, the Pearson's Coefficient Correlation test results were not statistically significant ($R^2=0.0186$). The regression line shows a slight positive relationship and the correlation coefficient is also positive. While, a variability may be perceived, it is not statistically obvious nor significant and maybe the result of inappropriate data in the DHIS, tools applied or a flawed assumption of a positive relationship between these two variables.

The system exists to ensure a safe drinking water supply to communities. Gaps in legislation, formal guidelines and other contributing factors at different levels need to be addressed by various key stakeholders. As part of the water quality monitoring programme implementation by municipalities, there should be a strong emphasis on data management and communication amongst stakeholder including the Department of Health. Similarly, serious gaps in staffing for environmental health services (70%) need to be addressed to meet the WHO staffing norms.

The following are recommended to strengthen water quality monitoring at municipal level:

1. There must be a strong policy to strengthen collaboration among key stakeholders on water provision services: water services authorities, environmental health services and the community to ensure effective and efficient service delivery.
2. Review legislation to harmonise functional powers between different ministries, including reviewing the powers of MECs responsible for health to support environmental health services at municipality level, and look at the roles and responsibilities of other relevant stakeholders.
3. EHPs should be more independent from municipal structures to allow for system that will function more efficiently without any hindrance.
4. The shortage of staff guided by the WHO Norm of 1: 10 000 EHPs per population needs to be addressed by municipalities.
5. Data management including reporting and communication should be strengthened at all levels.

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Acronyms and abbreviations

DHIS	: District Health Information System
DM	: District Municipality
DOH	: Department of Health
EHPs	: Environmental Health Practitioners
EHS	: Environmental Health Services
GDWQ	: Guidelines for Drinking Water Quality
GHS	: General Household Survey
MECs	: Member of the Executive Council
METRO	: Metropolitan Municipality
MHS	: Municipal Health Services
NGOs	: Non-Governmental Organisations
NPOs	: Non-Profit Organisations
PHC	: Primary Health Care
RSA	: Republic of South Africa
RWQOs	: Resource Water Quality Objectives
SANS	: South African National Standards
SDGs	: Sustainable Development Goals
WHO	: World Health Organization
WSA	: Water Services Authority

Definition of terms

For the purpose of this study, the following definitions apply:

Description of the compliance	Compliance in this paper refers to the adherence to SANS 241 in relation to microbiological quality drinking water standards which specify there should be no presence of <i>E. Coli</i> .
Determinants	Micro-organism, physical or aesthetic property or chemical substance of which the risk posed is classified as chronic health -1, chronic health -2, aesthetic, chronic health or operational category.
Drinking water	Water that is intended for human consumption.
Environmental Health Services	Environmental health services are concerned with those aspects in the environment that constitute health risks: for example water quality, waste management, environmental pollution, food safety, vector control, control of premises, and chemical safety.
Municipal Health service	Municipal health services include most environmental health services and according to the Constitution of the Republic of South Africa, are part of a basket of services that have to be provided by local authorities including water quality monitoring. The term refers to health services to be rendered by local government
South African National Standards (SANS) 241.	The SANS 241 specifies the quality of acceptable drinking water in South Africa, defined in terms of microbiological, physical, aesthetic and chemical determinants at the point of human use that present an acceptable health risk for lifetime consumption.
Water Safety plan	A systematic process that aims to consistently ensure acceptable drinking water that does not exceed the numerical limits in SANS 241-1: 2011 by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery.
Water Services Authority (WSA)	Any municipality that has been designated as such and has the executive authority to provide water services within its area of jurisdiction in terms of the relevant national legislation or the ministerial authorizations made in terms of the relevant national legislation.
Water Quality Monitoring	A systematic process including water sampling and testing in order to ascertain the presence of biological (microorganisms) and chemical properties. In this paper water quality focuses on to microbiological quality drinking water standards.
Water Services Provider	The water services provider physically provides the water supply and sanitation services to consumers under contract to the water services authority. This function can be performed by the municipality itself or any other public or private body, such as a water board, a non-governmental organisation (NGO), a community-based organisation (CBO) or a private sector company, with whom it contracts.

CHAPTER 1

INTRODUCTION

Water quality and sanitation are known to be important determinants for good health and well-being. In South Africa, metropolitan and district municipalities play a critical role in water quality monitoring as provided for in the national guidelines and standards. Factors that influence achievement of a well performing water quality monitoring system include environmental factors, available human resources, adequate funds, and compliance to set standards.

1.1 Background of the Study

The 2030 Sustainable Development Goals (SDGs) agenda recognises health and well-being as central to sustainable development, as a precondition, an outcome, and as an indicator of a sustainable society.¹ Almost all of the other sixteen goals are directly related to health or will contribute to health indirectly. Health and well-being contribute to the attainment of the SDGs and thus benefit from their implementation. The environmental health service therefore becomes central to the implementation of the SDGs to attain good health standards and play a critical role in promoting healthy living practices in order to promote sustainable development for the present and future generations.

Water is a critical resource to maintain human well-being, as it is essential for sustaining basic human functions, health and food production, as well as for preserving the integrity of the world's ecosystem.² Access to safe drinking water is a basic right to all human beings, and their well-being is critically dependent on both the quality and the availability of water, and how well this precious resource is managed.

1.1.1 Water quality and health implications

Many African countries face considerable challenges with multiple issues that adversely affect public health.³ One such significant challenge for public health is the ability of both rural and urban Africans to access a clean water supply.³ The absence, inadequate, or inappropriately managed water and sanitation services expose individuals to preventable health risks³, with contaminated water and poor sanitation implicated in the transmission of diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio. Inadequate management of urban,

industrial and agricultural wastewater means that the drinking-water of millions of people is dangerously contaminated or chemically polluted.³

Diarrhoea is the most widely known disease linked to contaminated food and water but there are other hazards. Globally, some 842 000 people are estimated to die each year from diarrhoea as a result of unsafe drinking-water, poor sanitation, and a lack of good hygiene habits.³ In children under five, it is estimated that diarrhoea contributes to 361 000 deaths each year which can be avoided if these risk factors were addressed. Of equal importance, almost 240 million people are affected by schistosomiasis – an acute and chronic disease caused by parasitic worms contracted through exposure to infested water.³

Nearly a billion people globally lack access to clean drinking water and 2.6 billion lack access to improved sanitation services.⁴ This has been documented to predispose many people, especially in underdeveloped communities, to the risk of water-borne related diseases or illnesses. For example, in Africa studies in east Nigeria and northern Cameroon have revealed that every 1% increase in use of unprotected water sources for drinking purposes is directly associated with a 0.16% increase in child mortality.⁵

Any changes in the ecosystem of water availability and quality will impact on human health and the environment. Already, one-third of the world's population lives in countries facing moderate to high water stress exacerbated by water tables falling on every continent.² South Africa is no exception to this: the country currently faces a crippling drought of unprecedented proportions.

Even where water is available, biological agents could contaminate the fresh water resources. Such contaminants enter into drinking water systems when the water source is polluted by waste material such as human or animal waste and sewage. Polluted water causes a range of diseases which are often life-threatening. These preventable illnesses and diseases impose further burdens on the public health system.

To ensure sustainable and effective water service delivery, beneficiaries of these services have a serious and critical role to play. Failure of the system to include communities to take ownership may have various negative effects, such as water-related diseases including acute diarrhoea outbreaks that could have been prevented through early detection by ensuring adequate community participation and consultation.

1.1.2 Importance of water quality monitoring

The impact of the environment on health is significant. In this regard, the importance of ensuring the quality of water cannot be overestimated. Water quality monitoring is essential in order to identify issues which pose problems at present, as well as for identifying potential challenges in the future. Regular monitoring also ensures that changes in water bodies can be mapped over time, and trends identified leading to appropriate corrective action. Data collected from water quality monitoring enables the design and development of proper pollution prevention and management strategies.

South Africa introduced a very good water monitoring system, the Blue Drop, wherein the performance of all water service authorities pertaining to compliance with water quality standards is monitored on a regular and stringent basis. Water Services Authorities, which are either municipalities or district municipalities, are required to submit information regarding water quality and management regularly to the National Blue Drop System authority.⁶ This system provides for an assessment of changes in water quality. In some instances, data in the system is mostly based on the information collected by Environmental Health Practitioners. According to the 2014 Water and Sanitation Department Blue Drop Report on the quality of drinking water in South Africa, drinking water quality fell by 8 % between 2013 and 2014. This is undoubtedly a serious concern, not least of all for public health. Only 44 of 1036 water purification systems within municipalities nationally achieved the Blue Drop status of excellence. According to the report, Gauteng Province was the best performing province, but even here the water quality declined by 6% as compared with the previous 2012 to 2013 Blue Drop report. Limpopo is the province with worst water quality in the country, and Mpumalanga was the only province whose water grade improved.⁷

1.1.3 Health financing

South Africa's expenditure on health at 8.5% of GDP is comparatively high for a middle-income country. However, the country spends a higher share of its total health expenditure on private voluntary health insurance (41.8%) than any other country globally. This is six times more than the Organisation for Economic Cooperation and Development's average of 6.3%, which only serves 16% of the population. This is equivalent to 3.7% of South Africa's GDP. Despite recent improvements in health care, the country's health outcomes are comparable to other low income countries and there remains significant inequities in access to health service provision.⁸

More than 80% of the population of South Africa is reliant on public-sector services; either totally (over 60%) or partially (about 23%).⁹ Since 1994, South Africa has pursued the path of developing a health system that provides universal health access. Government is progressively moving away from a health system which is hospital-centric and focused on curative services leading to a primary health care (PHC) focus that advocates strongly for health promotion and prevention of illness. Building a high quality and effective PHC service delivery platform as the foundation for the health system is critical because the emphasis on prevention and promotion through PHC can reduce the burden of ill-health and the need for curative health services.^{9,10}

1.1.4 Justification for the study

It has become evident in South Africa in the recent past that there are serious challenges in terms of water quality compliance standards and monitoring. According to the 2013 National District Health Information System Report of the Department of Health¹¹, diseases associated with water quality are on the increase, and especially so in children under five years of age. This data is communicated to the National Department of Health; though little effort is made to address the root cause of increases in the mortality rate for children younger than five years when considering issues of water quality. This is arguably because the health system is biased towards a curative model of public health, thus treating patients presenting symptoms of waterborne diseases without properly addressing the environmental conditions to which they return and which created the health problem in the first instance.

Furthermore, even though compliance is important and municipalities continue to take samples, the data collected is rarely analysed to inform policy decisions and interventions both by the municipalities and the National Department of Health. Collection of such data over the past years has been more for compliance, with little focus on monitoring service delivery.

The country has appropriate policies and standards for ensuring water quality at metropolitan and district municipalities – this includes having a primary health-care policy in place that focuses on financing health service delivery. However, the burden of preventable waterborne infection and diseases in particular, remain high in parts of the population. This study aims to assess the water quality monitoring by local municipalities in the country in order to ascertain compliance level to set standards and make recommendations for improved water services.

1.2 Environmental Health Services

Environmental health services is an important agent of the preventive and promotive approach to public health systems. This service has a significant bearing on health service delivery through its potential to alleviate pressures on curative health services. According to the WHO, environmental health has an impact on 85 of the 102 listed world diseases and injuries.¹²

Environmental health as a science has essentially two aspects:

- It studies hazards in the environment, their health effects and variations in sensitivity to exposure.
- It explores the development of effective interventions to protect against hazards in the environment.¹²

An effective environmental health services system in relation to water quality management depends on appropriate legislation, governance and having a strong water quality monitoring system in place. In addition, social and environmental determinants that have the potential to influence the effectiveness of the system, must be considered and managed.

1.2.1 Environment health and water service delivery

Environmental health is a critical and integral part of PHC as it contributes to the promotion of wellness and prevention of disease, primarily by controlling environmental factors that negatively impact on the health of individuals. Investments in the control of hazardous environmental factors through an efficient and effective environmental health system can lead to the reduction in the burden of disease faced by the country. The health service delivery by municipalities faces serious challenges, particularly in relation to the capacity of the municipalities to render quality municipal health services. This is evident by the high number of complaints received from members of the public, often manifesting in service delivery protests, most of which pertain to the quality of water provision as one of the issues.

Water quality monitoring is one of the crucial functions expected to be delivered by municipalities as part of environmental health services. The National Department of Health receives data from the municipalities through the service provided by Environmental Health Practitioners but has never fully analysed it to inform policy-direction or to evaluate the efficiency of municipalities in providing municipal health services.

1.2.2 Legal Framework

The legal framework providing the mandate for the delivery of municipal health services is entrenched in the Constitution of SA, 1998 (Act 108 of 1996)¹³ and in particular in sections 24 and 27 respectively (Bill of Rights) as well as Section 152(1)(d) setting it as an objective for local government to ensure a safe and healthy environment, whilst the Constitution mentions the term municipal health services in Schedule 4B. These functions are exclusive local government functions that are to be rendered by the Metropolitan (Category A) and District (Category C) Municipalities, as determined by the Local Government: Municipal Structures Act, 1998 (Act 117 of 1998)¹⁴ Section 84(1)(i) and Section 32 of the National Health Act, 2003 (Act 61 of 2003)¹⁵ as part of the package of services for environmental health practice. The Municipal Systems Act (Act 44 of 2000)¹⁶ allows for the cooperative governance which enables different sectors to work together in order to ensure effective delivery of services within the municipality including water related activities.

1.2.3 Water quality monitoring system

A water quality monitoring system is introduced to ensure adequate and safe water supply in the country. Drinking water compliance rate data is collected in all nine provinces and measures the compliance rate for domestic water from Water Services Authorities - these being mainly municipalities. This data is communicated on a monthly basis and monitored through the District Health Information System (DHIS) on a quarterly basis. Data in the DHIS is based on samples collected by environmental health practitioners through the municipal health services water quality monitoring system.

1.2.4 Factors affecting water quality

Social determinants of health such as living conditions, access to health facilities, resource depletion and broader social protection issues are the major focus areas of environment health. In order to curb the rise in South Africa's quadruple burden of disease (HIV/AIDS, underdevelopment, non-communicable chronic diseases related to unhealthy lifestyle, and injuries), the country will need to give greater priority in addressing up-stream (primary contributing factors) health determinants including water, air pollution, food safety, to mention just a few.¹⁷ This requires recognising that the social determinants of health arise from the

conditions in which people are born, grow up in, live in, type of work, and age. This entails facing those key determinants of health, such as provision of sufficient clean water, safe sewage disposal and good hygiene, which are fundamental to children's growth and to public health and human and economic development. In addition, when a population is exposed to environmental hazards, a relationship is established between the levels of exposure and health outcomes, which requires a return to foundational principles and strengthening of the provision of environmental health services, focusing on the assessment, correction, controlling and prevention of those environmental factors which are detrimental to public health.

Environmental health practice, mainly located within local government, provides the means to enhance health by planning and developing health-promoting environments that contribute to better health outcomes.¹⁸ Environmental health practice covers the assessment, correction, control and prevention of environmental factors that can adversely affect health.¹⁸ Environmental health requires local governments to identify and undertake necessary measures to deal with issues such as environmental degradation and climate change, including hazards such as chemical exposure and contamination of water and food.¹⁹

Since 1994, government has promulgated extensive legislation and regulations on health issues and some sectors of government are actively addressing threats to environmental and human health. Nevertheless, a number of limitations become clear. These include:

- the limited ability to manage environmental health impacts;
- inadequate integration across government departments;
- the inadequate capacity to implement environmental health services;
- limited community involvement;
- a lack of equity in the planning and delivery of services; and
- inadequate consideration of global environmental health and preventative health issues.¹⁸

1.3 The overall problem

South Africa has sufficient legislation and systems in place to ensure the safe and adequate provision of water to the communities. However, challenges associated with implementation of legislation, insufficient or inadequate resources and inadequate feedback, negatively impact on the provision of optimal service-delivery including water quality monitoring. This therefore results in poor delivery of services which is associated with the increase in preventable health risks.

Municipalities regularly collect water samples as part of the responsibilities required by law. Furthermore, District Health Information System of the National Department of Health compels municipalities to report on monthly basis the compliance rate of the domestic water sampled. The department receives such information and uses it to compile quarterly reports as part of monitoring and evaluation to make sure that the quality of water supplied complies with legally set standards. During the period of collecting data for this study, system to provide regular feedback reports from the Department of Health to the municipalities was not clear. Previously the Department of Health has been very active in developing new policy documents guiding the delivery of environmental health services (EHS) which resulted in additional burdens to the municipalities such as funding, human resources and logistical needs. Furthermore, the Department of Health has existing structure where various activities relating to the delivery of environmental health services at all levels of governance is discussed on a quarterly basis. Such a structure can be used effectively to ensure that regular feedback relating to water quality monitoring is given.

There are National Data Indicators for work conducted by environmental health practitioners (EHPs) which are conveyed by municipalities. These indicators only reflect a portion of work conducted by EHPs at the local government level. According to the records at the National Department of Health, there are approximately 2200 functional EHPs (those which are registered with the Health Professions Council of South Africa) at the municipality level, with an additional 2874 EHPs required for the current national population in order to meet the 1:10 000 environmental health practitioner to population ratio as prescribed by the National Environmental Health Policy in accordance with World Health Organization standards.²⁰

1.3.1 Legislation and environment

Rapid urbanisation, climate change, globalisation, pollution (water, air and land), including poverty and inequity are amongst the key concerns in environmental health. Deregulation and relaxation of certain environmental health related legislations post-1994 have resulted in and given rise to other challenges in terms of implementing the set norms and standards.^{10,19} The resultant non-optimal compliance to the law has resulted in people's negative behaviours that increase exposure to risks that lead to emerging and re-emerging diseases.

Policies in place to regulate environmental health-related matters have proven to be adequate and appropriate. The Government of South Africa has adopted a PHC approach through the *National Health Plan for South Africa* and the Reconstruction and Development Programme in 1994, and subsequently the *White Paper on Health: Towards a National Health System*, published in November 1996.¹⁰ The *White Paper* provides for the establishment of a national health system in South Africa which, will in broad terms, consist of three levels of health service delivery with each level responsible for specific functions.¹⁰ These functions provide for, inter alia, the rendering of services aimed at, amongst others, ensuring safe water provision to the community.

1.3.2 Governance and Leadership

In addition to a critical shortage of human resources, a 2016 audit on the National Environmental Health National Norms and Standards conducted by the Department of Health also revealed a lack of proper planning and budgeting for environmental health services by municipalities to provide programmes based water quality monitoring. A lack of planning means that services are not provided based on the needs of the communities, and are not informed by identified and pre-assessed analysis of risks. This renders the service reactive and not proactive, contrary to good environmental health practice.

1.4 Aim of the Study

The aim of the study is to assess the water quality monitoring system and the factors that influence its optimal performance and the implications thereof for policy and legislation implementation on environmental health service delivery by municipalities.

1.5 Specific objectives of the study

The specific objectives of the study are:

- to describe the water quality monitoring system by metropolitan and district municipalities in the country;
- to assess the compliance rates of domestic water quality samples taken by EHPs per municipality;
- to assess the staffing norm of EHPs per municipality in comparison to the population served;

- to establish the relationship between the results of water compliance rates and the EHP staffing rate per municipality; and
- to assess for presence of any the relationship between the results of water compliance rates and incidence of acute diarrheal diseases in the three Provinces that reported outbreaks in 2013/14.

1.6 Research hypotheses

The Water quality monitoring compliance rate is influenced by various factors within the water management system. It is hypothesised that the performance of municipalities on compliance with water monitoring standards is positively related to the number of EHPs available to the municipality. More specifically, it is hypothesised that there will be an association linked to:

- the water compliance rates by municipalities and the number of EHPs employed therein;
- the water compliance rates by municipalities and the population size of the municipality; and
- the occurrence of acute diarrhoea diseases in children under five in provinces that reported outbreaks, and this will be associated with the low water compliance rate.

1.7 Scope of the study

In 2000, the DHIS was adopted as the official South African routine health information system for managing aggregated routine health service-based information. All 52 identified categories of municipalities are expected to report on prescribed indicators to the National Department of Health using the DHIS, which in many cases in district municipalities are the water services authorities.

For the purpose of the study, out of the Ten (10) environmental health indicators monitored by EHPs at district municipalities, only one key indicator has been selected, that is, Environmental Health Domestic Water Compliance Rate, as a measure of the efficiency of each municipality in executing this particular functional mandate. The DHIS health information data system has been utilised to work on municipal indicator reports for Environmental health domestic water analysis to demonstrate compliance to water standards by each metropolitan and district municipality and also to ascertain the human resource capacity in each municipality.

1.8 Structure of the thesis

- a) Chapter one outlines a general introduction, the background of the research study, the statement of the problem, and the objectives. This chapter further outlines the aim, the objectives, the research hypothesis and the scope of the study.
- (b) Chapter two comprises the background to the government context for water quality monitoring. This section covers legislation governing water quality monitoring in South Africa, roles and responsibilities of different sectors in water quality management, water quality and health, and water quality monitoring.
- (c) Chapter three explains the research methodology. It includes the study design, the data collection method and the data analysis process that will be undertaken to analyse data.
- (d) Chapter four presents the results and reports on the study findings.
- (e) Chapter five discusses the results of the study and the limitations of the study.
- (f) Chapter six discusses the conclusion drawn from the study, and provides recommendations for consideration by the National Department of Health.

CHAPTER 2

BACKGROUND AND CONTEXT: POLICY AND LEGISLATION

2.1 Literature review

The quality of drinking water is an issue for public health in both developing and developed countries. According to the World Health Organization (WHO), annually there are four billion cases of water-related diseases which result in at least 1.8 million deaths, making it one of the leading causes of morbidity and mortality.¹⁷ An estimated 99.8% of such deaths occur in developing countries - 90% are children under the age of five.¹⁷ Half of the world's hospital beds are estimated to be occupied by people suffering from water-related diseases.¹² In addition, 88% of these diseases are attributed to inadequate water supply, poor sanitation and hygiene.¹⁷

According to the WHO, an estimated 23% of all the deaths in Africa are as a result of avoidable environmental health hazards such as contaminated water, poor hygiene, and inadequate sanitation, amongst others.²¹ Poor quality of the environment contributes to around 25% of all preventable ill-health cases in the world today, and the majority of these diseases are associated with poverty.²¹ Diarrhoea and other waterborne diseases cause hundreds of deaths annually.²² Many South Africans live under conditions where the risk is high for contracting water and sanitation-related diseases such as diarrhoea, cholera, dysentery, and typhoid, to mention just a few.¹⁷ This is mostly linked to the lack of basic services like access to safe food, safe water supply, and sanitation facilities such as toilets and waste management services which result in unsafe hygiene practices in households and communities. Research has already established that poor sanitation, lack of safe and clean drinking water, and poor hygiene contribute largely to the increasing global mortality rate of children, particularly those five years and younger.²²

2.1.1 Overview of Water in South Africa

South Africa is a water-scarce country and ranks as one of the driest countries in the world with an average rainfall of 40%, less than the annual world average rainfall.²³ In addition, the country has recently experienced a drop in the availability of this important resource. The country's state of water storage is estimated at 64.3% of normal full supply compared with a 74.6% storage level in 2014.²³ The downward trend is indicative of hydrological and meteorological droughts.²³ In KwaZulu-Natal, it has been reported that as a result of the drought, young children are at

higher risk of diarrhoea, which remains the most prominent single cause of mortality in children under the age of five years in the country.²³

In order to ensure that local communities receive water quality of acceptable standard, there is a need for proper water quality monitoring. In this regard, EHPs located in municipalities have a critical role to play.

2.2 What is water quality?

Water quality is the term used to describe the chemical, physical, biological and aesthetic properties of water, usually with respect to its suitability for an intended purpose or use.²⁴ These characteristics are controlled or influenced by substances, which are either dissolved or suspended in water. Thus, when water is polluted, it means it has certain characteristics that make it unfit for its intended use, and thus it has the potential to cause harm to people and their health, safety and welfare; including the environment or to property.²⁴

Every effort should be made to ensure that we get drinking-water that is safe, accessible and available. Safe drinking-water refers to water that has been tested and does not present any significant risk to health in terms of its microbiological, physical and chemical qualities.²⁵ Accessibility relates to water facilities that are easy to reach and located in an environment that is safe, as well as the provision of technology that is easy to use and operate. Availability refers to the total volume of water that the consumer accesses from the water source within a period of 24 hours.²⁵

2.3 Legislation governing water provision and water quality monitoring in South Africa

The Strategic Framework for Water Services in South Africa, approved by cabinet on 17 September 2003,²⁶ sets out a comprehensive approach with respect to the provision of water services in South Africa, ranging from small community to large regional water supplies. It addresses the full spectrum of water and sanitation supply provision services. To fulfil this mandate of water supply service, water should be accessible, adequate, affordable, reliable and potable to all.

Section 3.6.4 of this Framework further allocates specific roles and responsibilities to other national government departments to support the Department of Water Affairs in fulfilling its

policy, regulatory, support and information management roles. The Department of Health plays specific roles at local government level.

The responsibilities of the Department of Health are further outlined in the National Health Act, 2003 (Act 61 of 2003)¹⁵ which defines MHS that covers - amongst other functions, water quality monitoring. This function is allocated to metropolitan and district municipalities as per section 32 of the National Health Act and as stipulated in section 84(1)(b);(d) and (i) of the Municipal Structures Act, 1998 (Act 117 of 1998).^{15,27} In addition to this function, the Scope of Profession of Environmental Health, as published under Regulation 698 of 2009 (26 June 2009), promulgated under the Health Professions Act, 1974 (Act 56 of 1974),²⁸ determines the role of environmental health in water quality monitoring, including:

- mapping of water sources;
- monitoring water quality and availability;
- law enforcement and regulations related to water quality management;
- ensuring water safety and acceptability in respect of quality (with emphasis on microbiological, physical and chemical properties), and access to an adequate quantity for domestic use;
- ensuring that water supplies are readily accessible to communities by providing inputs toward the planning, design and management of the water supply system, and ensuring healthy community water supplies through surveillance;
- ensuring effective monitoring of waste water treatment and water pollution control, including the collection, treatment and safe disposal of sewage and other waterborne waste, including surveillance of the quality of surface water (including the sea) and ground water;
- advocacy on proper and safe water usage and waste water disposal; and
- water sampling and testing in the field, and examination and analysis in a laboratory.

2.3.1 Policy and legislative framework

In addition to the Scope of Practice for Environmental Health, there are various policies and legislation that EHPs are required to fulfil with regard to water quality management. Such legislation includes the following:

a) The Constitution of South Africa, 1996

The Bill of Rights contained in the Constitution enshrines the right of all South Africans to have access to water; section 27(1) (b).¹³

The Constitution outlines the responsibilities of local government to manage its administration, budgeting and planning processes to give priority to the basic needs of the community, to promote the social and economic development of the community with the support of national and provincial government. The Constitution allocates the MHS under Schedule 4B, and Section 156(1), as a local government function (South Africa, 1996). The term MHS evolved in SA to define the package of health services to be rendered by local government. Therefore, MHS is subsequently defined in the National Health Act, 2003 (Act 61 of 2003) as a component of health services.^{10,27} According to the agreement reached by Ministers and Members of the Executive Council (MINMEC) on 21 August 2003, and with the approval of the Minister for Provincial and Local Government and National Treasury, the MHS delivery will be the responsibility of metropolitan and district municipalities. It was further decided that the policy decisions regarding MHS would apply from 1 July 2004.²⁷

b) Water Services Act, 1997 (Act 108 of 1997)²⁹

The Water Services Act provides a legislative framework for the rights of access to basic water supply and sanitation. It provides for the setting of norms and standards for tariffs. The Act also provides for water services development plans as well as a regulatory framework for water services institutions and water services intermediaries.

c) National Health Act 2003, (Act 61 of 2003)

The National Health Act provides a framework for a structured uniform health system within South Africa and in particular provides for the establishment of municipal health services (section 32) at district municipality level. The Act defines and allocates the health services to be provided by municipalities. These are defined as MHS comprised principally of the basket of environmental health services. Water quality monitoring is one of the functions located within this basket.

d) South African National Standard (SANS) 241 ³⁰

The SANS specifies the quality of acceptable drinking water in South Africa, defined in terms of microbiological, physical, aesthetic and chemical determinants at the point of human use that present an acceptable health risk for lifetime consumption.

e) Guidelines and Policies initiated during the period of the study

During the course of this research, guidelines on the norms and standards for water quality monitoring were in the process of compilation, including circulation for comments in provinces and municipalities. These were, however, being utilised as a guide in some provinces and municipalities. After receiving minimal inputs, the official publishing for implementation only occurred in 2015.

2.4 Roles and responsibilities of different sectors in water quality management

The collective pieces of legislation identify and clarify the various responsibilities of different government departments related to water quality management. Role clarification is critical as it assists the role-players, including EHPs and the various departments, to understand the responsibility of each sector so as to avoid confusion and duplication in providing the service. The most important role-players are the Department of Water Affairs and Sanitation, the Department of Corporate Governance and Traditional Affairs, and the Department of Health. The roles and responsibilities for each sector as summarised by the National Environmental Health Norms and Standards³⁰ is clarified as follows:

2.4.1 Water Sector

2.4.1.1 Department of Water Affairs

The Department of Water Affairs (DWA) is the custodian of the water resources and the overall leader of the water sector. The DWA is therefore responsible for:

- a) providing leadership within the water sector;
- b) policy development and regulation of water services;
- c) providing support to municipalities in line with the regulatory function to ensure compliance with national norms and standards;
- d) managing water information; and
- e) designating Water Services Authorities.

2.4.1.2 Water Boards

- These are bulk water suppliers in the country. In total, there are 13 water boards which supply 24 million people in 90 Municipalities which is inclusive of Metropolitan, District and Local. The Water Boards are responsible for operating dams, supplying bulk water infrastructure; however, Inkangala Water Board in the Mpumalanga Province was disbanded. As of September 2012 there is a total 12 water boards (Figure 1).
- Some retail infrastructure and some wastewater systems across the country.
- Some also provide technical assistance to water service authorities.
- Through their role in the operation of dams, they also support water resources management.

In terms of coordination, the Water Boards report to the Department of Water Affairs (DWA).³²

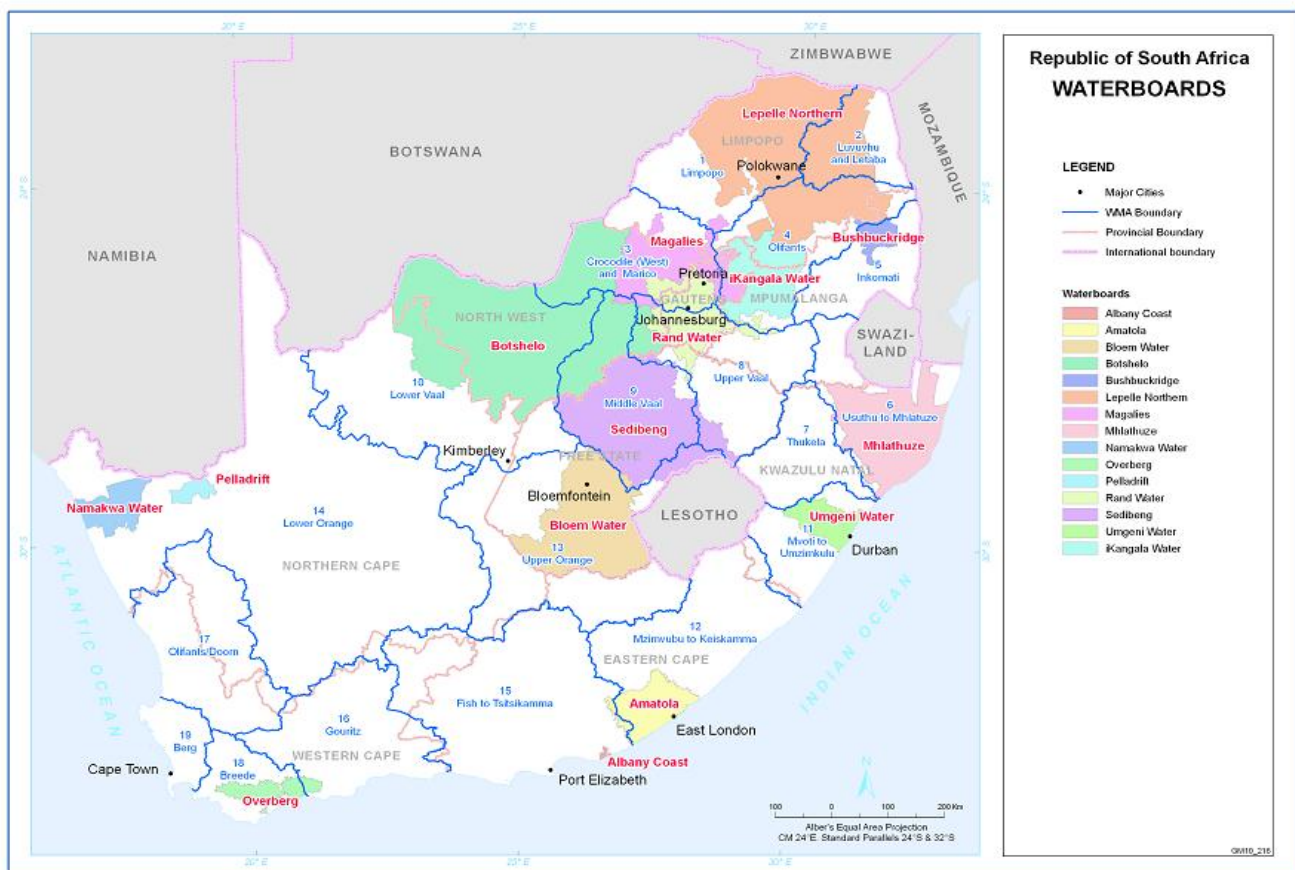


Figure 1: Map of Water Boards in South Africa, 2012. Source: Department of Water Affairs

2.4.1.3 Water Service Authorities

Municipalities that are designated as Water Services Authorities (WSAs) are responsible for:

- water services planning;

- b) ensuring access of community to water; and
- c) regulating the provision of water services within their area of jurisdiction.

National Government has implemented regulations and policies to deliver safe water to all communities in South Africa, but some local municipalities have not necessarily fully complied with the national guidelines.¹⁸ This policy guidelines is broad and makes provision for the water service provider to perform this function, and it further allows for the formation of a joint venture with another water service institution. This scenario mostly exists in rural municipalities.

2.4.2 Department of Corporative Governance and Traditional Affairs³³

The mandate of the Department of Corporative Governance and Traditional Affairs (COGTA) Ministry oversees:

- the system of Cooperative Government as per Chapter 3 of the Constitution;
- provinces (Chapter 6 of the Constitution);
- local government (Chapter 7 of the Constitution); and
- traditional leaders (Chapter 12 of the Constitution).

The mission is to ensure that all municipalities perform their basic responsibilities and functions consistently by putting people and their concerns first, supporting the delivery of municipal services in attaining the right quality and standard, promoting good governance including transparency and accountability, ensuring sound financial management and accounting, and building institutional resilience and administrative capability.³³

2.4.2.1 Department of Corporative Governance and Traditional Affairs and municipal service

To ensure a smooth service delivery, environmental health services at the municipality level need to work closely with other key stakeholders including the Department of Corporative Governance and Traditional Affairs (COGTA) and the Department of Water Affairs. This arrangement is made possible by policies governed by GOGTA which is mandated to oversee and guide services implemented by municipalities.

2.4.2.2 District Municipalities in relation to Municipal Health Service

Most district municipalities have been designated in terms of the Water Act as water services authorities. In terms of the law, EHPs are employed in this sphere of government and one of

their duties is to monitor the quality of water supplied to communities. The funding model of the municipalities in providing this service is based on equitable sharing (population and/or household-based) which is a form of bulk allocation for the comprehensive services within the municipality.

2.4.3 Health Sector

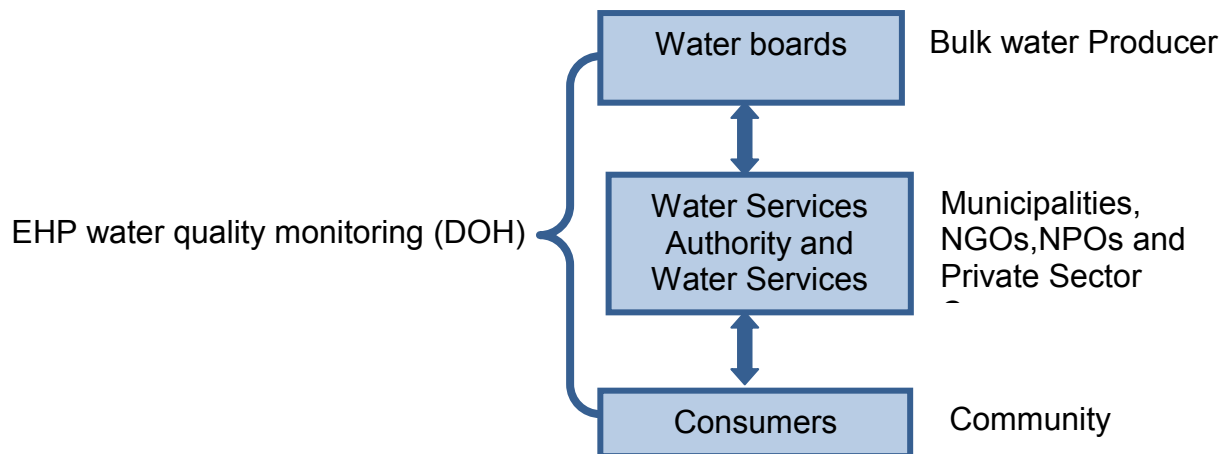
2.4.3.1 Department of Health

As the custodians of the health of the citizens of South Africa and in fulfilling its constitutional and legislative obligations, the Department of Health incorporates considerations regarding environment and health into its policy and legislative development processes and actions.³⁴

In addition to the roles and responsibilities as allocated in the Strategic Framework for Water Services 2003, the Department of Health is also responsible for:

- a) monitoring compliance with and enforcement of health-related water legislation, regulations and norms and standards;
- b) monitoring of water (both surface and ground water) in respect of accessibility, quality (microbiological, physical and chemical) and quantity for human consumption as well as in respect of the quality for recreational and industrial use;
- c) audit sampling and compliance enforcement sampling;
- d) risk identification for the purpose of managing the risks;
- e) surveillance of waterborne related diseases to ensure healthy community water supplies;
- f) ensuring monitoring of effective waste water treatment, including the collection, treatment and safe disposal of sewage and other waste;
- g) advocating for proper and safe water usage and waste water disposal;
- h) coordinating programmes aimed at creating the demand for safe water and sanitation through health and hygiene awareness and education; and
- i) risk management through water pollution control.²⁶

Within the Department of Health (DOH), water quality monitoring is spearheaded by Environmental Health Services. The Diagram below summaries the relationship between the key role players and their respective functions.



2.5 Water and health

The poor quality of drinking water has been directly or indirectly responsible for the spread of waterborne diseases such as cholera, dysentery, hepatitis A and E, giardiasis, and haemolytic uremic syndrome.²² Diseases and illnesses due to a lack of potable water further threaten the human security of vulnerable communities. The implications of this lack of clean water and access to adequate sanitation are widespread. Young children die from dehydration and malnutrition; these result from suffering with diarrheal illnesses that could be prevented by consuming clean water and maintaining good hygiene habits.²²

Diarrhoeal diseases are regarded as significant public health problems in South Africa; they are rated the 3rd leading cause of death in the country.²² For example, of the 34 828 (children under five) diarrhoeal admissions reported in 2011 in South Africa, there were 1846 reported deaths.²² In 2012, there were 1457 deaths reported out of 34 216 diarrhoeal disease admissions.²² In addition to children being at higher risk of diarrhoeal diseases, they also suffer long-term consequences, such as malnutrition, growth retardation, and impairment of cognitive development.

Safe and readily available water is thus critically important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. In 2010, the UN General Assembly explicitly recognised the human right to water and sanitation.³⁵

2.5.1 Diarrhoeal Diseases Incidence in South Africa

There was evidence of a rise of diarrhoeal cases reported to health facilities in some provinces in the country.¹⁷ During this period, reports of upsurges and outbreaks of diarrhoeal cases were

from the three provinces: North West, KwaZulu-Natal and Northern Cape. During the same time, assessment of water quality data was found to be non-compliant to the set standards in the selected province.

Below are the summary reports of acute diarrhoeal disease outbreaks that were reported in a specific period:

2.5.1.1 Diarrhoeal outbreaks reported between February 2013- February 2014

a) North West Province

During May 2014, there was an outbreak of diarrhoea in Bloemhof in North West Province - 400 cases of acute diarrhoea were reported to local health facilities, including three deaths.^{11,17} It was later confirmed that the outbreak was waterborne-related, as evidenced by the laboratory results of stool-analysis, as well as the analysis of drinking water samples at various points of use within the community. Further evidence was provided by the findings that the affected municipality had experienced water quality system failures linked to suspected sewage leakage. Upon investigation (including discussion with the local municipality) it was confirmed that it was pollution due to leakage from a sewage pipe into a clean water system.

The South African Human Rights Commission provided a report after three infants died from water contamination in Bloemhof. The community suspected cholera as a number of patients exhibited symptoms of diarrhoea. The contaminated water was suspected as the cause of the disease due to neglected sewage-system maintenance.³⁶

Following the admission of eight babies to the hospital, an outbreak of acute diarrhoea was declared. Five deaths of children under five years of age were reported, leaving many more suffering from the disease. Cholera was excluded as the possible cause of the outbreak but more tests were conducted to confirm other possible causes of the disease. During this outbreak, over 200 people reported to local clinics with symptoms of acute diarrhoea which included severe diarrhoea exhibiting abdominal pain and cramping. The suspected cause was gastro-enteritis. The outbreak was controlled following intensive public health interventions coupled with the restoration of the Bloemhof water supply to comply with the health standards.^{17,36}

b) KwaZulu-Natal

In February 2013, an outbreak of diarrhoea was reported in the Zululand District Municipality, KwaZulu-Natal Province where over 40 cases of this disease were reported. The cause of the diarrhoea was confirmed to be waterborne sources, after deficiencies in water quality were detected in the tap water provided by the municipality.¹⁷

During May and June 2013, a rise in the number of diarrhoeal cases was reported in various hospitals in the Ethekwini Municipal area. There were about a 1000 fatal cases who were infected and they were from Inanda, Ntuzuma, uMlazi, Amoati, Mayville and uMbumbulu areas. Rotavirus was confirmed as the cause of the outbreak. Although water analysis did not detect any fault in the quality of water, sanitation posed a different scenario - more than a third of the communities in these areas had access to non-water borne sanitation facilities.¹⁷

Poor hygiene was related as the cause of the disease. The National Health Laboratory Service tested 242 specimens from hospital and clinics in the Ethekwini Municipality in June, and 55% was attributed to rotavirus.¹⁷

c) Northern Cape

Between February and May 2013, a suspected outbreak of diarrhoea was reported in Upington, where a total of 138 cases and 5 deaths were reported at Gordonia Hospital. It was later confirmed that it was due to Rotavirus infection.¹⁷

Diarrhoea had caused one death and infected 150 pupils at schools in the Northern Cape in Upington in ZF Mgcawu District Municipality. The village of Garuele in the Northern Cape was the most affected with one death attributed to the outbreak of diarrhoea; the culprit was suspected as being contaminated water supply. About 150 learners at a school in Mothibistad and some of the villagers were also affected.¹⁷

2.6 Water access and use

South Africa has done well in ensuring that its citizens have access to water; however, the biggest concern remains the quality of the drinkable water. According to the General Household Survey (GHS) of 2012-13 published by Statistics South Africa,³⁷ the proportion of households in

the country with access to piped or tap water in the dwelling, offsite and onsite is 91.2%. The provincial breakdown is as follows:

- Western Cape (98.9%)
- Gauteng (97.3%)
- Eastern Cape (79.0%)
- Northern Cape (95.6%)
- Free State (96.7%)
- KwaZulu-Natal (87.3%)
- North West (91.1%)
- Mpumalanga (87.5%)
- Limpopo (80.1%)

Four provinces (Western Cape, Gauteng, Free State and Northern Cape) have a very high access rate of above 95 %. This information is based on the provincial aggregated figure, and the figures vary across individual districts within the provinces.³⁷

2.6.1 Level of satisfaction by water users

According to the GHS, there was a decline in household satisfaction with water services: 75.4% in 2005 rated that the water service they received as being good compared to 60.1% in 2013. The percentage of water users who rated water services as average increased from 15.8% in 2005 to 31.8% in 2009, before declining to 27.1% in 2010 and rebounded to 27.8% in 2012. Similarly, the percentage of users who rated water services as poor has slightly increased to 10.2% in 2009 before shifting to 12.1% in 2012.^{17,37}

Households in Western Cape and Gauteng provinces were satisfied with universal access to water and perhaps, predictably, most content with the quality of water services they received. Despite the noticeable improvements since 2002, the percentage of households with access to water in Eastern Cape, Limpopo, KwaZulu-Natal and Mpumalanga still lags behind the national average of 90.8%.^{17,37}

Whereas access to water is high in most parts of the country the biggest concern remains the quality of drinkable water.

2.7 Water quality

Water quality is defined as water which is safe and drinkable. In South Africa, scarce fresh water is decreasing in quality because of an increase in pollution.^{2,38} Moreover, water service quality is highly variable and the data for monitoring it, is often incomplete.³⁸ In 2003, 63% of municipalities were not able to demonstrate adherence to safe drinking water quality standards.^{39,40} The Blue Drop Strategy introduced by the Department of Water Affairs and Sanitation in 2008, not only focuses on compliance with water standards, but also the existence of water safety plans, including processing, controlling and maintaining credibility of sample results, amongst other key requirements.⁴⁰

A system is in place to ensure the acceptable quality of water at municipal level; however, it comes with some serious implementation challenges. A study by Ulrike (2013)⁴⁰ critiques the national monitoring "blue-drop" system as disadvantaging under-resourced municipalities. It argued that the current system implemented to monitor drinking water quality compliance nationally favours the economically affluent municipalities who have the ability and means to implement policy and best practices. The small and under-resourced municipalities, on the other hand, could be negatively impacted by these systems to the extent that water quality monitoring has been reduced to mostly a bureaucratic function that has limited impact on municipal decision-making. Other salient factors which cannot be ignored include rapid urbanisation and climatic changes.⁴⁰

All required resources to ensure and maintain the acceptable standard of water quality such as funds, human resources, materials and equipment must be adequately provided. Hence, water quality monitoring should be adequately resourced including a feasible budget within the funding mechanisms of municipality.

2.7.1 Water Quality Monitoring Programmes

The supply of drinking water must be regularly sampled to assess its fitness for human consumption, both on an operational level and on a compliance level.²⁵ The National Environmental Health Norms and Standards 2015, states that environmental health services should develop and implement Water Quality Monitoring Programmes. The purpose of the programme concerns the monitoring of water which has the potential to impact human health from catchment to consumer. Dedicated personnel should be available to coordinate health-

related water quality monitoring within the municipal health services in order to ensure effectiveness of environmental health water quality monitoring programmes.³¹

At present many rural communities are not served from water treatments works and are still reliant on groundwater and other local water sources.³ This also poses considerable public health risks to these populations. The problems arise as a consequence of contamination of water by faecal matter, particularly human faecal matter, containing pathogenic organisms. The contamination of drinking water by pathogens causing diarrhoeal disease is the most important aspect of drinking water quality control and assessment.⁴¹ The purpose of water quality monitoring conducted by environmental health practitioners is to identify potential problems in time, in order to take corrective measures and mitigate the impact on citizens' health.

For lifetime consumption, the microbiological, physical, aesthetic and chemical quality of water provided by Water Services Institutions and Water Services Authorities must conform to the requirements as set out in the **SANS 241** for drinking water:

- (a) Water must be suitable for all domestic uses (drinking, food preparation and personal hygiene).
- (b) Water provided must not only be safe but also acceptable in appearance, taste and odour (aesthetically acceptable water).
- (c) Water must not be harmful to water supply systems and household appliances; for example, geysers and kettles.³⁰

2.7.2 Functions of Environmental Health Practitioners

2.7.2.1 Environmental Health Practitioners

Environmental Health Practitioners (EHPs) hold a three-year Diploma in Environmental Health registered with Health Professions Council for an independent practice. These EHPs are employed directly by district municipalities which are mostly designated water services authorities that operate in a semi-autonomous system of governance. Information gathered within the municipalities is reported through the District Health Information System. Such data is consolidated at national level, analysed and expected to provide feedback as part of the service- delivery monitoring.

2.7.2.2 Sampling and Analysis of water by Environmental Health Practitioners

The use of a range of different techniques periodically by EHPs, which is dependent on the availability of resources (funds, logistics and supplies) take water samples at the point of use such as water taps, boreholes, rivers, and so forth. These samples are then taken for laboratory analysis and the results are reported into the DHIS.

Monitoring of source water at the point of use is done to ensure that water is safe. Recommended parameters that should be monitored include *E. coli* or thermotolerant (faecal) coliforms (microorganisms associated with human excreta and pathogens), disinfectant residual (to determine its presence and absence and to check for post-treatment contamination), if chlorine is used it should be no less than **0,2mg/l** and no more than **5mg/l**, chemicals of acute significance (lead nickel, iron, cadmium and copper leachate), corrosion-related contaminants, turbidity (possible transfer of dirt), heterotrophic plate count (for the general status of microbial life in the system) and aesthetic parameters.^{25,30}

No *E. coli* must be found in a 100ml of sample water as it is indicative of presence of bacteria or pathogens associated with human excreta.^{25,30}

All samples must meet the WHO Guidelines for Drinking Water Quality or South African National Standards for chemicals as there are potentially significant effects associated with chronic exposure (Table 1).

Table 1: Microbiological determinants

1	2	3	4
Determinant	Risk	Unit	Standard limits
<i>E.coli</i> ^a or faecal coliforms ^b	Acute health - 1	Count per 100ml	Not detected
Cytopathogenic viruses ^c	Acute health - 2	Count per 10 L	Not detected
Protozoan parasites ^d <i>Cyptosporadium</i> species <i>Giardia</i> species	Acute health - 2 Acute health - 2	Count per 10L Count per 10L	Not detected Not detected
Total coliforms ^e	Operational	Count per 100 mL	10
Heterotrophic plate count ^f	Operational	Count per mL	1 000
Somatic coliphages ^{cg}	Operational	Count per 10 mL	Not detected

^a Definitive, preferred indicator of faecal pollution.

^b Indicator of unacceptable microbial water quality, could be tested instead of *E coli*, but is not

1	2	3	4
Determinant	Risk	Unit	Standard limits
the preferred indicator for faecal pollution.			
<p>^c Confirms a risk of human infection and faecal pollution, and also provides information on treatment efficiency. The detection of selected viruses confirms faecal pollution of human origin.</p> <p>^d Confirms the risk of infection and faecal pollution, and also provides information of treatment efficiency. The detection of a selection of selected protozoan parasites confirms human health risk.</p> <p>^e Indicates potential faecal pollution and provides information on treatment efficiency and after growth.</p> <p>^f Process indicator that provides information on treatment efficiency, after growth in distribution networks and adequacy of disinfectant residuals.</p> <p>^g Process indicator that provides information on treatment efficiency.</p>			

Source: South African National Standards, 241³⁰

2.7.3 Water safety plans

The WHO has identified that the most effective means of consistently ensuring the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management approach, which encompasses all steps in the water supply system from catchment to consumer. Water safety plans are powerful tools for the drinking-water supplier to manage the supply safely. These are also valuable to assist surveillance of water supply safety by public health authorities (e.g. environmental health services). The Water Services Act and subsequent Strategic Framework on Water Services 2008 require that Water Services Authorities have Water Safety Plans in place. These must ideally be developed by a multi-disciplinary team of experts, such as engineers, planning officers, architects, infection control coordinators, occupational health and safety personnel, standard-setting bodies, as well as public health or hygiene professionals.³¹

Consequently, EHPs are indispensable for developing and reviewing water safety plans by Water Services Authorities. In addition, EHPs help to ensure that health-related aspects are considered, thus improving health surveillance and opening communication channels among the various role-players involved in water quality management. Water Safety Plans should highlight the risk of water quality issues and water sources outside catchment areas, such as rivers and streams; and environmental health services should provide public health oversight of drinking water supplies. This includes ensuring that communities and households without

access to treated water are provided with health-related information on water treatment at household level including the danger of utilising untreated water.³¹

2.8 State of water quality in South Africa

According to the National State of Water Quality Review (DWA, 2010), only 17% of all sites assessed in the country complied to all the Resource Water Quality Objectives (RWQOs).^{42,43} This study is limited to the microbiological (bacterial) analysis of water compliance and the performance measure being *E. coli*. The ideal performance standards should include and meet other components of the water quality standards (Sulphate, Chloride, Orthophosphate, Ammonia and pH) as stipulated in the RWQOs; however, these are not covered in this study. Water quality is monitored at two different levels: in stream (before purification) and also at the point use (Figure 2).

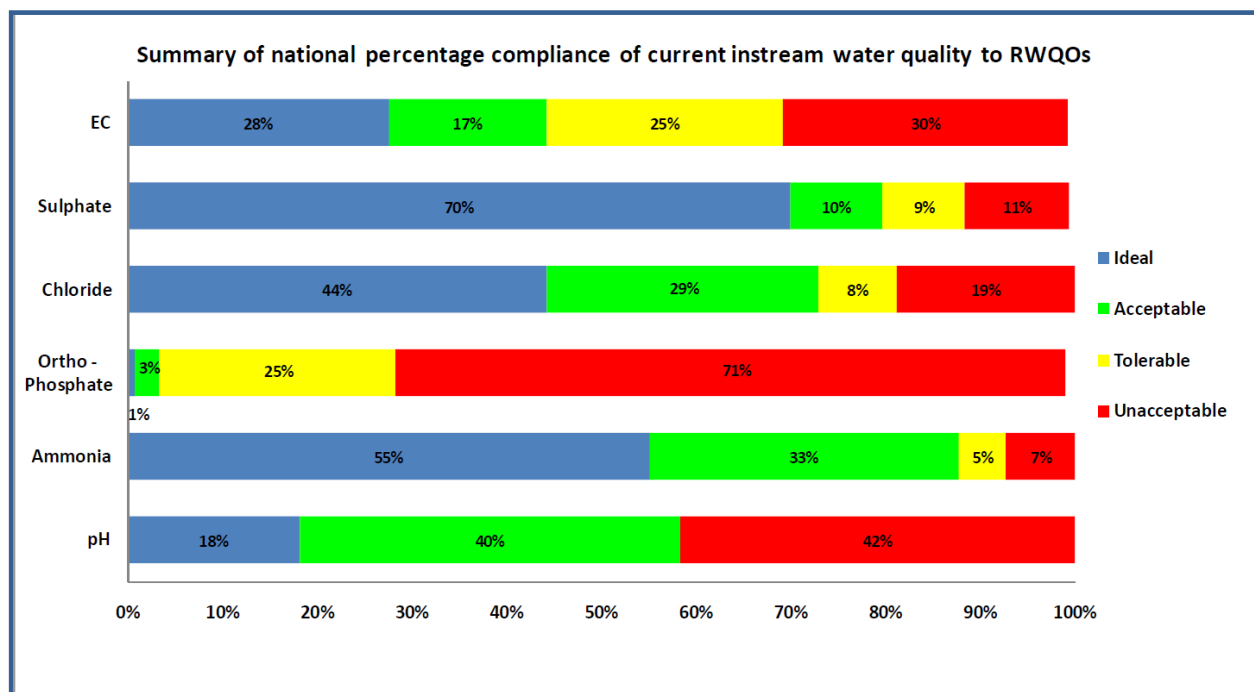


Figure 2: Summary of National Percentage Compliance of current in-stream water quality to RWQOs.
 Source: National State of Water Quality Review, DWA, 2010

The study aims to explore aspects within the system taking into consideration governance and leadership issues that can contribute to the supply of safe water to community in South Africa.

CHAPTER 3

METHODOLOGY

3.1 Data and study design

This study was a retrospective qualitative and quantitative cross-sectional research investigating the water quality compliance rate using the routine data from DHIS for the period 2010-2014 with the focus on 2013-2014 (Appendix 1). The initial analysis covered the annual National Water compliance rate using data from 2010-2014, and was followed by a detailed analysis for 2013-2014 which focused on water quality compliance rate per municipality per month, EHPs' staffing norms in municipalities per province and the compliance rate of domestic water samples taken by EHPs per municipality.

3.2 Study population

3.2.1 Population

The study population consists of all eight metropolitan and forty-four district municipalities in South Africa. Local municipalities were excluded in the study. The report analysed data from all fifty-two municipalities that reported in the DHIS. Data was not available from four district municipalities including three from Mpumalanga Province (i.e. Ehlanzeni, Gert Sibande and Inkangala) and Mopani from Limpopo Province.

3.3 Identifying variables

3.3.1 Outcome variable

The outcome variable was the rate of compliance of water samples taken for human consumption in municipalities with the focus on the microbiological component. This rate is dependent on the quality of water samples taken meeting the compliance standards in terms of the SANS 241. Compliance in this paper refers to the adherence to SANS 241 in relation to microbiological quality drinking water standards which specify there should be no presence of *E. coli*. The quality of drinking piped water generally should comply with national standards prescribed to ensure water that is fit for human consumption. Key factors that influence the compliance rate will be identified, and hence this provides a good assessment of the performance of the relevant authority in relation to water quality monitoring.

3.3.2 Explanatory variables

- a) Existing water related legislation and systems for water quality monitoring.
- b) Size of the municipality in terms of its population.
- c) Number of EHPs per municipality based on the WHO standards.

3.4 Analysis Plan

3.4.1 Relationship amongst variables

The following relationships were examined:

- a) the relationship between results of water samples compliance rate from municipalities and the EHP staffing rate;
- b) the relationship between size of the municipalities and number of EHPs;
- c) the relationship between results of water samples compliance rate from municipalities and occurrence of diarrhoeal incidence in the three provinces; the relationship between results of water samples compliance rate from municipalities and the province under which the metropolitan and/or district municipality is located; and
- d) other factors such as change in legislation during the period under review, plans for municipalities such as resource allocation for water quality monitoring including compliance of water quality rate and the monitoring of diarrheal disease outbreak in selected provinces.

3.5 Data analysis

3.5.1 Descriptive component

Data was gleaned and then analysed descriptively using frequency tables, line curves and bar charts presented per municipality. Categorical variables are represented as frequency counts and percentages, while continuous variables are summarised using mean, median, standard deviation and range. Trends on water quality compliance rate were also analysed.

The national average performance for domestic water compliance rate was analysed per province with the aim of assessing the state of drinking water quality supplied by the metropolitan and district municipalities in the country; and secondly to identify if there is any

relationship with other factors such as legislation, human resources and changes in the system during the period under review.

3.5.2 Analytical component

In all statistical testing, a p-value of less than 0.05 was considered statistically significant. Data were analysed using STATA version 12.1(Stata Corp, Texas, USA).

Data for five years (2010-2014) from the Environmental Health Indicator Data Report was considered in the study. Data from provinces that reported incidences of acute diarrhoea including outbreaks during the same year under review was also analysed.

A total of 48 of the 52 district municipalities (92.3%) that reported in the District Health Information System (DHIS) were assessed for water quality compliance rate. Factors such as staffing that may have a potential impact on water quality management system were also analysed and are presented. Data was not received from four district municipalities including three from Mpumalanga Province and one from the Limpopo Province.

3.6 Ethical consideration

Ethical approval was obtained from the University of Cape Town. All data used is available in the District Health Information System of the National Department of Health and no ethical clearance was needed for its use as the study was conducted as part of the operational activities of the National Department of Health, and this was approved by the employer.

CHAPTER 4

RESULTS

4.1 Water quality compliance rate performance

4.1.1 Trend of performance at National Level from 2010 to 2014

Figure 3 below shows the monthly national trends of water quality compliance rate during the period 2010-2014. The fluctuation in the water quality compliance rate has been observed through the years. Following very low compliance rates which were observed for 2010-2011, a high compliance rate of 100% (absence of microbiological organisms) was reported in 2011-2012 over a period of seven months. However, it is important to note that there were identified data gaps in the DHIS (Appendix 1).

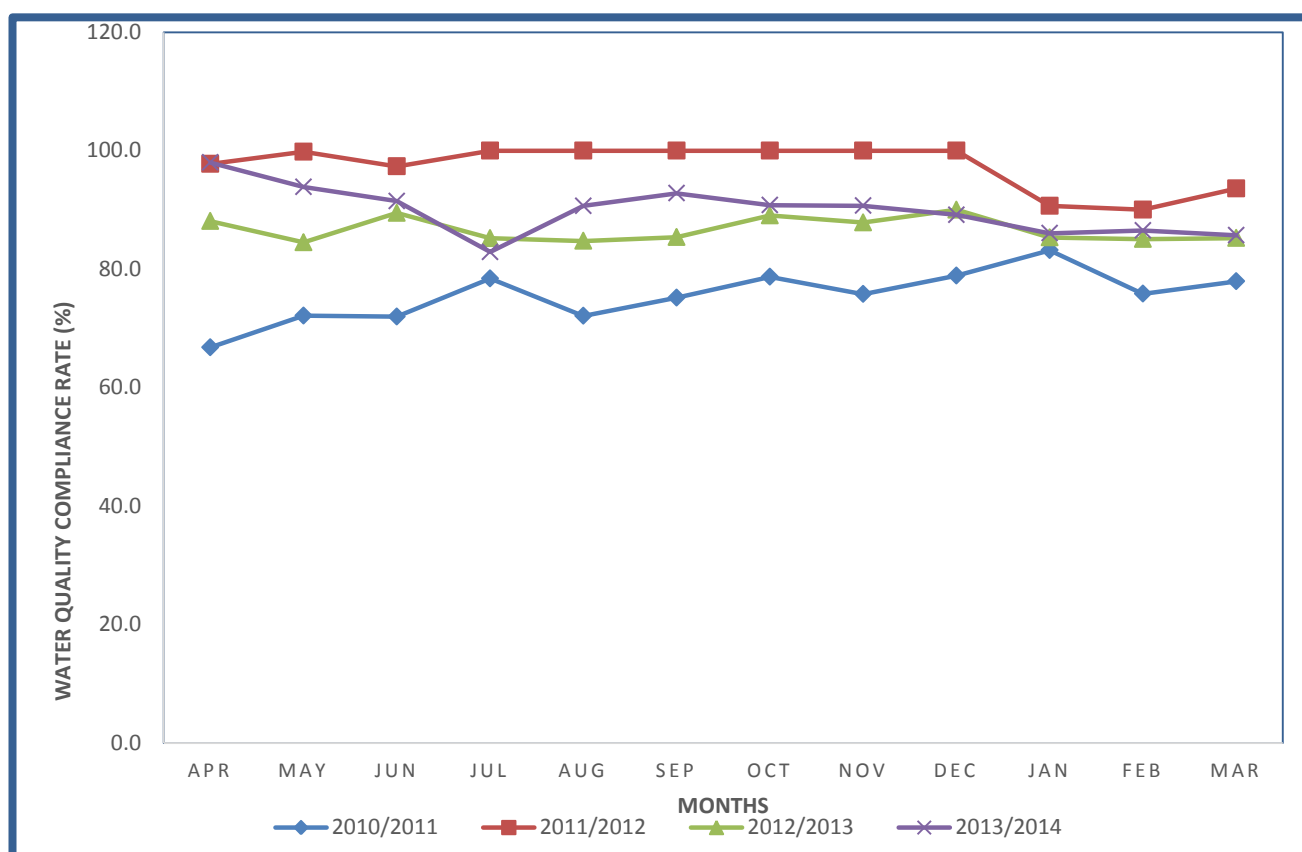


Figure 3: National monthly water quality compliance rate, April 2010-March 2014. Source: DHIS Data, 2013/14

4.1.2 National water quality compliance rate performance per province 2013/14

The provincial trend of water quality compliance rate (quarterly) for the period 2013/14 is shown in the Figure 4 below.

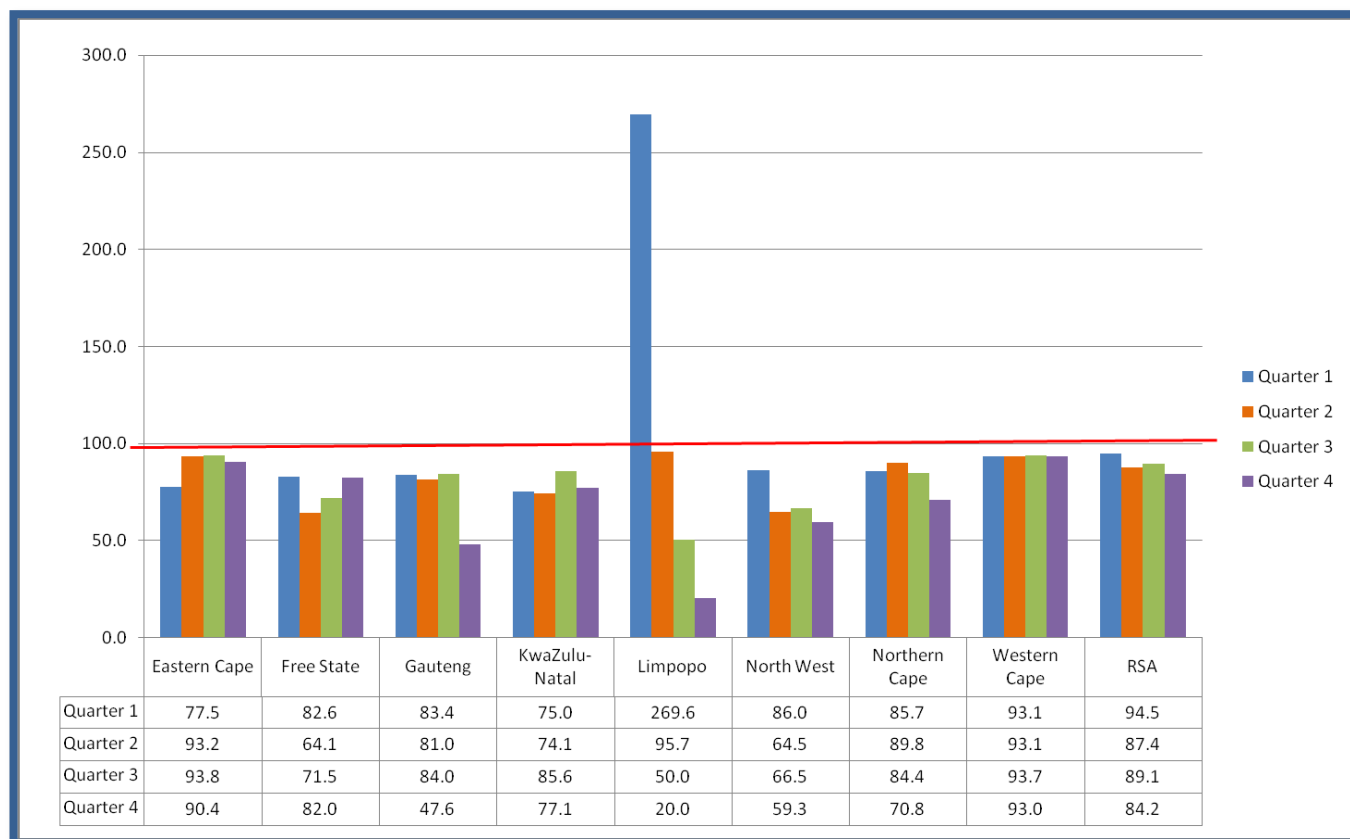


Figure 4: EH Domestic Water sample quality compliance Rate per quarter per province during the financial year 2013/ 2014. Source: DHIS Data, 2013/14

None of the provinces met the acceptable standards (100% i.e. free of *E. coli*). The national average performance for domestic water compliance rate was at 88.8% with the highest achievement noted in Limpopo Province at 96% during the second quarter for the financial year 2013/2014. Though the compliance rate is high in the Limpopo Province, it is skewed by the data for quarter one which indicates a theoretically invalid compliance rate in excess of 100% in the first quarter. The lowest performance (20%) was reported during quarter four in the same province. The abnormal quarter one figure which is an outlier introduces the bias into the overall performance (108%) for the province in comparison to other provinces, and should be regarded with caution due to likely data reporting errors.

Eastern Cape improved its compliance rate from 77.5% in the 1st quarter to slightly above 90% in all the quarters, and KwaZulu-Natal also showed an increase though it fluctuated in-between the quarters. A number of provinces showed a decline. Gauteng declined from 83.4% in the

first quarter to 47.6% in the last quarter; a decline that is significant, however, it is not possible to verify reasons for this big drop, considering that data used is routine DHIS data. The other provinces declined also: North West declined from 86.0% in the first quarter to 59.3% in the last quarter; and Northern Cape from 85.7% in the first quarter to 70.8% in the last quarter. Therefore, it is important to ascertain the possible root causes for the observed decline.

The Western Cape was consistently above 90% in all the four quarters. Mpumalanga did not report on this indicator which affects the national figure for the year, but is erroneously indicated at 88.8%.

4.1.3 Monthly trend of performance at national level for 2013 / 2014

Between April and November relatively high (above 90%) water compliance rate coverage was attained; however, the ideal status as set out in the standards was not achieved. The water quality compliance rate was particularly low (83%) during the month of July (Figure 5). A decline (89% - to 86%) was also observed during December 2013 to March 2014, a period which coincides with the warm summer rainy season. This could raise the question of variation in the sampling points, considering that some water sources are likely to be contaminated during this season.

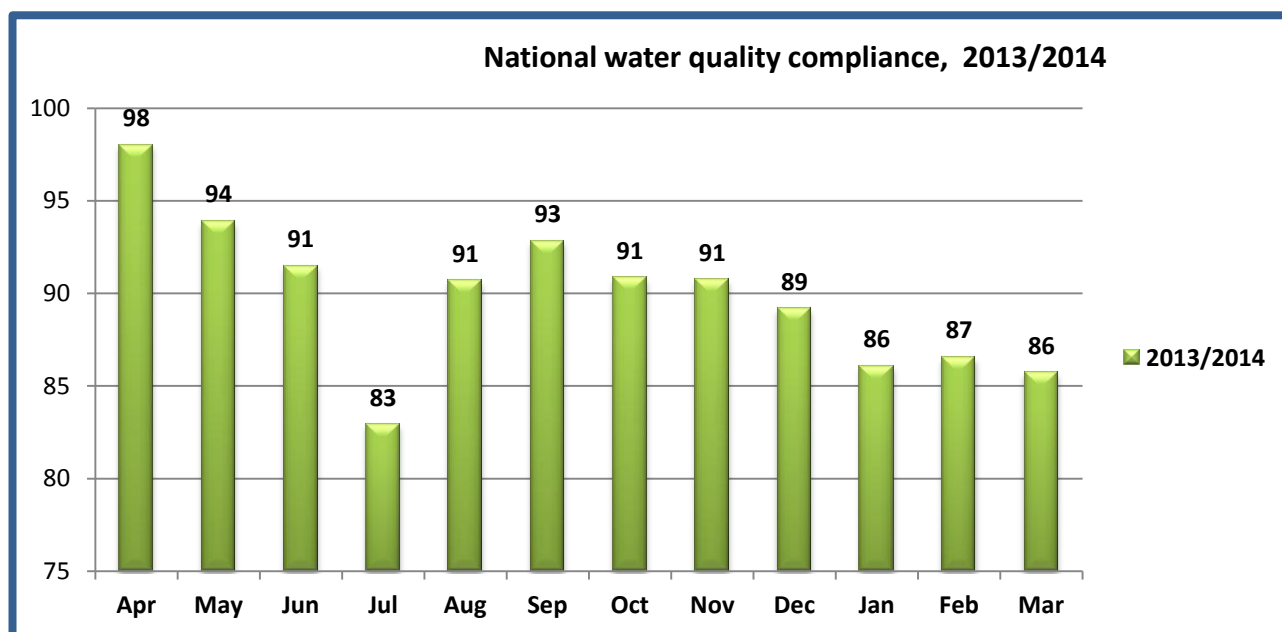


Figure 5: National water quality compliance rate (monthly), April 2013- March 2014. Source: DHIS Data, 2013/14

4.1.4 Water quality compliance rate of metropolitan and district municipalities, 2013/14

Figure 6 shows the results of drinking water quality compliance rate data collected in 48 metropolitan and district municipalities. This is based on samples collected through municipal health services water monitoring programmes by EHPs. Water quality compliance rate to SANS 241 in terms of bacteriological quality during April 2013 to March 2014 is shown.

None of the municipalities were found compliant within the minimum acceptable standard level. The water quality compliance rate ranges between 0% in three municipalities (Joe Gqabi District Municipality in Eastern Cape as well as Mopani and Sikhukhune District Municipalities in Limpopo) to 100% in the Ekurhuleni Metropolitan in Gauteng and Uthukela District Municipality in KwaZulu-Natal. The results of the compliance rate in Capricorn District Municipality in Limpopo Province is an outlier with the water quality compliance rate of 136%, but this will need in depth analysis to identify possible reporting errors.

District municipalities that did not report during the year under review include: all the three district municipalities (Ehlanzeni, Gert Sibande and Nkangala) in Mpumalanga Province and one (Vhembe) out of the five district municipalities in Limpopo Province. The non-reporting by Mpumalanga Province raises a serious concern and needs to be investigated further.

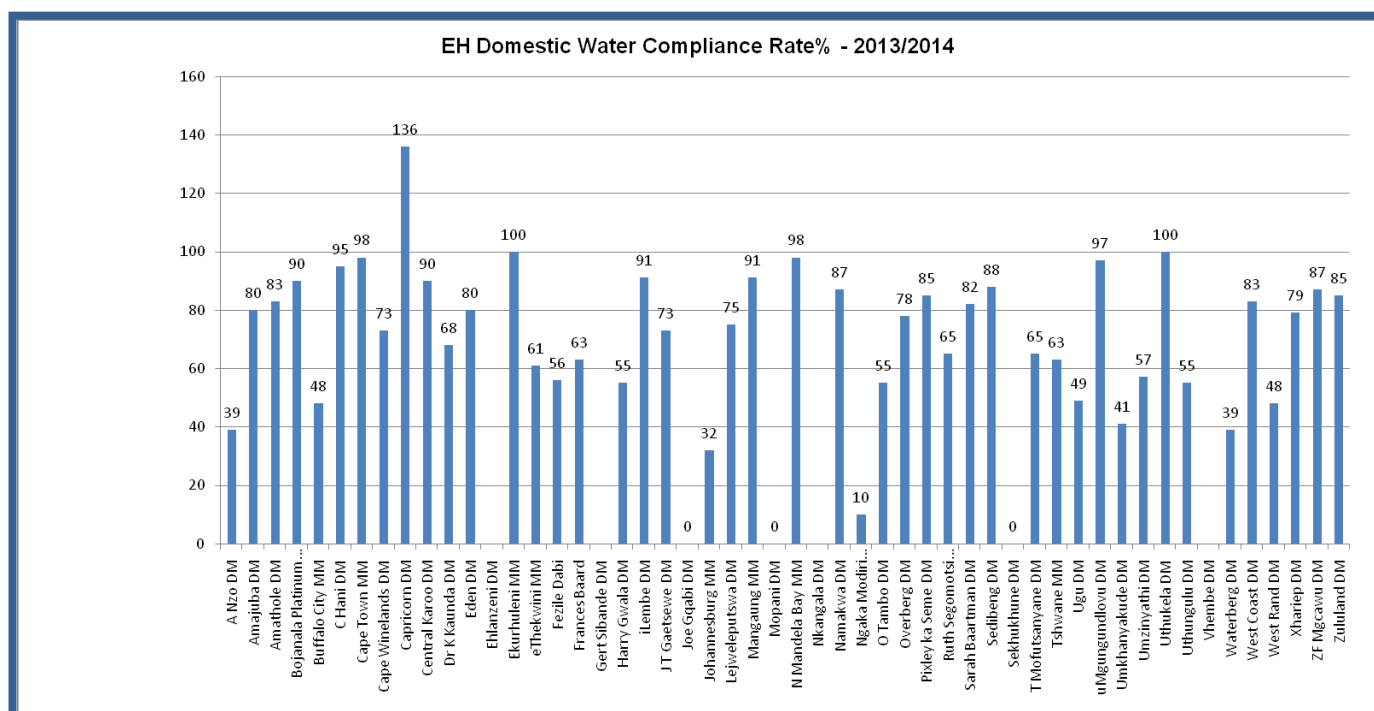


Figure 6: National water quality compliance rate by Municipalities, April 2013- March 2014. Source: DHIS Data, 2013/14

4.2 EHP staffing and water quality compliance rates in the country for 2013 / 2014

Table 2 below shows the EHPs' staffing status, compliance to the staffing norms, the staffing gap and water quality compliance rates per metropolitan and district municipalities in the year 2013/2014.

The number of EHPs varied widely and did not necessarily have an influence in the water quality compliance rate: for example, in Gauteng, the city of Ekurhuleni with the staffing gap of 65% met the required standard (100%); in KwaZulu-Natal, UThukela District Municipality with the staffing gap of 76% also met the required standard (100%). In Gauteng in the City of Johannesburg where there are 244 EHPs with a staffing gap of 199 EHPs (45%), the compliance rate is very low, (32%). In the Eastern Cape in the Joe Gqabi District Municipality with 20 EHPs (a shortage of 43%) had a 0% compliance rate while in Limpopo, Mopani and Sekhukhune District Municipalities with 6 and 19 EHPs which is 95% and 82% staff shortages respectively also had a 0% compliance.

Number	Name of the Municipality	Province	Compliance Rate 2013-14 (%)	Number of EHPs 2013/14	EHP Staffing rate (%) against WHO norm	Population Size / Municipality (2011)	Population covered per EHP (Number)	Gap Shortage based on WHO Norm (1EHP: 10 000 population)	Total number of EHPs required	Shortage rate (%)
GAUTENG PROVINCE										
1.	Ekurhuleni Metro	Gauteng	100	110	35	3178470	28895	208	318	65
2.	City of Johannesburg Metro	Gauteng	32	244	55	4434827	18176	199	443	45
3.	City of Tshwane Metro	Gauteng	63	70	24	2921488	41736	222	292	76
4.	Sedibeng DM	Gauteng	88	33	36	916484	27772	59	92	64
5.	West Rand DM	Gauteng	48	23	28	820995	35695	59	82	72
Sub Total for Gauteng			66.2	480	39	12272264	123379	747	1227	61
KWAZULU-NATAL PROVINCE										
6.	Ethekwini Metro	KwaZulu-Natal	61	119	35	3442361	28927	225	344	65
7.	Harry Gwala DM (Former Sisonke DM)	KwaZulu-Natal	55	6	13	461419	76903	40	46	87
8.	uMzinyathi DM	KwaZulu-Natal	57	9	18	510838	56760	42	51	82
9.	Ugu DM	KwaZulu-Natal	49	16	22	722484	45155	56	72	78
10.	Umgungundlovu DM	KwaZulu-Natal	97	23	23	1017763	44251	79	102	77
11.	iLembe DM	KwaZulu-Natal	91	14	23	606809	43344	47	61	77
12.	Amajuba DM	KwaZulu-Natal	80	6	12	499839	83307	44	50	88
13.	Zululand DM	KwaZulu-Natal	85	10	12	803575	80358	70	80	88
14.	uMkhanyakude DM	KwaZulu-Natal	41	8	13	625846	78231	55	63	87
15.	King Cetshwayo DM (Former UThungulu M)	KwaZulu-Natal	55	24	26	907519	37813	67	91	74
16.	uThukela DM	KwaZulu-Natal	100	16	24	668848	41803	51	67	76
Sub Total for KwaZulu-Natal			70	251	24	10267301	40905	776	1027	76
EASTERN CAPE PROVINCE										
17.	Nelson Mandela Bay Metro	Eastern Cape	98	40	35	1152115	28803	75	115	65
18.	Buffalo City Metro	Eastern Cape	48	24	32	755200	31467	52	76	68
19.	Joe Gqabi DM	Eastern Cape	0	20	57	349768	17488	15	35	43
20.	Alfred Nzo DM	Eastern Cape	39	31	39	801344	25850	49	80	61
21.	OR Tambo DM	Eastern Cape	55	28	21	1364943	48748	108	136	79
22.	Chris Hanu DM	Eastern Cape	95	30	38	795461	26515	50	80	62

Number	Name of the Municipality	Province	Compliance Rate 2013-14 (%)	Number of EHPs 2013/14	EHP Staffing rate (%) against WHO norm	Population Size / Municipality (2011)	Population covered per EHP (Number)	Gap Shortage based on WHO Norm (1EHP: 10 000 population)	Total number of EHPs required	Shortage rate (%)
23.	Amatole DM	Eastern Cape	83	25	28	892637	35705	64	89	72
24.	Sarah Baartman DM (former Cacadu DM)	Eastern Cape	82	16	36	450584	28162	29	45	64
Sub Total for Eastern Cape			62.5	214	33	6562052	242738	442	656	67
LIMPOPO PROVINCE										
25.	Capricorn DM	Limpopo	136	24	19	1261463	52561	102	126	81
26.	Mopani DM	Limpopo	0	6	5	1092507	182085	103	109	95
27.	*Vhembe DM	Limpopo	No report	23	18	1294722	56292	106	129	82
28.	Greater Sekhukhune DM	Limpopo	0	19	18	1076840	56676	89	108	82
29.	Waterberg DM	Limpopo	39	28	41	679336	24262	40	68	59
Sub Total Limpopo			44	100	19	5404870	54048.7	440	540	81
NORTH WEST										
30.	Bojanala Platinum DM	North West	90	25	17	1507505	60300	126	151	83
31.	Dr Ruth Segomotsi Mompati DM	North West	65	8	17	463815	57977	38	46	83
32.	Ngaka Modiri Molema DM	North West	10	13	15	842699	64823	71	84	85
33.	Dr Kenneth Kaunda DM	North West	68	18	26	695933	38663	52	70	74
Sub Total for North West			58.3	64	18	3509952	221763	287	351	82
WESTERN CAPE PROVINCE										
34.	City of Cape Town Metro	Western Cape	98	135	36	3740026	27704	239	374	64
35.	Cape Winelands DM	Western Cape	73	49	62	787490	16071	30	79	38
36.	West Coast DM	Western Cape	83	28	71	391766	13992	11	39	29
37.	Overberg DM	Western Cape	78	16	62	258176	16136	10	26	38
38.	Eden DM	Western Cape	80	41	71	574265	14006	16	57	29
39.	Central Karoo	Western Cape	90	4	56	71011	17753	3	7	44
Sub Total for Western Cape			83.4	273	47	5822734	105662	309	582	53
MPUMALANGA PROVINCE*										
40.	Gert Sibande DM	Mpumalanga	No report	38	36	1043194	27452	66	104	64
41.	Nkangala DM	Mpumalanga	No report	10	8	1308129	130813	121	131	92
42.	Ehlanzeni DM	Mpumalanga	No report	12	7	1688615	140718	157	169	93
Sub Total for Mpumalanga			No report	60	15	4039938	67332.3	344	404	85

Number	Name of the Municipality	Province	Compliance Rate 2013-14 (%)	Number of EHPs 2013/14	EHP Staffing rate (%) against WHO norm	Population Size / Municipality (2011)	Population covered per EHP (Number)	Gap Shortage based on WHO Norm (1EHP: 10 000 population)	Total number of EHPs required	Shortage rate (%)
FREE STATE PROVINCE										
43.	Mangaung Metro	Free State	91	20	27	747431	37372	55	75	73
44.	Xhariep DM	Free State	79	5	34	146259	29252	10	15	66
45.	Lejweleputswa DM	Free State	75	10	12	627626	62763	53	63	84
46.	Thabo Mofutsanyane DM	Free State	65	19	26	736238	38749	55	74	74
47.	Fezile Dabi DM	Free State	56	15	31	488036	32536	34	49	69
Sub Total Free State			73.2	69	25	2745590	39791	206	274	75
NORTHERN CAPE PROVINCE										
48.	ZF Mgcawu DM (former Siyanda DM)	Northern Cape	87	10	38	263783	26378	16	26	62
49.	Namakwa DM	Northern Cape	87	10	86	115842	11584	2	12	14
50.	Pixley kaSeme DM	Northern Cape	85	5	27	186351	37270	14	19	73
51.	Frances Baard DM	Northern Cape	63	4	10	382086	95522	34	38	90
52.	John Taolo DM	Northern Cape	73	6	27	224799	37467	16	22	73
Sub Total Northern Cape			79	50	43	1172861	23457	67	117	57
Grand Total			88.8	1561	30	51797560	2419038	3619	5180	70

Table 2: EHP Staffing status, gap and water quality compliance rates by Municipality, 2013/2014

**No data was collected in Mpumalanga Province and in Vhembe District Municipality in Limpopo Province during this reporting time*

4.3 The comparison of EHP staffing and size of municipality to water quality compliance rate

To test whether there is an association between water quality compliance rate, EHPs' staffing rate and size of the municipality, a simple linear regression test was performed. Population figures for the 2011 Census were used for the size of the municipality.

4.3.1 The relationship between water compliance rate and the environmental health practitioner staffing rate based on WHO Standard (1:10 000 population) per municipality

The scatterplot graph provided in Figure 7 shows the correlation coefficient between the EHP staffing rate and water quality compliance rate from municipalities is 0.17. This graph suggests that there is a weak positive linear association between the water quality compliance rate and the EHP staffing rate (Table 3). Furthermore, the Pearson's Coefficient Correlation test results were not statistically significant ($R^2 = 0.0186$). Whereas a variability may be perceived, it is not statistically obvious nor significant and maybe the result of inappropriate data in the DHIS, tools applied or a flawed assumption of a positive relationship between these two variables.

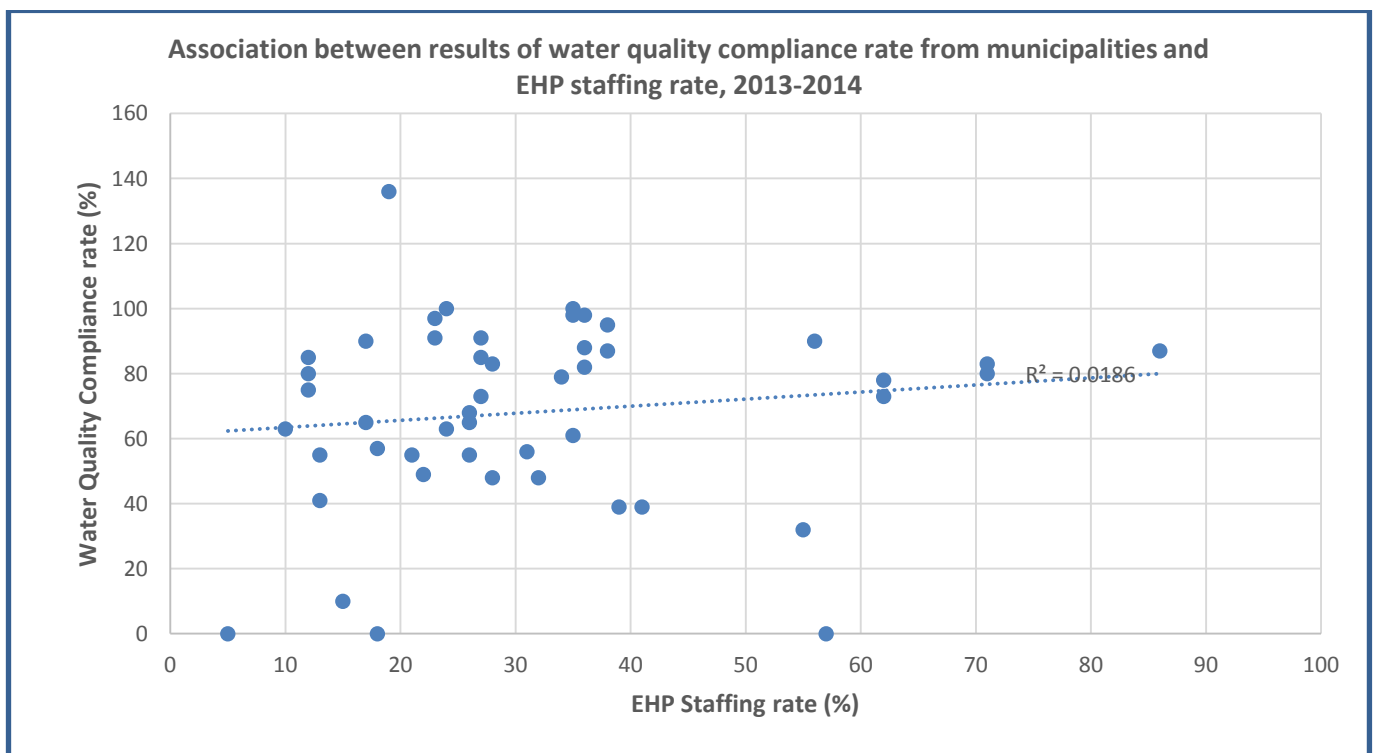


Figure 7: Association between results of water quality compliance rate from Municipalities and EHP staffing rate, 2013/2014

4.3.2 The relationship between water quality compliance rate and the size of the municipality

The relationship between water quality compliance rate and the size of the municipality (population) is shown in the graph below (Figure 8). The scatterplot and the correlation coefficient table (Table 3) show that there is slight negative linear association between compliance rate and both population size of the municipality and EHP staffing rate. The Pearson's Coefficient Correlation test results were not statistically significant (p -value > 0.05). The regression line shows a negative relationship and the correlation coefficient is also negative.

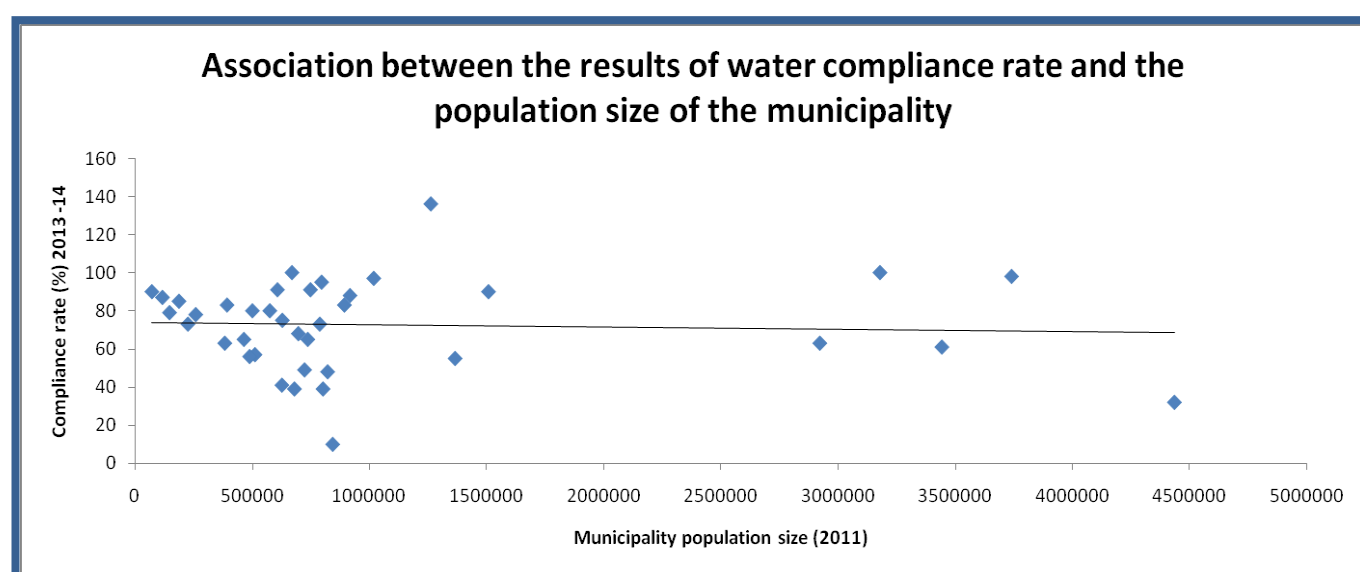


Figure 8: Association between results of water compliance rate and the population size of the Municipality

Table 3: Correlation coefficients

	Compliance Rate 2013-14 (%)	EHP Staffing Rate 2013-14 (%)	Population Size of the Municipality (2011)
Compliance Rate 2013-14(%)	1		
EHPs staffing rate (%)	0.1656664	1	
Population Size of the Municipality (2011)	-0.0526524	0.911327407	1

4.4 Occurrence of Acute diarrhoea, 2013/14

Acute diarrhoea occurs commonly amongst children under five years of age in the country (DHIS Data System) and it is also one of the most common water-borne related diseases (Figure 9).

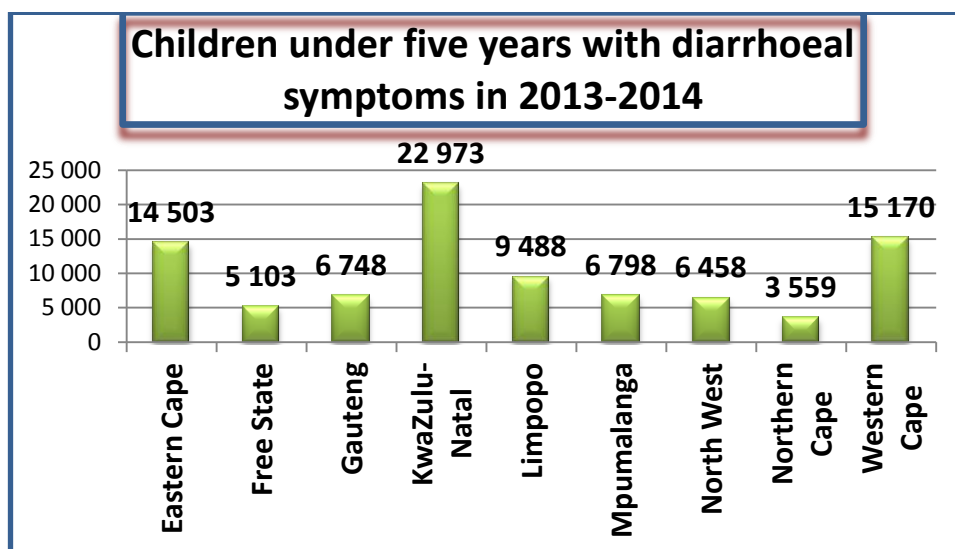


Figure 9: Acute diarrhoeal disease amongst children under five, 2013-2014. Source: DHIS Data, 2013/14

4.4.1 Water quality compliance rate and incidence of acute diarrhoea

During the year under review all provinces reported cases of acute diarrhoea in children under five years of age. There is no obvious relationship between the water quality compliance rate and the prevalence of acute diarrhoea amongst children under five (Table 4).

A review of records of incidence of acute diarrhoeal diseases amongst children under five was conducted for the period 2013-2014. All provinces had reported incidences of acute diarrhoea, with Northern Cape reporting the highest prevalence (303/100000 population) followed by Western Cape (261/100000 population), KwaZulu-Natal (224/100000 population) and Eastern Cape (221/100000 population).

Province	EHP Numbers/ Province	Compliance to the Norm 1:10 000	Staffing Gap	Acute Diarrhea/100000 population	Water quality Compliance Rate
Eastern Cape	214	27413	442	221	62.5
Free State	69	32465	206	186	73.2
Gauteng	480	18168	747	55	66.2
KwaZulu-Natal	251	37352	776	224	70
Limpopo	100	21500	440	176	43.8
Mpumalanga	60	32590	344	168	nil report
North West	64	31381	387	184	58.3
Northern Cape	85	17522	67	303	79
Western Cape	273	17183	309	261	83.4

Table 4: Occurrence of Acute diarrhoea and water quality compliance rate 2013/14. Source: DHIS Data, 2013/14

4.4.2 Districts that reported an occurrence of acute diarrhoeal disease outbreaks and water quality compliance rate in the three provinces (KwaZulu-Natal, North West, Northern Cape), 2013/14.

A review of the water quality compliance rates in the three provinces that reported outbreaks of diarrhoea during the year under review varied: in the North West, the range is between 10% in Ngaka Modiri District Municipality and 90% in Bojanala Platinum District Municipality; in KwaZulu-Natal the range is 41% at UMkhanyakude District Municipality to 100% at Uthukela District Municipality; and in Northern Cape the range is between 63% in Francis Baard District Municipality and 87% ZF Mgcawu and Namaqua District Municipalities.

With the exception of time periods when the standard (100%) was achieved (Dr Ruth Mompoti DM during the months of July-September 2013, Ethekewini Metropolitan Municipality and Zululand District Municipality November 2013, and ZF Mgcawu District Municipality March 2014), the rest of the months were below acceptable standards in all the four municipalities that reported outbreaks of acute diarrhoea during the period under study (Figure 10). Data is incomplete for ZF Mgcawu District Municipality during the month of January 2014.

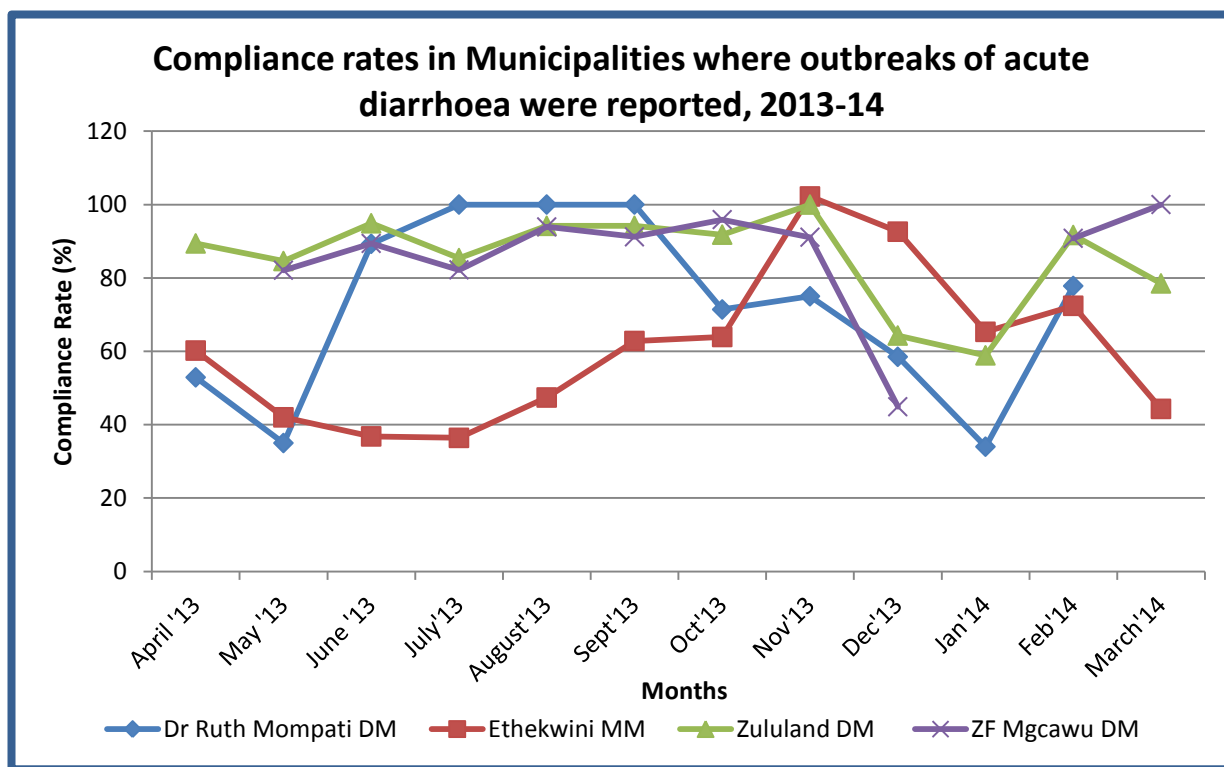


Figure 10: Trend of water compliance rate (April 2013 to March 2014) per district municipality. Source: DHIS Data, 2013/14

4.4.3 Towns in districts municipalities that reported outbreaks of diarrhoeal diseases and water quality compliance rate in the three provinces (KwaZulu-Natal, North West, Northern Cape), 2013/14.

4.4.3.1 North West Province

The Lekwa-Teemane Local Municipality is a local municipality situated in the Dr Ruth Segomotsi Mompoti District Municipality in the North West Province. This district municipality with a population of 463815 was served by 8 EHPs having a staffing shortage of 83% (Table 2) and had a water quality compliance rate of 65%. Bloemhof, is the town within this local Municipality which had a reported an outbreak of acute diarrhoea. This outbreak occurred in May 2014 which is outside the study period (Table 5). It was therefore impossible to assess for any association.

Provincial Compliance rate (%)	Dr Ruth Mompoti District Municipality Compliance Rate (%)	Number of EHPs	Local Municipality	Name of the Town where outbreak occurred	Compliance rate by local Municipality(%)	Month of the Outbreak	Lowest Compliance Month and rate (%)
58.3	65	8	Lekwa-Teemane Local Municipality	Bloemhof	58	May, 2014	May 0
			Greater Taung Local Municipality	Not applicable	49	No reported outbreak	April 44.4
			Mamusa Local Municipality	Not applicable	93	No reported outbreak	Not applicable
			Naledi Local Municipality	Not applicable	100	No reported outbreak	Not applicable
			Kagisano-Molop Local Municipality	Not applicable	100	No reported outbreak	Not applicable

Table 5: EHP Staffing, water quality compliance rate and month of outbreak at Bloemhof, Town in Lekwa-Teemane Local Municipality, 2013/14. Source: DHIS Data, 2013/14

4.4.3.2 KwaZulu-Natal Province

- EThekweni Metropolitan Municipality

The outbreak of diarrhoea occurred in various townships within Durban and its surroundings situated in the EThekwini Metropolitan Municipality in the Province of KwaZulu-Natal. This municipality with a population of 3442361 was served by 119 EHPs which was a staffing shortage rate of 65% (Table 2) and the water quality compliance rate of 61%. The outbreak of acute diarrhoea occurred in May 2013 (40%) when the compliance rate was on a decline with the lowest being in July (36.4%, see Table 6). Although the staffing norm is close to the WHO standard, this is an area requiring an in-depth analysis to explore other possible factors that could be affecting water quality compliance and the occurrence of acute diarrhoea outbreaks.

- Zululand District Municipality

The outbreak in this district occurred in the KwaNongoma area which is situated within the Nongoma Local Municipality in the Province of KwaZulu-Natal. This district municipality with a population of 803575 was served by 10 EHPs which was a staffing shortage of 88% (Table 2) and the water quality compliance rate of 85% (Table 6). Although the staffing shortage is very high, a high water compliance rate was reported with the lowest being 75% during the month of February 2014. The outbreak occurred in February 2013 which is outside the study period. This therefore limits further assessment including association to the outbreak.

Provincial Compliance rate	Ethekwini Metropolitan Municipality	Number of EHPs	Local Municipality	Name of the Town where outbreak occurred	Compliance rate by local Municipality (%)	Month of the Outbreak	Lowest Compliance Month and rate (%)
70%	61%	119	Ethekwini Metropolitan Municipality	Durban and Surrounding: Inanda Ntuzuma Umlazi Amoati Mayville and Umbumbulu	61	May, 2013	July 36.4
	85%	10	Zululand District Municipality	Name of the Town where outbreak occurred	Compliance rate by local Municipality	Month of the Outbreak	Lowest Compliance Month and rate (%)
			Abaqulisi Local Municipality	Not applicable	85	February, 2013 and May, 2013	January 47.4
			eDumbe Local Municipality	Not applicable	100	No reported outbreak	Not applicable
			Nongoma Local Municipality	Nongoma	94	February 2013	February 75
			Ulundi Local Municipality	Not applicable	92	No reported outbreak	January 5.6
uPhongola Local Municipality	Not applicable	52	No reported outbreak	September 20			

Table 6: EHP Staffing, water quality compliance rate and month of outbreak at Durban and the surrounding areas, in Ethekwini Metropolitan Municipality and at Kwa Nongoma in Nongoma Local Municipality, 2013/14. Source: DHIS Data, 2013/14

4.4.3.3 Northern Cape Province

The outbreak in the Z.F Mgcawu District Municipality occurred in Upington which is situated within the David Kruper Local Municipality in Northern Cape. This district municipality with a population of 263783 was served by 10 EHPs which presented a staffing shortage of 62% (Table 2) and the water quality compliance rate was 87% (Table 7). The lowest water quality compliance rate was reported in December 2013. The outbreak that occurred between February and May 2013 was mainly due to rotavirus, hence further analysis to look at risk factors needs to be done.

Provincial Compliance rate	Z.F Mgcawu District Municipality	Number of EHPs	Local Municipality	Name of the Town where outbreak occurred	Compliance rate by local Municipality	Month of the Outbreak	Lowest Compliance Month and rate
79%	87%	10	!Kheis Local Municipality	Not applicable	66%	March-May 2013	February 60%
			Dawid Kruiper Local Municipality	Upington	84%	February-May 2013	December 2013
			Kai !Garip Local Municipality	Not applicable	80%	No reported outbreak	April 64.5%
			Kgatelopele Local Municipality	Not applicable	100%	No reported outbreak	Not applicable
			Tshantsabane Local Municipality	Not applicable	99%	No reported outbreak	February 92.3%

Table 7: EHP staffing, water quality compliance rate and month of outbreak at Upington in Dawid Kruiper Local Municipality, 2013/14. Source: DHIS Data, 2013/14

Overall, the national average water quality compliance rate was 88.8% for the year of the study with wide variations at metropolitan and district municipality level. Existing policy framework which has a bearing on the water quality monitoring, the role of EHPs and the staffing status in the relation to the population served, have also been analysed. The occurrences of diarrhoea including outbreaks in some parts of the country were analysed to determine possible causes linked to the use of unsafe water. The next chapter discusses in detail the findings of the study.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1 Introduction

This study aimed at assessing water quality compliance in the metropolitan and district municipalities to the set standards,^{25,30} as well as to gauge the effectiveness of environmental health practitioners in monitoring compliance to meet these standards. The case of diarrhoeal outbreaks and the potential consequences of the use of unsafe drinking water³ during the year of the study is also presented. In this Chapter the findings of this study are discussed in greater detail.

5.2 Policy, legislation and administrative arrangements for water quality monitoring systems

A system of water quality monitoring is in place governed by specific policy and legislation at national, provincial and municipality levels. The study has confirmed that a framework exists for the provision of safe water in the country. This is clearly provided for through the Constitution, the Water Act of 1998 and the National Health Act of 2003, with each of these also providing clear strategic guidance in relation to the allocation of the functions and responsibilities. Although these roles or functions are clearly stipulated in the policy guidelines, the implementation varies at different levels. The National Government has implemented regulations and policies to deliver safe water to all, but some local municipalities have not necessarily ensured compliance with these national guidelines.²⁶

At national level there exists policy that provides for the establishment of the framework for inter-sectoral collaboration amongst the key line departments (the Department of Water Affairs, Department of Cooperative Governance and Traditional Affairs (COGTA), and the Department of Health) outlining clear output indicators for guiding the provision of the water quality monitoring service. The fact that different departments manage water quality in each of the municipalities indicates that understanding of the decentralisation of water quality management is vital if a national monitoring system is to be successfully implemented.²⁶

Notwithstanding the above, municipalities have to comply with different legislation which addresses a vast array of issues to facilitate appropriate service delivery in general.

Furthermore, with the communities becoming more aware of their rights and the responsibilities of municipalities, pressure is mounting on municipalities, resulting in the neglect of core funded mandates such as water quality monitoring. South Africa is said to have one of the highest number of service delivery protests in the world.⁴⁵ One of the driving forces is the increasing levels of public frustration due to the disconnect between the state and citizenry in terms of service delivery - and water is included within this ambit.⁴⁵

Given these findings, COGTA, with the mandate to oversee municipal service delivery³² needs to strengthen its coordination role within these sectors involving other key role-players, including water services authorities, environmental health services and the community, in order to effectively achieve and sustain water quality monitoring at municipality level. Although this was not part of the study, efforts that aim at strengthening policy implementation need to be critically reviewed. For example, analysis of the existing policies within COGTA and establishment of mechanisms for collaboration where there are shared common outputs must be thoroughly looked into. This can be achieved through enhanced joint planning, monitoring and reviews with clear indicators of accountability.

Another factor identified in this study that has the potential to negatively influence the delivery of water quality monitoring service is the employment of EHPs by metropolitan and district municipalities that are also designated Water Services Authorities. The present arrangement could be conflictual and thus needs to be addressed through the amendment of legislation. A policy change will assist to prevent interference with the independent roles of EHPs in the delivery of their mandated responsibility as per their Scope of Practice prescribed in the Health Professions Act. In order to protect public health, a dual-role approach has been proven to be effective; differentiating the roles and responsibilities of service-providers from those of an authority is effective in the protection of public health.⁴⁰

Minimising identified possible conflict areas within policy, legislation and administrative arrangements will require a review to harmonise functional powers among different ministries, powers for the MECs responsible for Health as well as other stakeholders who support environmental health services at municipality level.

5.3 Water quality monitoring compliance rate and EHP staffing rate

During the year under review, the national average water quality compliance rate was recorded at 88.8%, indicating a gap of 11.2 %, with possible disease-causing micro-organisms⁴¹ being

present. This has the potential to predispose the community to waterborne diseases, including instances such as acute diarrhoea³.

It was hypothesised that the frequency of monitoring and the water quality compliance rate would be higher in local municipalities with higher numbers of EHPs. The study revealed a weak relationship between EHP staffing rate and water quality compliance rate. However, the exception was at Namaqua District Municipality in the Northern Cape with a relatively high staffing status (86%) and a relatively high water quality compliance rate (87%).

Interestingly, low staffing did not necessarily influence the water quality compliance rate performance. For example, in KwaZulu-Natal the overall staff shortage is 76% and the province had an overall water quality compliance rate of 70%; the UThukela District and Umgungundlovu District Municipalities, with staffing shortages of 76% and 77% had high water quality compliance rates of 100% and 97% respectively. A similar observation was noted in Gauteng Province with a metropolitan municipality such as City of Ekurhuleni, which had 110 EHPs (35% of staff establishment) but which nevertheless achieved a water compliance standard of 100%.

These findings tally with the analysis of the weak association between EHP staffing rate and the water quality compliance rate in that the strong association could not be established and in this study. It is possible that the status of staffing could have an influence on the performance of water quality monitoring.

One strength of this study is the observed staff shortage throughout the country for the effective delivery of one of the critical health services in the metropolitan and district municipalities. Municipalities do not have sufficient EHPs to ensure that there is good coverage of environmental health services in their areas of jurisdiction. For example, Limpopo (Mopani District Municipality) has a shortage of 95%, followed by Northern Cape (Francis Baard District Municipality) with 90% and KwaZulu-Natal (Amajuba and Zululand District Municipalities) with 88%. Of major concern is Mopani District Municipality which had an EHP to population ratio of 1: 182 085. Overall, South Africa falls short of this exigency by 3 619 (70% shortage rate) EHPs based on the 2011 population census.

This staffing status is way below the recommended WHO staffing norm of one EHP for every 10000 members of the population. This aspect will need urgent attention by metropolitan and district municipalities to ensure compliance with the WHO staffing standard.

It is possible that the compliance rate is affected and/or associated with many other factors which are not covered in this study which will need to be established. An in-depth analysis or a specific study to look at impact of other factors including other resources that could have influence on water quality monitoring compliance rate within the municipalities will need to be carried out.

The above findings concur with Ulrike Rivette's *et al.* in the paper where the low compliance rate is generally attributed to other factors such as under-resourcing, skills shortages, lack of understanding of required standards, lack of intervention to address problem areas, inadequate management, and limitation of finances, assets and fiscal accountability.⁴⁰

5.4 Water quality compliance rate and occurrence of acute diarrhoea

This study attempted to demonstrate the impact of the use of unsafe water through the case analysis of the outbreaks of acute diarrhoea. Research has shown that poor sanitation, lack of safe and clean drinking water and poor hygiene contribute largely to the global mortality rate of children, especially those five years and younger.^{4,12} During the period of the study, data available on the three provinces that reported outbreaks of acute diarrhoea (North West, KwaZulu-Natal and Northern Cape) was analysed to assess the relationship between such outbreaks and the water quality compliance rate. However, because of gaps in the data it was also not possible to properly analyse the association between water quality compliance rate and the occurrence of these acute diarrhoeal outbreaks.

Furthermore, health studies in this domain (other than diarrhoea-related diseases and deaths resulting from inadequate water and sanitation considerations) are currently under-researched.⁴⁵ More evidence on these topics would enable more meaningful estimates of the potential health benefits of improving water and sanitation.

5.5 Summary

Despite the Constitutional mandate and role clarification by legislation prescripts, this study has shown that the water quality monitoring programme is not implemented effectively by most municipalities. Data gaps in the DHIS could not allow for detailed and systematic analysis of the service in the study which could have influenced the findings. The importance of quality data is

highlighted in a report on Water Supply and Sanitation in South Africa in 2003 that showed 63% of municipalities were not able to say whether or not they met drinking water quality standards.⁴⁶ This reaffirms the urgent need to address monitoring and data management issues. In general, the literature on the information system suggests that failures occur when some aspects of the system context - social, technical or political - are inadequately understood, ignored or underestimated.⁴⁰

5.6 Limitations of the study

Given the wide scope of work conducted by EHPs and the timeframe for this study, it was not possible to analyse all the indicators reported in the DHIS. The study was thus limited to analysis of one indicator out of the ten relating to functions conducted at municipality level - a factor that might prejudice the findings.

Available data used in this study derives from that which was available for programme routine purposes and is not optimal for research. This posed challenges for framing and addressing specific research hypotheses, and in-depth analysis of some aspects of the study objectives.

Furthermore, the challenges of obtaining data from the comparable source of other countries is lacking and thus study could not benchmark the performance of other middle income countries in relation to water quality monitoring. The interest of the study was to ascertain the use of available data in order to identify strengths, gaps and /or weaknesses in water quality monitoring for the purpose of health systems strengthening at metropolitan and district municipalities.

National Norms and Standards for Water Quality Monitoring were published in 2015. Data used in this study covers the period 2010 to 2014, therefore no common standards were available to all municipalities, meaning that the methodology used for sampling and reporting to the DHIS could have been varied among municipalities.

Other potential factors that could influence the water quality compliance rate but have not been covered in this study include the favouring of sampling points that are conveniently selected by the EHPs because of easy access and hence the inaccessible areas may not be covered. As a result, the available data may be biased as water sampling may have been collected to meet the

monthly sampling target, with such targets not being framed by the formal water quality monitoring and risk assessment plans due to unavailability of norms and standards at the time.

The study only concentrated on the data as reported in the DHIS and it could not test other variables that could have assisted in understanding the influence of the lack of other resources, such as logistics and supplies on the achievement of the water quality compliance rate.

A critical factor that can affect the performance in any given system is funding, which was also not considered. Whilst South Africa has a high expenditure on health (8.5% of GDP)⁸ it would have been of interest in this study to assess how the allocation of funding influences water quality monitoring and drinking water compliance in metropolitan and district municipalities. However, the scope of the study did not cover aspects of financing and the data source was limited to the information reported to the DHIS. This could be addressed in another study where the detailed analysis to evaluate the budgeting and the proposition allocated for primary health care services in particular water quality monitoring.

Given that water quality monitoring is one of the key activities of the municipalities, the presence of competing priorities or needs may inadvertently influence or affect financial allocation for optimal management of water services.

Another critical variable missing from this analysis with a considerable potential to influence water quality, is sanitation-related activity. This may lead to underestimation of the true baseline or outcome as set out in the standards (SANS 241).

CHAPTER 6

RECOMMENDATIONS

Clean, safe drinking water is fundamental for all of us. All role-players have a responsibility in assuring that our drinking water remains clean and safe. The study has demonstrated that a system has been built to ensure safe water supply and drinking water quality. This system ranges from legislation to clear guidance on implementation and performance indicators. It has further assisted in identifying implementation gaps at all administrative levels, including inadequate monitoring and utilisation of data. In order to ensure that the process for water quality monitoring is strengthened at municipality level, the following recommendations should be considered:

1. Strengthen the policy structure to ensure synergy amongst the various key stakeholders, especially the Department of Water Affairs, COGTA and the Department of Health, as well as local communities. Hence, COGTA needs to strengthen its coordination role between the sectors and other key stakeholders to achieve and sustain water quality monitoring at municipality level. Policies that allow for active community involvement in water quality monitoring should also be strengthened.
2. Though Section 32 of the National Health Act of 2003 stipulates the quality of health service to be provided by the municipalities, it should be amended to make provisions and powers for the Health MECs and the National Minister to take remedial measures should a local authority fail to fulfil its duties in rendering effective and efficient Environmental Health Services, including water quality monitoring.
3. Review legislation related to employment of EHPs at district municipalities that are also designated Water Services Authorities. It is recommended that EHPs should be more independent from municipal structures to allow for system that will function more efficiently without any hindrance. This can be achieved through amendment of the National Health Act of 2003, thereby separating functional powers to avoid legislation conflict (referee and player) and/or the COGTA must develop policies and guidelines for better coordination of mandatory functions performed by multiple departments within the municipality.

4. Municipalities must review and develop human resource plans to address staff shortages and to progressively meet the staffing WHO Norm of 1: 10 000 EHPs per population.
5. In order to strengthen the water quality monitoring programme implementation by municipalities, there should be a strong emphasis on data management, including effective reporting and communication at all levels, strengthen system for regular feedback from the Department of Health to the municipalities through existing communication structures such as Interprovincial Management Committee and Municipal Health Forum. This can also be strengthened by developing a formal feedback system by the Department of Health to the municipalities.
6. Finally, it is recommended that the study should be repeated for the 2016/17 financial year as municipalities are already implementing the 2015 Environmental Health National Norms and Standards for Water Quality Monitoring.

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Appendix 1: Data in the DHIS, 2010-2014

Number	Name of the Municipality	Province	Compliance Rate 2010-11 (%)	Compliance Rate 2011-12 (%)	Compliance Rate 2012-13(%)	Compliance Rate 2013-14 (%)
Gauteng Province						
1.	Ekurhuleni Metro	Gauteng	75	85	86	100
2.	City of Johannesburg Metro	Gauteng	No data	No data	79	32
3.	City of Tshwane Metro	Gauteng	93	No data	79	63
4.	Sedibeng DM	Gauteng	59	83	93	88
5.	West Rand DM	Gauteng	46	22	89	48
KwaZulu-Natal Province						
6.	Ethekwini Metro	KwaZulu-Natal	No data	55	46	61
7.	Harry Gwala DM (Former Sisonke DM)	KwaZulu-Natal	No data	61	23	55
8.	uMzinyathi DM	KwaZulu-Natal	No data	54	64	57
9.	Ugu DM	KwaZulu-Natal	No data	49	163	49
10.	Umgungundlovu DM	KwaZulu-Natal	No data	28	90	97
11.	Ilembe DM	KwaZulu-Natal	No data	59	No data	91
12.	Amajuba DM	KwaZulu-Natal	No data	42	24	80
13.	Zululand DM	KwaZulu-Natal	No data	50	83	85
14.	uMkhanyakude DM	KwaZulu-Natal	No data	34	22	41
15.	King Cetshwayo DM (Former UThungulu M)	Kwazulu-Natal	No data	42	8	55
16.	uThukela DM	KwaZulu-Natal	No data	48	59	100
Eastern Cape Province						
17.	Nelson Mandela Bay Metro	Eastern Cape	74	85	89	98
18.	Buffalo City Metro	Eastern Cape	53	75	57	48
19.	Joe Gqabi DM	Eastern Cape	61	57	No data	0
20.	Alfred Nzo DM	Eastern Cape	34	33	35	39
21.	OR Tambo DM	Eastern Cape	23	64	No data	55
22.	Chris Hani DM	Eastern Cape	75	86	89	95
23.	Amatole DM	Eastern Cape	75	72	79	83
24.	Sarah Baartman DM (former Cacadu DM)	Eastern Cape	79	64	58	82
Limpopo Province						
25.	Capricorn DM	Limpopo	No data	No data	No data	136
26.	Mopani DM	Limpopo	No data	No data	No data	0
27.	Vhembe DM	Limpopo	No data	No data	No data	No report
28.	Greater Sekhukhune DM	Limpopo	No data	No data	No data	0
29.	Waterberg DM	Limpopo	No data	No data	No data	39
North West Province						
30.	Bojanala Platinum DM	North West	No data	No data	No data	90
31.	Dr Ruth Segomotsi Mompati DM	North West	No data	No data	No data	65
32.	Ngaka Modiri Molema DM	North West	No data	No data	No data	10

Number	Name of the Municipality	Province	Compliance Rate 2010-11 (%)	Compliance Rate 2011-12 (%)	Compliance Rate 2012-13(%)	Compliance Rate 2013-14 (%)
33.	Dr Kenneth Kaunda DM	North West	No data	100	No data	68
Western Cape Province						
34.	City of Cape Town Metro	Western Cape	No data	99	99	98
35.	Cape Winelands DM	Western Cape	77	70	70	73
36.	West Coast DM	Western Cape	No data	87	91	83
37.	Overberg DM	Western Cape	No data	82	74	78
38.	Eden DM	Western Cape	No data	83	82	80
39.	Central Karoo	Western Cape	62	89	91	90
Mpumalanga Province						
40.	Gert Sibande DM	Mpumalanga	No data	No data	No data	No report
41.	Nkangala DM	Mpumalanga	No data	No data	No data	No report
42.	Ehlanzeni DM	Mpumalanga	No data	No data	No data	No report
Free-State Province						
43.	Mangaung Metro	Free State	No data	No data	100	91
44.	Xhariep DM	Free State	No data	No data	No data	79
45.	Lejweleputswa DM	Free State	No data	No data	No data	75
46.	Thabo Mofutsanyane DM	Free State	No data	No data	No data	65
47.	Fezile Dabi DM	Free State	No data	No data	No data	56
Northern Cape Province						
48.	ZF Mgcawu DM (former Siyanda DM)	Northern Cape	No data	No data	No data	87
49.	Namakwa DM	Northern Cape	No data	No data	No data	87
50.	Pixley kaSeme DM	Northern Cape	No data	No data	No data	85
51.	Frances Baard DM	Northern Cape	No data	No data	No data	63
52.	John Taolo Gaetsewe DM	Northern Cape	No data	100	No data	73

NB: Data presented in the Table above may not be the true representative of the water compliance rates due to the serious gaps in the District Health Information System (DHIS), 2010-2014 data. *Source: DHIS Data, 2013/14*

Appendix 2: Data analysis plan

PROJECT: To assess the drinking water quality compliance and the effectiveness of water quality monitoring by environmental health practitioners at metropolitan and district municipalities in South Africa during 2013- 2014.

Aim of the Study

The aim of the study is to assess water quality compliance rate, the monitoring system and the factors that influence optimal performance in municipalities.

Analysis plan

- National water compliance rate 2010-2014 by month and by year.
- Water quality compliance rate per municipality per month 2010-14.
- Staffing norm in municipalities during 2010- 2012 per province.
- Staffing norm in municipalities during 2013-2014 per province.
- Staffing norm in municipalities during 2013-2014.
- The compliance rate of domestic water quality samples taken by Environmental Health Practitioners per municipality in 2013-2014.
- The staffing norm of Environmental Health Practitioners per municipality in comparison with the population served in 2013-2014.
- The relationship between the results of water compliance rate and Environmental Health Practitioners staffing rate per municipality.
- The relationship between results of water samples compliance rate from municipalities and occurrence of diarrhoeal incidence in the three provinces (KwaZulu-Natal, North West and Northern Cape).
- Ranking provinces according to the 1/ 10000 compliance (e.g. have a benchmark for comparison purposes).