Faecal Sludge Production and Management Projections in the City of Polokwane, South Africa

By

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DEDICATION

I dedicate this project to my fellow country men and women who live in poor conditions after having been greatly oppressed, exploited as well as disregarded and plan to never become victims of no proper social amenities because the resources get diverted to peoples' accounts.

To God be the glory.

DECLARATION

This mini-dissertation is submitted under the University of Limpopo regulations for the award of Master of Public Administration Degree. I, Phuti Alfred Patrick Mabotha, Student Number 9731796 declare that this dissertation was not previously submitted by me for any other degree at the University of Limpopo or any other university or institution of learning. This is my work in design and in execution; all materials contained herein are duly acknowledged.

25 January 2019

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Phuti Alfred Patrick Mabotha Date

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It is said that the beginning of wisdom is fearing God and where wisdom ends, belief starts. The two philosophical statements made me realise that the one above all creations made me finally end this journey with a smile on my face, which will not only end with me but will affect my entire family.

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ABSTRACT

Polokwane Municipality is currently experiencing water shortages, which is affecting households and industries' which is used to remove faeces and transport them to the sewage plant through sewer networks, as the system is waterborne. This research study aims at determining the status of faecal sludge management with the aim of developing a faecal sludge management projection plan for the City of Polokwane. The plan will enable the city to understand the current and future levels of faecal sludge production and it will also highlight the water demand for faecal sludge disposal. As a result of this plan, the appropriate systems, which can be used for faecal sludge production, can be managed better and there will be relief in the current non-coping sewage plants in the municipality. The sewage plants are not coping with the amount of faecal sludge due to the growing population and the fact that the infrastructure was built before South Africa's 1994 democratic dispensation. The empirical enquiry was conducted through the use of the interview guide and the purposive sampling strategy in order to obtain an in-depth context of the subject being studied. The study has noted that the Seshego and Polokwane Sewage Plants are receiving more sewage than they were built for. The only plant that is still within its capacity is the Mankweng Sewage Plant. Currently, the municipality does not have alternative plan to re-use water in the yards. It is also not planning to develop any other form of faecal sludge management to transport faeces from the toilets to the sewage plants despite the use of clean water.

It is questionable as to whether the cleaned water or effluent released from the sewage to the environment meet the required standards. In Polokwane, the released effluent does not go back to the people directly but it is used to recharge 37 boreholes, which are used to supply water to the people. The other challenge in Polokwane Municipality, especially in Mankweng, is the petrol stations, hospitals, and abattoirs whose effluents are creating a problem to the water treatment plants. Therefore, there is a need to have a pre-treatment plants for hospitals and filling stations.

Key Words: Sanitation, faeces, faecal sludge, sewage plants and water borne.

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LIST OF ABBREVIATIONS

ADWF	Average Dry Weather Flow
BOD	Biological Oxygen Demand
COHGSTA	Co-operative Governance, Human Settlement and Traditional Affairs
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
DWAF	Department of Water Affairs and Forestry
EHO	Environmental Health Officers
FS	Faecal Sludge
HDI	Historically Disadvantaged Individuals
IDP	Integrated Development Programme
IUWM	Integrated Urban Water Management
MDG	Millennium Development Goal
MISA	Municipal Infrastructure Support Agency
NDP	National Development Plan
NWA	National Water Act
O & M	Operation and Maintenance
OSS	On Site Sanitation system
PPP	Public Private Partnership
PSP	Private Sector Participation
PST	Primary Segmentation Tank
RDP	Reconstruction and Development Programme
SAHRC	South African Human Rights Commission
TAC	Thematic Content Analysis
UNICEF	United Nations Children Fund
VIP	Ventilated Improved Pit Latrine
WHO	World Health Organisation
WWWTP	Waste Water Treatment Plant

CHAPTER 1:
INTRODUCTION

1.1 Introduction and Background

After the 1994 democratic elections, South Africa introduced the Reconstruction and Development Programme (RDP) framework. Its aim was to redress the distribution of resources from the racial segregation of the pre-1994 constitutional dispensation. Racial segregation affected most areas including the Bantustans, which were mostly underdeveloped. The RDP contains various objectives which include amongst others, water and sanitation for the Historically Disadvantaged Individuals (HDI). The RDP's long-term goal is to provide every South African with accessible water and sanitation. The current challenge is that South Africa is a water scarce country, and if proper care is not exercised, water projections indicate that there will be serious water shortages in most parts of the country in the future. To resolve this problem, Integrated Urban Water Management (IUWM) was developed in order to have an integrated solution in household, neighbourhood, city, catchments and trans-boundary water use as well as to provide an efficient, flexible urban water system which comes with a holistic approach on the urban water cycle (Nnadozie, 2013).

The Bantustans areas received insufficient water and sanitation services. The pre-1994 policies left the majority of the people with inappropriate, poorly structured water and sanitation services which have negatively impacted on the health, well-being, dignity and integrity of the civilians as they have no or poorly managed faecal sludge management technologies. This is evident in the lack of adequate infrastructure in areas that have high levels of poverty and overcrowding as there are no adequate systems to dispose human waste and this leads to faecal sludge contributing to the degradation of the areas and lives are threatened due to poor health standards. Faecal sludge in the congested and overcrowded areas was collected through bucket systems, which were poorly managed (Mjoli, 2012).

Furthermore, literature indicates that the costs of faecal sludge management technologies are five times less expensive than the conventional sewer based system despite the differing local conditions. If the system is properly managed and implemented there shall be promotion and protection of human health as there will be no faecal deposits running into the rivers and dams (Dodane, Mbequere, Sow & Strande, 2012).

The problem with the use of clean water in faecal sludge flushing emanates from the fact that the total volume of water in the world remains constant. From the 2.5% of non-saline, the change is brought by the demand of the resource as the population grows. Thus, 97.5% of the water in the world is salty and has saline and therefore, it cannot be used for human consumption. The demand for clean water is very high and it is caused by population growth. In towns and cities, it is caused by rural-urban migration (Mishra & Dubey, 2015).

Studies by the World Cup legacy report shows that: South Africa is a water scarce country, as a result, it is projected that if the rate at which water is used currently is not reduced, the demand is likely to exceed the supply at some point in the near future. The focus is now on the improvement of water conservation, water quality and efficient water use. It is also said that South Africa exploits 98% of its available water supply resources and most of the dams in areas such as Durban are presently unable to sustain the demand from the community and industries (Bond, 2014).

This study focuses on measuring the current and projected faecal sludge production (human excrements) in the Polokwane municipality. Furthermore, the study calculate, the water that is used to flush waste (faecal sludge) and project the future amount of water demand in Polokwane.

In the sections that follow, the problem that informs this research is fully explored with the research aims and objectives being outlined. The proposed methodologies to be followed in executing the research are also highlighted.

1.2 Background of the Study

In South Africa, the perception that sewerage systems are the only effective faecal waste management system was fuelled by the bucket system which was introduced during the apartheid era in black residences. The system was poorly managed and it was hazardous to health as the people used buckets to dispose of human waste and these buckets were seen as the breeding ground for flies and they also caused bacterial and viral infections. The process was seen as dehumanising (Steward, 2014).

Water and sanitation service delivery is the local government's responsibility as outlined by the National Development Plan vision 2030. unfortunately, many municipalities, particularly in the poor or rural areas, do not have the skills and capacity to implement their mandate. It is, therefore, the provincial and national government's responsibility to apply their oversight role as legislators and monitor progressive realisation of rights as enshrined in Article 11 of the International Covenant on Economic, Social and Cultural Rights of 1966, which stipulates that; the right to water and sanitation is a fundamental requirement to meet the standard of living (Human Rights Commission, 2014).

The oversight role provided by the provincial government and legislators will further ensure that local government performs its responsibilities and functions effectively with less corruption. The Cooperative Governance, Human Settlement and Traditional Affairs (CohGTA) and Treasury need to evaluate how government can strengthen its management role on the municipalities to ensure that sewer plants are effectively maintained so that they can be able to handle the incoming sewage (Human Rights Commission, 2014).

According to Kings (2015), The Department of Water Affairs (DWA) finds it difficult to improve the management of sewer plants as they are under the auspices of the Co-operative Governance Department and they cannot directly interfere in the day to day running of other departments.

The DWA developed the Green Drop Awards so that the municipalities can improve and solve the existing problems speedily and encourage efficiency. The department further issued directives and strongly worded letters to the concerned municipalities

and co-operative governance about poor conditions but in most cases, no improvements were experienced because the inter-ministerial requirement does not permit one ministry to criticise another in public as the voters' opinion can be compromised or influenced negatively (Kings, 2015).

In trying to resolve some of the problems in poorer and outlying municipalities, the Department of Co-operative Governance provided the deployed technical capacity into districts to render support through planning, design, implementation, skills development, reporting, monitoring and evaluated the functions of the municipalities in the Municipal Infrastructure Support Agent (MISA). They also facilitated the government's capacitation of grants, capital grants and technical assistance grants with the intention of ensuring that municipalities efficiently executed their powers and functions. Furthermore, national departments had to make sure that if vacancies are not filled or in some instances if there was a lack of capacity and skill they needed to facilitate redeployment from other municipalities or national and provincial departments (Human Rights Commission, 2014).

1.3 Statement of the Research Problem

The predominant faecal sludge management systems in South Africa are sewer plants and pit latrines. Both have an adverse effect on the quality of water provision. The sewer systems are not well managed and pollute the rivers while the pit latrines pollute the underground water (Strande, Ronteltap & Brdjavonic, 2014). The continuous expansion of these two faecal sludge management methods has huge long-term effects on the quality and volume of water provision for human consumption.

Literature provided by The United Nations Children Fund (UNICEF) and the World Health Organisation (WHO) suggests that the water flushing toilets phenomenon is a contributing factor to polluting the nation's water reserves and estimate that one in five children in the world dies from water borne diseases such as diarrhoea (Strande, Ronteltap & Brdjavonic, 2014).

Most municipalities' infrastructure which are operating on the conventional sewer network have not been expanded since 1994. For instance, the Municipality of Polokwane, which is the focus of this research had an improvement of 10 km sewer

network in Mankweng / Dikgale / Sebayeng cluster and less effort was made to provide sanitation services to the community (Polokwane Municipality, 2007).

Consequently, the waste water treatment plant ended up not keeping pace with the growing urban population especially with the illegal extension of houses for backrooms. There was lack of maintenance plans for sewer infrastructure, low budget allocation for operation and no plants maintenance (Polokwane Municipality, 2018).

Furthermore, according to the Draft IDP (2018), the Municipality has three treatment plants (Polokwane, Seshego & Mankweng). The Polokwane plant is capacitated to 28ml/day but currently, the load is at 34ml/day. It is only now that the Municipality is planning to expand the plant with an additional 6ml/day with the help of Anglo American (Polokwane Municipality, 2018).

If the waste water treatment plant experiences an intake which is higher than its capacity, the water streaming out of the plant pollutes the downstream rivers which are used by the local communities for consumption, bathing and for other household chores. The current wastewater management system has a negative impact on humans and the environment (Human Rights Commission, 2014).

Still, Walker and Hazelton (2009) state that information on alternative sanitation management is currently not accessible to most planners, managers as well as the communities who view the current water flushing toilets as the only and best system for urban areas. The introduction of new sanitation management systems may be regarded as outdated and may be out rightly rejected mainly by politicians as well as users due to their being familiar with the waterborne system. Furthermore, the lack of education and advocacy for alternative faecal sludge management creates a problem for the society whose general perception of the bucket system is a close association with apartheid segregation policies.

The existing perception is that the bucket faecal sludge management system has resonance only in relation to the informal settlements in South Africa. Poor faecal sludge management and its consequences, however, are worldwide problems that affect the rich and poor alike. South African municipalities should also start participating in programmes that are designed to look at alternative faecal sludge management since the country is water scarce. For example, the Ventilated Improved

Toilets (VIP) installed in Newline Mpumalanga fulfilled their function for almost 11 years after installation and the feasibility to use pour flush or low flush systems needed to be tested (Still *et al,* 2009).

Even before alternative faecal sludge management systems can be sought; the study needs to determine the amount of faecal sludge that is produced in the Municipality of Polokwane. According to Sustainable Sanitation and Water Management (2012), there are faecal sludge production aggregates produced in other countries, but South Africa is yet to provide measurements for current and projected faecal sludge production. How this is managed in the future is dependent on the current and projected plans hence the importance of this research.

1.4 Aim of the Study

The study's aim is to evaluate the current status of faecal sludge management in order to develop a faecal sludge management projection plan by measuring faecal sludge production in the City of Polokwane. The faecal sludge measurements will enable the city to understand the levels of current and future faecal production, water demand for faecal sludge disposal and therefore put appropriate systems for its management.

1.5 Research Objectives

The research intends to achieve the following objectives:

i. To determine the processes that the Polokwane Municipality apply on faecal sludge management;
ii. To ascertain how water conservation can be applied in faecal sludge management in Polokwane Municipality;
iii. To evaluate the cost management system which Polokwane Municipality applies on faecal sludge management;
iv. To investigate the faecal sludge management approaches/plans applied by the Polokwane Municipality;
v. To examine how the faecal sludge production and management system can be improved in the Municipality of Polokwane.

1.6 Research Questions

Given the research objectives mentioned above, the research intends to answer the following questions:

i. What processes do the Polokwane Municipality apply on faecal sludge management?
ii. How is water conservation applied in faecal sludge management in Polokwane Municipality?
iii. What cost management system does Polokwane Municipality apply on faecal sludge management?
iv. What are the faecal sludge management approaches/plans applied by the Polokwane Municipality?
v. How can the faecal sludge production and management systems be improved in the Municipality of Polokwane?

1.7 Definition of Key Terms

Sanitation: Refers to all facilities, hygienic principles and practices related to the safe collection, removal, or disposal of human excreta (Antwi-Agyel, 2009).

Faecal Sludge: It is an onsite sanitation technology which is not yet transported through a sewer. It is the raw or partially digested slurry or semisolid results from the collection, storage or treatment of excreta and black water combinations with or without grey water (Strande, Rontellop & Brdjanovic, 2014).

Municipality / Local Government: Majekodunmi (2012) defines the local government as that part of government, which is closest to the people at the grass roots level. Reddy (1999: 9) in Mothepu (2013) defines the local government as that level of government that is created to bring government to the local populace and to give citizens a sense of participation in the political process that influences their lives. Heymans and Totemeyer (1988:2) define it as, “a decentralised representative institution with general and specific powers devolved on it in respect of an identified restricted geographical area within a state”.

Bailey (1995) defines the two concepts as being used interchangeably with local authorities, councils and municipalities and argue that they are sometimes referred to, in the economics literature as 'sub-central authorities'. Although accurate, this generic term fails to distil the essence of the local government. Furthermore, local government can be thought of as democratically elected bodies whose jurisdiction is on a local rather than regional or national scale (Bailey, 1999).

Commercial wastewater refers to non-toxic, non-hazardous wastewater from commercial facilities which is usually similar in composition to domestic wastewater, but which may occasionally have one or more of its constituents exceeding typical domestic ranges.

Domestic wastewater: Water that has been used by the community containing different materials such as faeces, urine and sludge (Mara, 2004:1).

Effluent: WHO (2015:16) defines effluent as the liquid discharge from the treatment tank after the solid separation of black water or sludge. Uhlman, Eden, Rock, Westfall and Sprouse (2012:2) define it as, "water that has been collected in a sanitary sewer for subsequent treatment" in a wastewater treatment facility.

1.8 Structure of the Study

Chapter 1: Introduction

The chapter will outline and define faecal sludge management, problem statement, research questions, research methodology, ethical considerations and the delimitation of the study.

Chapter 2: Literature Review

The chapter will give an in-depth review of the available literature on the subject and the phenomenon being studied. It will further expose the importance of faecal sludge management alternatives and the different methods applied in other countries for saving water from being wasted in the sewer.

Chapter 3: Research Design and Methodology

The chapter will focus on and explain the used research techniques and research methods. Generally, it will explain the research techniques, sampling, research instruments, data presentation and data analysis.

Chapter 4: Results, Analysis and Discussion

Data collected from the sampling proposition will be analysed and presented based on the tools that were used.

Chapter 5: Conclusion

A summary of findings and recommendations from the study is outlined and shows areas that might need further investigation for the improvement of faecal sludge management implementation, planning and budgeting for the municipalities as well as the sanitation service providers.

1.9 Significance of the Study

This study will have benefits for a variety of stakeholders both in practice and in academia as reflected below:

i. The study will be useful to both practitioners of public administration and those who study public administration as a subject. The knowledge gathered from the literature and findings will change the mindset of all the practitioners such as planners, engineers, policy makers and environmentalists to consider different methods of sanitation and not only view waste water as a sanitation method;
ii. In some instances, the study will encourage intergovernmental planning as it cuts across the different disciplines in practical terms and municipal service delivery implementation.

This study will be limited to the effects of faecal sludge management on water and how that impacts on the people's lives, health and the environment. Furthermore, data will be collected from a few cases and individuals then it will be generalised to a larger population as per the 2011 Census.

CHAPTER 2:
LITERATURE REVIEW

2.1 Introduction

This chapter will cover the theoretical aspects of the phenomenon and it will also present the contextual background of the study as well as the literature review. The contextual background of the study is within Polokwane Municipality and the discussion will be on the water and sanitation policy in relation to the research problem. The researcher will ensure that sufficient literature from different books, journals and newspapers is reviewed in order to gather relevant data to support the research. This chapter will cover and discuss the existing literature on the research problem and it will also highlight the approaches on faecal sludge production and management systems that are currently applied in various sectors.

2.2 Contextual Background

Polokwane Municipality has suffered water restrictions in the past six years and it was forced to reduce water consumption by 30% prior to the 2010 FIFA World Cup. Literature indicates that there are thousands of pollutants whose effects are a major concern and their number increases annually as new compounds and discoveries of scientific formulas on products increase in the commercial sector (Drangert, 2010).

In line with the *supra* paragraph, The Department of Water Affairs (DWA) and Sanitation's motto is, 'Water is life, Sanitation is dignity'. Everybody who has experienced the bucket system as a form of sanitation knows very well that it is an arrangement that does not ensure users' dignity and integrity. The users of this system only tolerated it but definitely hated it since its inception and they hoped to see a fundamental change in the dawn of democracy. However, this has not materialised for everyone but where this has happened, the beneficiaries' jubilation is immeasurable (Molose, 2015).

When the population grows, the municipalities need to establish longer wastewater pipes so that the effluent can be transported far from the residential areas into lakes, rivers and oceans. This strategy was made to ensure that people are not aware of how faecal sludge is removed from the water and how the water is eventually released into the near stream or river. Most people just know that faecal sludge is managed at the purification plant and the water is cleaned and ready for use at that point. The education provided was intended to make people happy since they have flushing toilets. The after effects were kept a secret as the population could not overpower the fresh water resources with water released from the waste water treatment plants (Dangert, 2012).

In the Municipality of Polokwane, access to sanitation is one of the most critical elements used by the municipality to contribute to the attainment of a healthy environment. The municipality has provided 1 050 Eco and Enviroloo toilets to beneficiaries at Ga Thoka and Nobody Ga Mothiba. In addition, the municipality has constructed a 10km sewer network in Mankweng / Dikgale / Sebayeng Cluster and further conducted feasibility studies for 16 regional sanitation schemes. The municipality has also upgraded a sewer purification plant to the maximum of 5ml day capacity. Despite this effort, it is clear that little has been done in providing sanitation services to the community. Most RDP rural villages in the municipality do not have sanitation services as they still use unimproved pit latrines, which constitute a major risk in terms of ground water pollution. The lack of water borne sewerage systems aggravates the situation as there is ground water contamination (Polokwane Municipality, 2007).

The Sewer and Sanitation Projects that are on the ground include: Reticulation sewer lines in the city cluster: 554 km, purification plants capacity: 25 ml/day, Seshego City capacity: 7ml/day and Mankweng City capacity: 6 ml/day. On site, there are dry VIP toilets in Sebayeng, Thogwaneng and Magowa. The Polokwane sewerage purification plant augments water in the Sand River North aquifer via three retention points. The purified water from the Mankweng Sewage Purification Plant augments water at the Sebayeng Aquifer in the Pour River. The Seshego Sewage Purification Plant supplies water to the Blood River Aquifer at Pelgrimruishoop and that needs to be developed (Polokwane Municipality, 2007).

The implementation of sanitation services in rural clusters was slow as the Municipality intended to meet the 2010 national sanitation targets. However, the other challenge that impacts on the delivery of sanitation is the choice of appropriate technology to be applied in the rural areas (Polokwane Municipality, 2007).

Drangert (2010) states that in the Municipality of Polokwane, the conventional sewer network has not been adequately expanded since 1994 and it is not matching the growing urban population. The water that is released from the plant pollutes the river from that point down to the stream, which is used by the local communities for consumption, bathing and for all the other social household chores.

This is also fuelled by the treatment processes which are unable to remove all the chemicals from the water. Thus, after the sludge is removed from the water, the clean water is discharged back into the environment. According to the statutory requirements, water care should meet strict effluent quality guidelines. For most people, there is a perception that transparent water is clean. After the treatment at the sewer plants, clear bottled water is shown as a sample but it is dirty as it contains micro-organisms, hormones and heavy metals (Drangert, 2010).

The problem experienced in Polokwane is the same as the one experienced at the Mangere Purification Works where the discharge goes into the harbour and the place is considered unsafe to collect shellfish because thousands of effluent and sludge is discharged into the water. This is so because for centuries it has been a practice throughout the world to dispose wastewater and effluent to streams and groundwater basins (Drangert, 2010).

The existing water scarcity and faecal sludge management production problems in Polokwane City are a result of rural-urban migration. Thus, as the population grows, the amount of faecal sludge production increases too. This puts more pressure on the existing sewer network infrastructure which is currently one of the 85% dilapidated infrastructures as spelled out in the special edition of the South African Medical Journal from 2009 (Kings, 2015). The migration to Polokwane Municipality is due to the hope that people possess in getting better job opportunities to improve their livelihoods (Maluleke, 2014).

For the city to manage this process, it should improve the management processes of pit latrines as well as sewer systems and it should improve water contamination processes by prohibiting spillage and directing effluent into other water sources, for example, it is said that four billion litres of polluted water is released into South Africa's rivers every day. This is so because most of the sewer plants were officially classified as "in crisis" in 2013, and out of 824 waste water works in South Africa, 60 are rated as excellent; 74 are rated as good; 281 are rated as average; 161 are rated as poor and 248 works are in a critical state (Kings, 2015).

Literature further indicates that, if the sewer plants cannot handle the sewer intake, the end result is the release of untreated waste into local water sources. This was proved in the Standerton Plant (Mpumalanga) where Rand Water indicated that the effluent that was released was raw sewage (Kings, 2015).

It was further reported that between 2010 and 2012, 23 municipalities were in a crisis state and diseases were just about to break while 38% were at high risk with the highest possibility of deteriorating into crisis because in some cases raw sewage was found pouring on the streets (Prakash, Saravanan & Chourey, 2012).

The other problem is in the rural areas which consist of roughly 26% (3.8 millions) of households' sanitation services which do not meet the required standards due to the deterioration of infrastructure caused by lack of technical capacity to ensure effective operation, timeous maintenance, refurbishment, pit emptying services and insufficient water resources (Human Rights Commission, 2014).

This statement proves the sentiments of Prakash *et al* (2012) that state that over 1 billion people do not have access to clean water while 2.6 billion lack adequate sanitation and ultimately experience water borne diseases. For example, this was experienced by the Thohoyandou Block G residents, when faecal sludge flowed like a river through the sewer. The odour around the area was so bad that most of the people suffered from breathing diseases and malaria as the area became a breeding ground for mosquitos (Nduvheni, 2017).

Literature stipulates that during rapid population growth in cities and towns social cohesion tends to collapse and revenue collection by the authorities becomes less efficient. At the beginning, the infrastructure will be present but as time goes on it becomes dilapidated and managing it becomes complex due to the increasing number of informal areas which are created by newcomers who end up developing an unacceptable means of drawing water and they also use sewer pipes for transporting excreta, wastewater management and for managing the produced faecal sludge (Drangert, 2012).

In some cases, inadequate housing, improper housing, inappropriate drainage and the lack of proper sanitation forces slum dwellers to defecate in the open which ultimately contaminates the water and land resources. This is caused by the fact that as the cities grow, their slum population also grows (Prakash *et al*, 2012).

According to Kings (2015), the Municipality of Polokwane's sewer plants are not managed well and data is not released due to the fear that it will be used to lay criminal charges against the government. Government is not releasing information to the public so that they do not have proof of what is polluting the water in their area.

In the Capricorn District Municipality (2013), sanitation is the hygienic means of promoting health through the prevention of human contact with the hazards of wastes. The fact that most households within the district do not have RDP level sanitation constitutes a major risk in terms of ground water pollution as well as environmental and health problems. The main types of sanitary systems used in the district are water borne sewerage (flush toilets), septic tanks, VIP latrines, French drains and ordinary pit latrines whilst some households do not have basic services at all. Water borne sewerage is mainly found in towns and townships. Septic tanks are mainly found on privately owned properties such as farms and hotels and the rest are primarily found in rural areas (Capricorn District Municipality, 2013).

The existing perception is that the bucket faecal sludge management system has resonance only in relation to the informal settlements in South Africa. Poor faecal sludge management and its consequences are, however, a worldwide problem that affects the rich and poor alike. South African municipalities should start participating in programmes that are designed to look at alternative faecal sludge management

more vigorously since South African is a water scarce country. In most cases, there is a wrong philosophy which states that water free pit latrines must be given to the poor while the rich are entitled to water based toilets (Steward, 2014).

Furthermore, in most instances, any ablution method which is not a flushing toilet is regarded widely as second-best and must be used in the interim until an appropriate toilet is installed. The reason that makes people think in this way is the fact that flush toilets are seen as being more convenient and they have more immediate benefits to the user as no education is provided to users like in the case of people who use dry toilets (WSP, 2015).

2.3 Water and Sanitation

South Africa is a country which was characterised by the unjust laws and policies that left a large majority of the people with inappropriate, poorly structured water and sanitation services which impacted negatively on the health, good being, dignity and integrity of the civilians pre – 1994 constitutional dispensation (WSP, 2015).

The Secretary-General of the Meteorological Organisation G.O.P Obasi (2003) indicated that it is estimated that not less than 300 million people in Africa live in the water scarce environment and as the population increases and if new solutions are not developed on faecal sludge management the situation will worsen. In the modern industrialised world, faecal sludge is not the only major water resources pollutant as man-made pollutants such as acid mine drainage contribute to the dangerous effects and raise serious concern as the people who cannot afford to buy water end up ill due to serious chemical pollution (Human Rights Commission, 2014).

Recent studies by the South African Research Commission have discovered that if the hospital wastewater is not pre-treated before being discharged to the sewage system, the raw wastewater enters the treatment plant with high levels of human – antimicrobials. The challenge is that the conventional sewer does not have easy means to remove the said bacteria (Hrevonic, Ganjto & Goil – Barisic, 2017).

2.4 Water Consumption

According to the WHO in Human Rights Commission Report (2014), each citizen should be entitled to at least 20 litres of water per day. It was further said that access to safe drinking water and sanitation is fundamental to the enjoyment of other rights such as education and information. In contrast to the aforementioned, literature suggests that the phenomenon of water flushing toilets is one of the contributing factors that pollute the nation's water reserves as in some areas sewer, which is not well treated, is released into the source of clean water such as rivers, wells and dams. These ultimately lead to high infant mortality, less cognitive development, less academic achievement, low economic growth and shows estimations that one in five children die from water borne diseases such as diarrhoea in the world (Strande *et al,* 2014).

According to Prakash *et al* (2012), if clean water can be provided with no human faecal organisms and toxic chemicals contamination, diseases such as diarrhoea and dysentery can be reduced by 50%; paratyphoid by 40%; trachoma by 60%; scabies by 80%, skin and subcutaneous infections by 50% and urinary schistosomiasis will be reduced by 40%.

King (2015) further states that the sewage plants in Polokwane Municipality are operating at red, because the river that passes through Polokwane town gets discharges from factories and illegal dumping is done by the people. This situation is the same as the one in South Asia where there are very few wastewater treatment plants and very little municipal sewage is treated. As a result, the Nnoyal Basin in Tamil Nadu, India became a dead river (Prakash *et al,* 2012).

In the United Kingdom, water undertakers supplied a total of 20 361 million litres of water to consumers each day. This included 17 381 million litres per day to about 50 243 000 people in England and Wales alone. In most cases, the areas of highest demand do not normally correspond to the areas where adequate water resources are found and this leads to shortages. At present, the demand for portable water is increasing at an estimated 13.56 to 19 617 million litres per day. Recently, the amount of used water has been steadily increasing since the 70's when the average water consumption was 110 litres per person, today that figure has risen to around 157 litres per person per day, one of the reasons being that more than a quarter of all clean

drinkable water that is used at home is used to flush the toilets. Older toilets can use up to 9 litres of clean water with every flush, whilst new toilets use only 6 litres. It should be noted that by 2025 there will be another 2 billion more people requiring food and water (Cymru, 2015).

In July 2016, it was reported that the Polokwane Municipality is experiencing a serious water shortage as the Flag Boshielo Dam, which is the city's main water supplier, was dropping at an alarming rate from the 27% of the water it had. To allow continuous use of water supply, the municipality has tightened the existing measures to the users. The restrictions include spot fines issued by the municipal officials to anyone found watering gardens and washing cars using hose pipes. The restrictions also apply to those residences using boreholes. It is said that the high consumption of water is caused by the lack of rain and people demand more water than usual for watering their gardens in residential areas (Viljoen, 2016).

2.5 The Water Cycle

"The total volume of water in the world remains constant, what changes is its quality and availability". Presently water is being recycled using the hydrological cycle system. Water is made up of 97.5% saline and some of it is found in the oceans and salt lakes. Only 2.5% of the world's water is non-saline. The unfortunate part is that not all the fresh water is available for human consumption. Of the 2.5%, almost 75% of this water is locked up as ice – caps and glaciers, with a further 24% being located underground as groundwater. This implies that only 1% of the 2,5% of the fresh water is found in lakes, rivers and soil. Thus, only 0.01% of the world's water is present in lakes and rivers, with another 0.01% present as soil moisture but not available for humans. In reality, there appears to be a lot of water, but that water is not readily available for human consumption (Mishra & Dubey, 2015).

2.5.1 Water Degradation

There are a number of pollutants that degrade water and their effects are creating much concern. Amongst the major causes of water degradation is the effluent discharge from sewers, treatment plants, drains and factories. These kinds of outfalls are called point–sources and their main causes are negligence, accidental spillage or illegal discharge from point sources (Bagul, Shinde, Chavan & Patil, 2015).

In some cases, pollution gets worse when pollutants get into the water from different points as man-made or natural causes. For instance, if untreated waste from industries as well as hospitals (human faeces, blood, toxic waste) and dangerous medical waste, as well as the agricultural sector's surface water runoff infiltrates groundwater, lakes and rivers then the water will become contaminated. Consequently, rivers get polluted before pumping water back into the community for normal daily chores such as drinking (Chakraborty, Ahmed, Mazaharus, Tuj – Zohra, Tabassum & Siddiqui, 2013).

2.5.2 Waste Water Treatment System

Municipal wastewater treatment is meant to prevent pollution of the receiving waters. The important characteristics of Municipal Wastewater depend on the type of sewer collection system and the industrial wastewaters entering the sewers. This determines the degree of usage which follows thereafter and the biggest trouble is the pollution of flowing water and the eutrophication of impounded waters as they are for supplies and recreation (Vissman, Hammer, Perez & Chadik, 2009).

2.6 Purpose of Wastewater Treatment

Grey water, waste waters from households and industries are transported and collected through a sewer system to the treatment plant. The treated effluent is commonly disposed off by dilution in rivers, lakes and estuaries. Disposal to the ocean happens if there is a submerged outfall sewer extending into deep water. In some instances, water re-use is utilised for irrigation purposes and urban landscapes (Vissman *et al*,2009).

If the treatment is not properly maintained, the area will be contaminated and this will expose people to health hazards. For instance, in Phillipi East Cape Town, residents found themselves in an environment flooded with poo around their houses, some coming out of kitchen sinks as a result of blocked sewage and storm water systems (Mnyakama, 2016).

2.7 Legislative Framework

The South African Constitution is seen as the cornerstone and the foundation of an equitable and just society. It is aimed at ensuring that everyone is guaranteed the right to a protected environment that is not harmful to their health or well-being and it gives

guarantees to the civilians that they will have water and proper sanitation (Department of Public Works, 2012).

According to LHR Publication Series (1/2009), South Africa is regarded as a country with scarce water resources and it is characterised by historical inequalities in the use of water. Furthermore, the executive power to deliver water and sanitation in terms of the constitution is the responsibility of the local government as prescribed by the Municipal Structures Act 117 of 1998; the Municipal Systems Act 32 of 2000, the Local Government: Municipal Finance Management Act 56 of 2003 and the Public Finance Management Act 1 of 1999.

2.7.1 National Bucket Sanitation Replacement

In his 2006 State of the Nation Address, former President Thabo Mbeki indicated that South Africa has to eradicate all the bucket toilets in the formal areas. This process became successful because there was a political will from the presidency, cabinet, ministers, members of the executive council and the provinces. The programme was termed ‘business unusual’ and it was adopted by the local governments so that there could be accelerated implementation (Mjoli, 2012).

The programme was taken forward by the new administration led by former President Jacob Zuma who in his 2014 State of the Nation address, stated that the South African Government has begun an intensive programme to eliminate the bucket system as part of restoring the dignity of the South African people. It was highlighted that the first phase would be eradicating buckets in the informal settlements of all provinces (Human Rights Commission, 2014).

When eradicating the bucket system, the water problem constraints and the lack of qualified human resources were overlooked as the interest was to put the favoured water borne toilets in all the areas as per the political decision that was taken. The engineers who were on site trained junior technicians to operate the wastewater treatment works. In some municipalities, there were no municipal staff who could be trained to operate the wastewater treatment plants and this ended with water sources being contaminated (Mjoli, 2012).

2.7.2 National Water Act (NWA), Act 36 of 1998

The National government through the minister must ensure that there is proper use, conservation, management and protection of water. The infrastructure should be developed and controlled in a sustainable and equitable manner in order for the people's benefits to be in accordance with the constitutional mandate so that the future generation can be catered for (LHR Public Series, 2009).

2.7.3 Water Service Act, (Act 108 of 1997)

According to Section 2 (a – e) when it is read with Section 6, it is the responsibility of the water authorities such as the municipalities, to ensure that there is access to both basic water supply and the right to basic sanitation services through water service providers. The municipalities should also ensure that the environment is not harmful to human health (Act 108 of 1997).

Furthermore, the Department of Water Affairs and Forestry has delegated the task of providing the citizens with free basic services such as water and sanitation to the municipalities. The task is not only focused on those living in formal settlements but also on those who are in the informal settlements. Any use of other services beyond the basic services has to be paid for by the user irrespective of where the person lives. The municipality is not only limited to providing free basic services but it also provides what is termed as full services in accordance to the service ladder which includes on-site waterborne septic tanks or French Drains (Carbonneau, Elbarg & Krasinkas, 2009).

2.7.4 The Local Government Municipal Structures Act, (Act 117 of 1998)

According to this Act, the municipality is required to review the community's needs and prioritise them as well as involve the community in the process of achieving the set objectives. This process applies to all the Municipal Categories as established by the Act. Those categories include the metropolitan, local or district municipality (LHR Public Series, 2009).

Amongst others, the municipality should provide, appropriate health and hygiene education, safe toilets which are reliable, environmentally sound and easy to keep clean. There should also be provision of privacy and protection against the weather

and the toilets must be well ventilated. They must also keep the smell to the minimum as well as limit the easy entry and exit of flies as well as any disease carrying pests. The services to be provided by the municipality include a VIP, a formal black bucket container and chemical toilets which are mostly used for communal services (Carbonneau *et al,* 2009).

2.7.5 The National Environment Management Act, (NEMA) (Act 107 of 1998)

This Act regulates, controls water pollution, fulfils the right to an environment that is not harmful to health or well-being and creates a specialised enforcement unit of environmental management. The inspectors are charged specifically with the enforcement of environmental management legislation and co-operative environmental governance by establishing principles for decision making on matters affecting the environment. They also enforce environmental management laws that foster intergovernmental co-ordination of policies, legislation and actions relating to the environment and eliminate negative impacts towards the environment (NEMA, Act 107 of 1998).

2.8 Water Use in the World

Water use has grown globally to more than twice the rate of population growth in the 20th century. This scenario places reliable water services and supply under serious constraints in most regions of the world. Furthermore, there is more pressure on the renewable but finite resources as they are affected by the demographic pressures, the role of economic development, urbanisation and pollution. It is estimated that in Africa only, more than three million people live in a water scarce environment (Carbonneau *et al,* 2009).

In terms of water consumption, the agricultural sector draws 57% of the freshwater. The municipality and domestic use account for 35% of which some of the water is returned to the environment with quality degraded and no evaporative ability. This leaves the industrial sector with 8% (Hedden & Cilliers, 2014).

2.9 Institutional Roles in Faecal Sludge Management

South Africa is rated as one of the countries which is producing the best theoretical knowledge in solving the water and sanitation problems and it does this through developing technical documents as well as enacting pieces of legislation and they have the best results out of their policies (Infrastructure Dialogue, 2015).

As a developing country, South Africa should invest in a strong water and sanitation infrastructure network with the aim of supporting the economy and meeting the industrial and commercial needs. In achieving this objective, the country should strive to maintain and expand the existing infrastructure. Currently, the problem is the poor and inadequate maintenance of existing infrastructure. This raises a serious concern because the government does not have adequate institutional as well as the financial capacity to implement the investment plans that are needed to finance the infrastructure on the required scale (National Planning Commission, 2011).

Currently, South Africa is facing a backlog of almost 1.4 million households and 2.1 million households respectively in the provision of adequate supply of proper basic services such as water and sanitation. In some areas, this backlog is caused by inappropriate infrastructure. For instance, the democratic dispensation has inherited a service backlog in municipalities with low infrastructure to cater for the current use (Infrastructure Dialogue, 2015).

All the three spheres of government should ensure that the produced faecal sludge is adequately managed in the country, as people are used to free services as introduced in 2003 through basic services to address the high unemployment rate problem which was being experienced within the jurisdictional areas of most townships. Furthermore, the sanitation sector is experiencing ongoing growth of formal and informal settlements due to rural and urban migration, population growth and the influx of foreign nationals (DWA, 2012).

Section (153) of the Republic of South Africa's 1994 Constitution provides the developmental duties that the municipalities must undertake when structuring and managing administration, budgeting and when planning in order to give priority to the community's basic needs. The duties also include promoting the social and economic

needs as well as participating in national and provincial community development programmes (RSA, Constitution, 1994).

2.9.1 Designs of Institutional Roles

In South Africa, the Department of Water and Sanitation Survey highlighted that 37% of the country ‘s water is consumed at municipal level and does not generate income due to the inappropriate systems that are applied which include the pricing strategy, water use metre monitoring, billing and payments (Infrastructure Dialogue, 2015).

One of the major factors which is not seriously taken into consideration in most parts of the world in system design is sanitation planning. It encompasses budgeting and requires a coordinated approach amongst the departments such as water and sanitation, solid waste, human settlement, roads, storm water and environmental health (Pearl, Evens, Blackett, Hawkins & Heymans, 2014).

Failure to co-ordinate this effort leads to information flow breakage between the end users and planners. This creates conflict between the dwellers and the local government as officials will implement a sanitation and faecal sludge management project which is not sustainable just because they have to spend the existing budget and want to avoid being accountable for non-spending (Pan, Amitage & Van Ryneveld, 2015).

Lack of education is also one of the contributing factors in designs as people believe only in water flush toilets despite the conditions they live in. For instance, in Cape Town, it was recommended that people use grey water to flush as there is a problem of portable water supply, but they profoundly refused saying that their dish water is not meant for flushing. The perception is that this system is meant for people in informal settlements and low income housing (Pan *et al,* 2015).

One of the contributing factors in the design of the institutional role of faecal sludge management is the lack of staff who have full technical requirements such as, planning skills, managerial skills, financial skills and have resources. Consequently, infrastructure ends up dilapidating and ageing with no proper care (Ruiters & Matjie, 2016).

In South Africa, the government has introduced the green and blue drop as the awards method given to the best performing municipality when meeting the requirements of water provisioning as well as faecal sludge production and management. This also encourages effective and efficient people engagement in planning and policy making with regards to sanitation. Addressing service delivery backlogs amongst the communities and people who never had those services before; refurbishing backlogs on sanitation infrastructure which is old and has deteriorated in value way below regular, maintenance requirements; extending backlogs on newly built areas and extensions of some townships or rural areas that need to be provided is not an easy task. Upgrading infrastructure that does not meet the minimum standards and making available adequate staff and funds to ensure proper operation and maintenance of the plants (DWA, 2012).

In 2014, Afriforum conducted a validity test of sewage plants around South Africa with the intention of ensuring that the effluent that is released to the environment meets the required standards as it has an impact on the eutrophication of the water systems. It was discovered that in some municipalities the samples that were taken above the point of discharge from the waste water treatment works and after the point of discharge results were not the same. After the point of discharge, it was found that the water is polluted by failing infrastructure such as manholes and pump stations which released untreated sewage into the rivers. Some contained 1000 000 E. coli / 100 ml of water (Kleynhans, 2014).

Out of the 100 towns that were tested by the Green drop by March 16, 2014, the results for 19 towns were not released. Results from four towns were discarded as they were not submitted to the labs on time as per the required standard. Generally, 33 of the 76 towns were not complying. This gives an indication that the rivers are polluted by the waste water treatment plants and pose a health threat and can also affect the community's ecosystem and food security (Kleynhans, 2014).

According to the Department of Water and Sanitation (DWS) index, South Africa is ranked 56 out of 178 countries on environmental performance. The water treatment works which obtain a score of less than 30% are placed under regulatory supervision because they are regarded as high risk in contaminating the natural resources. Gauteng obtained 9%; KZN 32%; Limpopo has shown a significant overall

improvement as it moved from 24% to 44.6% with only one waste water treatment obtaining a green drop certificate (Ntombela, Funke, Meissner, Steyn & Masangane, 2016).

The second method which can be applied is by allowing the cooperatives or the private sector through Private – Public Partnership to run the process with the agreed private sector principle such as being legally independent but taking the mandate from the sitting government of the day. In this case, the government ‘s role will be to set the basic goals while the actual job is done by whoever will be appointed through the service level agreement. In drawing the agreement for managing faecal sludge representatives from the communities, traditional authorities, relevant government authorities and experts need to be involved from planning the planning stage to the formulation of policy (Friedman, 2016).

2.9.2 Public Private Partnership (PPP) in water provision.

In the developing countries including South Africa, water infrastructure is highly needed to improve people’s lives. Given the high cost of infrastructure, the provision of low cost as well as free water become uneconomical, create infrastructure backlog, poor access to service delivery and inefficiency. To address this problem, the South African government through the DWS is looking at the funding model of PPPs with the private sector with the intention of eliminating infrastructure backlog. Some municipalities contracted the private sector operators under lease or concession contracts (Ruiters & Matji, 2016).

In considering the PPP, care should be given as prices might rise because water will be treated as an economic good and people will have proper management and best technologies. Contracts will be given to those who demonstrate the best system and best control of key functions such as staffing, procurement, working capital and the best method of skills transfer as the project unfolds (Ruiters & Matji, 2016).

Furthermore, it will also result in water and waste water utilities having efficiency gains through revenue flow, quick debt recovery, improved service and faster investment in expanding services. The other option is leasing contracts where the government or the municipality install the required facilities and hire a private company to run the day to day operations of the facility and this method helps to guarantee a better flow of

services. In this case, the contractor is liable to commercial risks and not the financial risks associated with the physical plant. A longer timeframe is important in this lease with exclusive rights of operation so that the return on investment can be experienced with the contract ensuring that the consumer's interest is protected with a three-year review and they have the contract fully monitored by the National Treasury to minimise potential abuse and create grounds for competitive advantage (Ruiters & Matji, 2016).

This practice is found in areas such as Kumasi in Ghana, where public toilets facilities are owned by the Kumati Metropolitan Assembly but leased to a private operator who has the required capacity and as per agreement shares profit with the assembly as per the agreed conditions (Osumanu, Rehim, Songsore, Braimah & Mulenga, 2010).

In South Africa, a culture of non-payment was created when collapsing the apartheid rule. It was worsened by the poverty level which the government mitigated by introducing indigent grants. With this condition, it is difficult to introduce or implement this system as it will have adverse consequences on the ruling party and it will be a political advantage for the opposition parties as there will be a weapon to campaign indicating that people should have access to free basic water and sanitation (Infrastructure Dialogue, 2015).

For instance, in Khayelitsha (Western Cape) and Rammulotsi (Free State), the municipalities constructed un-enclosed toilets for civilians and this was used as a good tool for campaigning in the 2011 local government elections. The opposition parties lodged complaints about these service delivery failures. The Cape High Court and the South African Human Rights Commission (SAHRC) found that the sanitation services were inadequate and the municipalities had violated the right to human dignity, privacy and the right to a clean environment, and in both cases, the relevant municipalities were ordered to enclose the toilets as a matter of urgency (DWA, 2012).

2.10 Three spheres of Government.

South Africa is not an investment-based society but a consumption based society with no proper prioritisation on maintenance and budgeting of infrastructure. The role of national government is to formulate policies that will solve strategic sanitation principles where possible and include policies that can provide for the division of sanitation functions. These functions include but are not limited to provision,

production, structuring of sanitation processes and the capacity to acquire funds to where there is a need, especially where there is a spill over or where service boundaries need to be expanded (Infrastructure Dialogue, 2015).

According to the Limpopo Development Plan (2015/2019) and the Water Strategy (2007 – 2012) (DWAF 2007), Limpopo had a deficit of 212 million m^3 between water utilisation and water availability in 2000. Currently, a deficit of 123 million m^3 is anticipated for 2025. To resolve this anticipated problem there is a serious need for improved strategies in water resource management. The water problem is worsened by the agricultural water requirement of 62% consumption and the fact that most of the infrastructure is ageing (Limpopo Development plan, 2015).

In South Africa as outlined by the National Development Plan (NDP) Vision 2030, local governments should retain responsibility for providing and managing water and sanitation services. They should also provide alternatives of community based management, local franchising or regional water utilities as they are essential for community health, development, cohesion and continued economic activity (National Planning Commission, 2011).

2.11 People's Involvement in System Design

Most of the times people are involved in designs only when they need services to reach them. Their involvement is not always constructive as it is portrayed when communities embark on strike action, both legal and illegal for non-delivery of basic services. One challenge which was faced by the municipalities in system designs over the past two decades (1990's) was that the majority of the municipal managers did not have appropriate knowledge on water and sanitation technology assessment requirements (Infrastructure Dialogue, 2015).

South Africa has established strategic water partners comprising of companies such as The South African Breweries, Eskom, SASOL, Coca-Cola, Water Research Commission and the DWS with the hope of getting rid and finding solutions of effluent management from mining and industrial sectors, agricultural irrigation schemes as well as supply chain management. Lastly, the focus is on leakage reduction, effective and efficient water consumption as well as usage (Infrastructure Dialogue, 2015).

In involving the people for the designs, the community should be informed and educated on the system that has to be implemented against the traditional method. It is said that, stakeholder's engagement is very important because it has the potential to break down the information sharing barriers and help with goal planning, decision making and absolute implementation process as all the stakeholders can advise on their expectations and can discuss and be understood by all players (Jacobsen, Webster & Vairavamoorthy, 2013).

According to Watson (2001) in Paradza, Mokwena and Richards (2010), as stipulated in the white paper on local government, it is expected that the municipal councillors should work with the institutions of civil society and the community structures for participation in matters that affect them so that there can be a local solution to the local problems.

This was well demonstrated in 2011 by UNICEF Malawi which used a mixed method market research option in improving sanitation in areas which were sandy and those with clay soil. The problem was the collapse of pit latrines in both areas. In the areas that had clay soil, the wooden flooring which was applied on the pit, hole was eaten by termites and rotted within 12 months due to intrusion by surface water. As a result, the sanitation programme could not meet the requirements of the household (Cole, 2013).

In resolving the problem, UNICEF Malawi moved away from the textbook approach of toilet construction and turned to participatory design known as 'spinuzzi'. The methodology of participatory design (2005) and IDEO's 'Human cantered design toolkit' (2009) where local builders / mansons, health workers, Environmental Health Officers (EHOs) were invited to develop designs and critique each design so that the best option would be adopted with professional engineers ratifying and authenticating the designs and structures (Cole, 2013).

The adopted design challenge created a low cost toilet that matched the needs of local villagers utilising local materials. At the end of the design, the total cost was based on one and half day labour of five American Dollars with bricks provided by the owner. The final product which was dummied on site was evaluated and critiqued by both males and females as users and the best design was chosen amongst the three built dummies (Cole, 2013).

2.11.1 Demographic Trends in South Africa

According to the National Development Plan Vision 2030 (2011), South Africa needs to develop better planning for rapid urbanisation. For this to happen there should be appropriate data on the movement of people within the country and those entering the country (National Planning Commission, 2011).

Furthermore, according to Dhesigen Naidoo, the CEO of the Water Research Commission, "*the movement of people from rural areas to towns and cities will increase while migration, predominantly from other African countries is likely to continue. This is a serious threat to the country given the scarcity of water, treatment plants of municipal and industrial wastewater which is reintroduced into rivers after treatment. There is a need to upgrade the systems so that water released should not contaminate the source at all. Currently, many municipalities lack the technical capacity to build and manage their wastewater treatment systems*" (National Planning Commission, 2011).

In resolving the water contamination and infrastructure problems, appropriate human resources should be selected on merit so that they can implement the research outcomes on the re-use of water and desalination technology (National Planning Commission, 2011).

2.11.2 Water Resources and Services

It is the responsibility of every South African to ensure that the right to live in a safe environment is upheld. This will not be realised if the problem and shortage of proper sanitation and water supply is experienced. The effective management of water and services needs to support a strong economy that will enhance a healthy environment through understanding the available water resources and effective planning. This is done to ensure that there can be an improvement on the economic sectors with natural water resources, which is protected with the aim of preventing excessive extraction and pollution of the scares resources (National Planning Commission, 2011).

In so doing, all the urban and industrial centres will meet their needs while the agricultural sector will experience improvement even in the rural areas. Furthermore,

water will be recognised as the bedrock of tourism which os responsible for a healthy life especially if all the domestic and shared rivers are protected as per obligation. Ultimately, this will culminate in South Africans in general and residents of Polokwane, in particular, having affordable, reliable access to sufficient safe water and hygienic sanitation (National Planning Commission, 2011).

Currently, South Africa is experiencing a serious challenge of water and sanitation administrators who can cope with the emerging challenges because most of the experienced water engineers and scientists are moving out of government employment. These problems apply to the administrative failures and create the absence of enforcement which brings about poor management quality and deteriorating institutional memory (National Planning Commission, 2011).

2.11.3 Managing Water Resources

In order for South Africa to have improved faecal sludge production and management, the applied technologies should manage and monitor water resources in a sustainable way without hampering economic growth. For this to happen, effective administration which involves the users and technical staff for the disposal of waste water needs to be on board when formulating legislation and policies (National Planning Commission, 2011).

2.11.4 Affordability

In South Africa, both towns and rural areas have been provided for with basic services such as water, housing, electricity and sanitation. The indigents are provided with basic services which are not paid for but are limited to each household. With these processes, it is becoming difficult in South Africa to implement a policy that might resolve the problem of faecal sludge management or sanitation. This is because of the political tensions, administrative interface, instability of administrative leadership, skills deficits, the erosion of accountability and authority, poor organisational design and low staff morale, tendency to jump from one quick fix or policy to the next as these led to instability in some areas (National Planning Commission, 2011).

An example is projected by the four bureaucratic practitioners of the passive revolution in Durban namely, Teddy Goudan, Bill Pfaff, Neil Macleod and Chis Burken who highlight, "*expect full pressure water supply and flushing toilets as the Neoliberalism*

nationalist overtones and tokenist welfarist concession for the rich and not for the poor who live in difficult terrains with the excuse that it is expensive to provide such services while it is possible to build stadiums for the world cup 2010 and provide such services to the settlements next to the city" (Bond, 2014: 3).

2.12 Sanitation Chain and Disposal of Human Faeces

In the disposal of human faeces, the fundamental principles that need to be understood are informed by understanding the sanitation needs that are sustainable, prevent diseases from spreading and promote public health, proper care on the key physical and hardware for good waste collection, environmental protection during waste treatment and disposal. They have to consider the '3Rs' – reduce, re-use and recycle so that funding and maintenance can be provided (Wilson, Rodic, Cowing, Velis, Whiteman, Scheinberg, Vilches, Masterson, Stretz & Oelz, 2014).

Furthermore, the problem which has been overlooked by the planners in sanitation was to focus mainly on access by the people and avoid the entire chain which encompasses product design, flow / transporting / conveyance, treatment and effluent disposal to the environment (Wilson *et al,* 2014).

In some Asian countries such as Cambodia and Vietnam, some households are connected to the sewer pipeline but still utilise pits and septic tanks as the pre-treatment sites. The problem in most countries is the lack of access to safe sanitation as it contaminates water with diseases such as diarrhoea, cholera, dysentery, typhoid which cause almost 115 deaths every hour in Africa alone. The biggest challenge in most countries is that they will not reach the millennium development goals because progress in improving sanitation is not easily achievable (Chowdhry, 2012).

In Dakar, the capital of Senegal, 30% of the population is served by centralised sewer systems and waste water treatment. 15% of the wastewater is treated using sludge technology which is activated and the rest of the untreated waste is released into the ocean. The majority of the people are served by the faecal sludge management system including cistern or pour flush toilets which are connected to septic tanks on a household level (Chowdhry, 2012).

The other technology used is a daily collection of faecal sludge of about six tonnes by the private vacuum truck companies and delivered to Rufisque faecal sludge treatment

plants where it is treated in settling or thickening tanks followed by unplanted drying beds. The other part of roughly 18 tonnes is disposed of directly into the environment or dumped indiscriminately (Chowdhry, 2012).

In the metropolitan areas of Ghana which is characterised by high population growth as a result of rural-urban migration, 15% of the people are served by a sewer system with no functioning wastewater treatment plant. The majority of the people are served by on-site sanitation facilities such as septic tanks, public toilets, VIPs and bucket latrines (Chowdhry, 2012).

In Kampala the capital of Uganda which had a population of about 1.7 million people in 2002 with an average growth of 3.7%, the population is served by a centralised sewer system and wastewater treatment which is treated by primary clarification tanks with subsequent trickling filters (Chowdhry, 2012).

In Africa and the third world countries, the situation is not the same as in the United States of America, where almost all the households have flushing toilets and clean water for drinking. In the third world countries, some use the honey sucker to remove faecal sludge from their premises. This is due to the geological challenges and lack of funds to put in the flushing toilets as they are perceived to be the best sanitation method (Lee, 2012).

2.13 Waste Water in Limpopo Province, South Africa

In Limpopo province, wastewater services are performed by 11 water service authorities, all connected to the infrastructure network comprising of 67 wastewater collector and treatment system that receives a total flow of approximately 123ml/day, to the total capacity of 150ml/day. This implies that almost 82% of the system capacity is taken up by the intake per day. Only 18% is left to meet the future demand at no new capacity being created. According to the green drop assessment, the 18% which is left is not readily available for use due to “poor maintenance and operational deficiencies at lower capacity municipalities (DWA and Green drop certification, 2011).

During the 2010/11 Green Drop Certification, it was found that the performance of wastewater plants has dropped tremendously. This compromised the process of sustainability and measure of gradual improvement. During this period, 63 of the water

treatment plants moved into high and critical risk positions with four plants still residing in low and medium risk spaces (DWA and Green Drop Certification, 2011).

The only plants which are not putting the public and the environment at risk are, Modimolle, Naboomspruit, Tzaneen and Warmbaths (Bela-Bela). Generally, the municipal wastewater management in Limpopo is not in a good state and is low on the national benchmarks (DWA and Green Drop Certification, 2011).

2.13.1 Capricorn District Municipality

The Capricorn District Municipality wastewater treatment is still not being managed in accordance with the regulation programme as expected due to the “lack of technical skills, hydraulic overload of systems, monitoring and effluent quality compliance, as well as lack of essential managerial procedures. The missing managerial procedures include incident response protocol” and disconcerting implementation as prescribed by the law (DWA and Green Drop Certification, 2011).

The Lebowakgomo Plant is currently experiencing 167% overload which results in poor effluent quality and it is now in a critical risk position of discharging the effluent to the environment. The main cause of poor performance is the lack of skilled staff. The problem experienced by the Lebowakgomo Plant on staff is also experienced at the Alldays and Senwabarwana Plants in the Blouberg Municipal area (DWA and Green Drop Certification, 2011).

2.13.2 Sekhukhune

The Sekhukhune wastewater services is one of the high risk factors as all the 17 treatment plants are without records to show the actual flow of data from which the operational capacity and procedures can be calculated, monitored, planned for maintenance. As there is no data, it is impossible to conduct technical audits, to budget and there are no expenditure records and no legal authorisation of the plants (DWA and Green Drop Certification, 2011).

2.13.3 Polokwane Municipality

The municipality is improving tremendously in its effort to keep the wastewater treatment in acceptable standards. The municipality is bridging the gap by improving monitoring, implemented flow measurement, data credibility and complying with the effluent quality discharge standards. This is possible because the municipality has enforced by-laws and is improving on capacity planning for the collection and treatment of infrastructure (DWA and Green Drop Certification, 2011).

Despite the efforts to keep the wastewater treatment in acceptable standards at the Polokwane plant, the other two plants found in the municipality (Mankweng and Seshego) are in a high risk position as they are deteriorating because the plants do not have appropriate and comprehensive monitoring, quality control and appropriate procedures in place. Furthermore, the plants do not comply with effluent quality discharge standards, there is no risk-based approach on integrated asset management practices and very poor sludge handling practice and facilities (DWA and Green Drop Certification, 2011).

The cause to most of this is the shortage of engineers and technical skills required on the ground for implementation. The available skills are found in the planning and management with limited practical applicability (Infrastructure dialogue, 2015).

2.13.4 Legislative Requirements

The treatment of wastewater is regulated by Section 60 of the Environmental Protection Agency Act of 1992, which intents that wastewater treatment plants are operated to the highest possible standards. They must also improve maintenance practices including assets, educate operators and equip them with the essential skills, provide knowledge of treatment standards as well as create awareness of the way in which the equipment provided is used (Environmental Protection Agency, 1997).

According to the regulations, a limited number of samples are allowed to fail where biochemical oxygen demand, chemical oxygen demand and suspended solids are limited to ‘50mg / 1 02, 250mg / 1 02 and 87mg / 1 are not exceeded. In Dzindi river, it was found that the coliforms are 900 times higher than the required 10fu / 100ml. when samples were collected at Mvudi river which is before the effluent discharge no

faecal coliforms were found. This implies that the Nandoni Dam has a microbial contamination (Mbewe, 2014).

The discharge to sensitive waste should be limited to total phosphorus (2mg/1p) and total nitrogen (15mg/1N) where the agglomeration population equivalent is between 10, 000 and 1000. Thus, the larger agglomerations have to comply with standards of 1mg/p and 10mg/1N (Environmental Protection Agency, 1997).

In order to ensure that the waste water entering the treatment plant does not hinder the performance of the plant, discharges of industrial waste to sewers are licensed under Section 16 of the Local Government (Waste Pollution Acts) of 1990 and 1997 or Section 85 of the Environmental Protection Agency Act of 1992 (Environmental Protection Agency, 1997).

2.14 Waste Water Treatment

Faecal sludge is the significant part of the wastewater treatment plant which involves the stabilisation, thickening and dewatering of sludge prior to re-use or disposal. It is on this basis that Kleynhans (2014), argues that it is the government ‘s constitutional obligation to provide the country’s citizens with clean drinking water irregardless of whether the water is free or paid for. It is also the government’s responsibility to ensure that wastewater treatment works are properly managed and there is no sewage pollution and eutrophication to the natural water system. If this is properly managed, the water quality will not deteriorate and rivers will not be threatened or endangered.

In some cases, water is polluted upstream and it affects the people who are downstream due to the point of discharge. The main source of pollution is the failing infrastructure and untreated sewage ‘pouring out of manholes and pump stations in the natural resources’. These create a strain and threat of local communities, food security and the ecosystem health (Kleynhans, 2014).

2.15 Water Usage and Available Technologies in the World

Water usage in the world has grown more than twice the rate of population growth in the 20th century. This scenario has placed reliable water services and supply under serious constraints in most regions of the world. Furthermore, it has affected the demographic pressures, the rate of economic development, urbanisation and pollution

with the agricultural sector drawing most of the world's freshwater. Thus, out of the 70% of the freshwater, 90% is used in agriculture. This leaves the domestic usage with 10% for consumption. The domestic water used and treated at the waste water treatment plant is returned to the environment with the degraded quality and no evaporative ability and the quality is highly suspected (Hedden & Cilliers, 2014).

Unlike in the first world countries, most third world countries experience the geological challenges and lack of funds to put in the flushing toilets in all dwellings as most people perceive them to be the best sanitation method without considering the consequences post flushing to the wastewater treatment plant (Lee, 2012).

Given the scarcity of water in most areas of the world, it is presumed that to improve the method of bucket system a waterless toilet system needs to be installed, as it will separate urine and faeces. The advantage with the waterless toilet is their technological ability to separate urine from coming into contact with human waste. Thus, urine will be led to an outlet pipe where it can be connected to a community lagoon or tank that can be collected later. Installing the waterless toilet can be an optional method as it reduces the possibility of contacting bacteria. At the same time bacteria, does not develop because there is no wastewater that will make it germinate, and reduce people 's hygiene in the community (Lee, 2012).

The problem with the waterless toilets in the third world is the cost implication involved as most of the people cannot afford. In some areas like South Africa where people are used to free services, it becomes difficult for people to buy such and implement the given technology. Currently, the installation of the toilet is estimated to be $ 1, 395.00 per structure (Lee, 2012).

One of the common methods found in the rural areas of New Forest, Bushbuckridge, Mpumalanga Province in South Africa and in Monwabisi Park situated in Cape Town is the pit latrine which the community members construct themselves in their yards (Mnisi, 2011).

This system solves the problem of pipe sewage system or septic tanks as there is a general shortage of water. To alleviate the problem of sanitation resulting from water shortage, which is estimated in 2025, South Africa has to develop new means and

must avoid the wastewater toilet system as it is becoming a limited exercise to build more dams due to the availability of streamflow (Hedden & Cilliers, 2014).

The study has shown that the pit latrine is a preferred system for many people, though the facility may cause many problems for the community, as the latrines are prone to harbour diseases such as cholera and acute diarrhoea. The other problem is caused by the unlined waste seeps that go into the ground and contaminate the ground water in areas where the water table is high. As an alternative to no pour-flush toilets, some people use the black bucket system at night to avoid going outside to the pit toilet at night. The challenge is that people dump the waste on the ground or in the same unlined pit toilet (Carbonneau *et al,* 2009).

2.15.1 Waterless Toilets

Given the scarcity of water around the areas of Cape Town South Africa, it is recommended that people should consider utilising either the hybrid vault toilet system or the enviroloo toilet system. The advantages of both systems are that they require no water for flushing, but provide a sustainable solution that improves public health and community needs (Carbonneau *et al,* 2009).

2.15.2 Hybrid Vault Toilet System

Maher and Lustig (2003) describe the hybrid vault toilet as a non-flushing drop toilet that feeds directly into the improved septic tank. Thing (2005) states that Paul Turner and Mark Langford developed the toilet system in Australia in the 1990s for the Aboriginal communities who did not have adequate water supply in their areas. The design combines a composting toilet and a septic system. The toilet breaks down waste and inactivates pathogens then the waste percolates into a gravel bed similar to the septic toilet system. The sludge continues to accumulate and is pumped out when it reaches the red zone of the toilet gauge on normal usage. The toilet chamber can take between 4 – 7 years to be full. Removal of sludge can be carried out by either a mechanical pump or through manual means (Carbonneau *et al,* 2009).

“Optimum conditions for anaerobic activity are PH of 6 – 8 and a temperature of 30 – 37 degrees Celsius”, with the separation chamber designed with thin slots to avoid larger solids to pass through. In the process, there is no mixing within the tanks while a steady gradient decreases oxygen levels (Carbonneau *et al,* 2009).

2.15.3 Enviro –Loo

According to Carbonneau *et al* (2009), since 1993, over 25,000 Enviro – Loo were installed worldwide. This system was developed in South Africa by Dr. Brian E. la Trobe in 1990. The system treats waste by dehydration and low temperature pasteurisation. Thus, when urine and faeces enter the toilet, they are separated by gravity with solids falling on the flapper and cast onto the drying plate. The liquid runs off the tray to the gallon vault which is dried up by an external wind powered fan placed outside the toilet top to accelerate the drying of the solids and the evaporation of the liquid at the bottom of the vault.

2.15.4 Biolytix

Bio pod is designed in a manner that does away with the mechanical complexity brought about by the conventional wastewater treatment system that is too costly to run. The system is efficient and does not reduce the quality of the effluent treated and released to the environment via irrigation of gardens, lawn and bush. The bio pod is contained in a single light weight injection moulded polypropylene tank (Biolytix, 2015).

The inside of the bio pod is composed of the layered aerobic filters containing two cubic metres of highly engineered high surface area treatment media. The media supports the organisms such as tiger worms that convert sewage or solids into humus or liquid. The organisms live throughout the filter bed and naturally ventilate the solids so that they are managed and filtered through the bed naturally to avoid the smells associated with other wastewater treatment systems. The tiger worms enhance the reduction of solids in the filter assisted by all the other micro-organism found in other wastewater treatment used to break organic waste (Biolytix, 2015).

The end result is to disperse the treated effluent to the land's aerobic topsoil layer irrigation drip line. The treated effluent can be used to irrigate the bush, gardens and lawn. In terms of the monetary value, the bio pod costs less than 20c a day (Biolytix, 2015).

The advantage with this system compared to the centralised wastewater treatment system is the fact that resources will no longer be wasted on collection, treating and delivering the water or wastewater that comes from the fossil fuels. In this case, treatment is done on site with nature playing an important role with no machinery being

applied. The used water might be from the rain and would be harvested into tanks (Maher & Lustig, 2003).

2.15.5 Compost Making Toilet

The waterless composting toilet originated in Scandinavia where there was a need for minimal maintenance, no water required, no smell produced and the end product was meant to be useful in the vegetable garden or could be used to grow trees. In building this type of toilet, care should be taken when constructing the slab, as it informs the type of structure to be built on the top for privacy. To avoid odour and create better compost, the user should add soil, wood ash and leaves to the excreta in the pit (Morgan, 2007).

2.15.6 Arboloo

It is regarded as the simplest single pit compost toilet with a shallow pit of between 1meter to 1.5 meter deep. To keep it in good health conditions, the users have to add soil, ash and leaves in the pit which is made of ring beam, slab and the top structure must be made of material which is affordable to the user such as local materials, steel, mortar or cement with bricks for the privacy of the user. The toilet is temporary, as it has to be used for a 6 – 12 months' interval. After this period, the site has to be covered with soil so that it can decompose. The compost can be dug and used elsewhere (Morgan, 2007).

2.15.7 Fossa Alterna

The second method of compost making toilet is known as the double alternating pit compost toilet. This is a permanent two sided shallow pit of approximately 1.5 metres deep, dug next to each other. It takes 12 months to fill up if it is used by an average medium sized family. This same period permits the mix of excreta soil; ashes and leaves to produce compost that can be excavated (Morgan, 2007).

2.15.8 Urine Diverting Toilet

The urine diverting toilet uses a special pedestal or squat plate which separates the urine from the faeces. With this methodology, faeces fall into a bucket that is kept in the brick vault and after every deposit soil and ashes are added to the bucket. The bucket is regularly removed to the secondary compost site and the diverted urine is collected in a plastic container for use in fertilising the soil and enhancing food production (Morgan, 2007).

2.15.9 Afrisan Wastewater Treatment Plant

The 50m3 day MC50 are mobile wastewater treatment solutions that can either be installed on a concrete platform or stands. The water discharged from this plant will meet all the requirements of being released into the natural resources with the biological oxygen demand of 100mg/L, suspended solids of 30mg/L and PH of 6 – 9 accompanied by Average Dry Weather Flow (ADWF) of 50m3/day with no rainwater infiltration or wet peak flows.

2.16 Sludge Products

According to Diener, Semiyaga, Niwagaba, Muspratt, Gning, Mbéguéré, Ennin, Zurbrugg and Strande (2014), harvested sludge can have positive economic spinoffs because the identified products can be utilised daily by people for fuel combustion, biogas and the protein derived from sludge can be processed to make animal feed. The sludge can also be used as a component in building materials and it can also be utilized as a soil conditioner. The sludge management products are not widely known because the technologies that are used to treat sludge are not known in many parts of the world (Chowdhry, 2012).

2.17 Water Harvesting and Water Cycle

Currently, most houses in the urban areas do not have any means of harvesting rain water, instead, water from the roof is directed to flow into the municipal storm water drainage and clean water is piped to the same houses from the central reservoir. At the same time, used waste water is piped away to the central treatment plant. If rain water can be stored in tanks, the impact on the municipal storm water drainage will be reduced from going to the catchments and such water will be a resource rather than a

problem. This will relieve the water burden that South Africa is facing as 98% of the water is fully allocated and the future generations are left with 2% for use (Hedden & Cilliers, 2014).

2.17.1 Water Re-use

In Sydney, they introduced Water Plan 21 which is intended to deviate the water management to a water cycle that will promote ecological sustainability by reducing water demand from the existing reservoirs, reducing treated wastewater to the environment such as oceans and rivers and by managing treated wastewater as a resource instead of a waste. In order to ensure that on site treatment is done properly, the United States of America implemented a licence inspection system which ensures that there is an improvement in the maintenance of households for water re-use. In South Africa, the system is monitored through the Green Drop and Blue drop. In a way, government is encouraging good maintenance by giving rebates to those who maintain the standard so that there will be no breakages and no polluting of the fresh water sources. These systems have more advantages and they are friendlier to the environment because if something wrong happens trained personnel will attend to the problem speedily and processes will be in place to quarantine the situation (Ntombela, Funke, Meissner, Steyn & Masangane, 2016).

In some parts of the world, industries treat their grey water on site so that they can remove chemicals which can be reused for production. The cleaned water will also be reused for production purposes. In the past water was the only bio degradable entity as there were few chemicals that were put in it such as plasticisers, deterrents and bleaches. Literature indicates that if water and greywater are properly managed, there will be no water shortages in cities as water can be reused with real treatment (Drangert, 2010).

2.18 Measurements of Water Used to Flush Poo

According to Conradin, Kropac and the University of Limpopo's Department of Water and Sanitation (2012), it is estimated that each person produces 50kg of faeces per year which equals to 500g per year divided by 365 days which is equal to 136.99 grams per day. On average, each person produces 500L of urine per year and if divided by 365 days it is equal to 1.37 litres per day or 1 370g per day. Ultimately, 20

000 litres of fresh water will be required to flush away the waste. That amounts to 54.8 litres of fresh water per person per day wasting water which is a scarce resource.

It is said that the quality of faeces produced daily depends on the food consumed and the people's lifestyle. Those who consume unprocessed food with high fibre produce a higher quality of faeces in terms of the mass and volume of faeces compared to those who take higher meat based and processed food (Nlwagaba, Mbequere & Strande, 2014).

The study further shows that in Hungary, the water consumption was 34, 1 m3 / year/person in 2011 and the joint amount of faeces and urine is estimated to be 1.5 litres a day and 550 litres per year (Zseni, 2015).

2.19 World Outlook

The challenges facing faecal sludge management in the world does not differ much from country to country. Most countries share almost same problems as outlined by the World Health Organisation and the UN – Water Global Analysis and Assessment of Sanitation and Drinking water (GLAAS). In addition to this conditions and findings of GLAAS (2014), Chowdy (2012) stated that problems in most countries is lack of access to safe sanitation globally as it contaminate water with diseases such as diarrhoea, cholera, dysentery, typhoid and cause of 115 deaths every hour in Africa alone'. The biggest challenge is that most countries will not reach the millennium development goals because progress on improving sanitation is not easily achievable (Chowdy, 2012).

2.19.1 Toilet as a suitable alternative

Studies conducted by the Welsh Water and confirmed by Genc (2009) as pronounced by Cater (2006) when stating that increasing world population brings forth new challenges on the environment and sustainability. This is as a result of the high consumption of utilising fresh water to flush toilets. Given the millions of people flushing waste daily creates environmental pollution on the natural resources, resulting in unhealthy conditions.

According to Quitzau (2007) in Genc (2009), there is serious need for the designers of flush toilets to change the system as these could result into the environmental

downfall of the world. This is proofed by the statistical figures on how much water is used at home for flushing the toilet compared to drinking water. From the water delivered to houses 95% goes down the drain and only 3% is used for drinking. Over the quarter of clean water which is estimated to be 30% is used to flush the toilets. Care needs to be taken that by 2025 there will be another 2 billion more people in the world requiring food and water. It is estimated that 1.8 billion people in the world have drinking water source which is faecal contaminated (GLAAS, 2014).

2.19.2 Findings of GLAAS 2014

In achieving the universal coverage in water, sanitation and hygiene there is a need for collective affords by national governments, local communities and international agencies to persuade governments to show strong support for universal access to drinking water and sanitation supported by the political will, improve countries capacity for monitoring, track funding to water and sanitation as well as proper utilisation of data for investment and report back on deliverables (GLAAS, 2014).

The findings further spelled out that one third of the countries in the world have no accurate plan for drinking water or sanitation in health care facilities and schools. Most countries indicate that faecal sludge management is mostly experiencing insufficient finances especially on operations and maintenance which is the key to sustainable and safe service provision. The other critical factor is lack of human resources in the sector where most countries reported to GLAAS that they do not have human resource strategies in water, sanitation management and hygiene for both urban and rural areas (GLAAS, 2014).

2.19.3 On site sanitation

In Sydney, they introduced water plan 21 which is intended to deviate from water management to water cycle that will promote ecological sustainability by reducing water demand from the existing reservoirs, reduce treated waste water to the environment such as oceans and rivers, manage treated waste water as a resource instead of a waste (Ntombela, Funke, Meissner, Steyn & Masangane: 2016).

In some parts of the world industries treat their grey water on site so that they can remove chemicals which could be reused for production. The cleaned water will also be reused for production purposes. In the past water was only bio degraded as there

were less chemicals put in them such as plasticizers, deterrents and bleaches. Furthermore, if water and greywater are properly managed, there will be no water shortages in cities as water can be used over and over with real treatment (Drangert, 2010).

CHAPTER 3:
RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The previous chapter covered the theoretical aspects of water and sanitation in relation to faecal sludge management from secondary sources such as books, journals and dissertations from other scholars and the contextual background of Polokwane Municipality was discussed as well as the current status of faecal sludge. In this chapter, the researcher ensured that the theoretical part ensured that the challenges faced by the municipalities in areas which are experiencing growth around the country as well as the challenges faced by the ageing sewage plants which ultimately contribute to water degradation which in some cases is caused by raw sewage from hospitals is covered. The chapter further discussed the importance of PPPs in developing faecal sludge management technologies, sanitation chains and the importance of faecal sludge products. This chapter provides information on the research approach, design and the methods that were used to acquire primary data on faecal sludge management and it also highlights the projection plan of the faecal sludge produced in the City of Polokwane, South Africa.

3.2 Research Methodology

Mabona (2016) states that a distinction has to be made between methodology and methods as *'Methodology is not the same as methods'.* The two can be summarised as, '*Methods is the tools and methodology is the toolbox'*. Methods refer to the way in which data is collected or the technique that is used to structure a study and gather as well as analyse information in a systematic manner (Porta & Keating, 2008).

Other scholars such as Polit and Beck (2008) described a method as a technique that is used to structure a study as well as gather and analyse information in a systematic manner. Porta and Keating (2008) define research methods as the way the researcher acquires data.

Bell, (1993) states that there is no prescribed method and there is no specific way of collecting data because the methods used to collect data depend on the researcher's choice and the 'research design'. This was attested to by Hale and Napier (2014) who state that "research methods are chosen to try and describe, interpret and explain events from the perspective of people who are subjects of research".

Methods can also be attributed as techniques for investigating or testing hypotheses with different methods such as surveys and experiments (Newsome, 2016). Rajaseka, Philominathan and Chinnathandi (2013) define methods as the various procedures, schemes and algorithms that are used in research.

Methodology refers to the general research strategy as well as the procedure of logical thought which is applied to a specific investigation (Okolie.,2011). Newton's analysis methodology is described as the collection of methods that are prescribed and used appropriately in some specific conditions. Rajaseka *et al* (2013) define research methodology as the systematic way to solve a problem. Furthermore, it is described as the science of studying how research is to be carried out. It implies the procedure which researchers go through in their work when describing, explaining and predicting a phenomenon under study. Researches such as Waller, Faruharson and Dembsey (2016) describe methodology as the manner in which the researcher plans to find answers to the research question as posed and outlined in the project scope.

3.3 Research Design and Rationale

This is the section that displays the type of data that is to be collected and how that data has to be collected. These include the peoples' perception, whether the data is narrative or statistical, qualitative or quantitative. According to Neuman (2011), research design is the development of a strategy that is to be used in guiding the research process and in planning in detail before collecting and analysing data. This can be argued to be the overall structure undertaken in the study. Mason (2013) describes research design as an ongoing grounded practice, process and the context of the actual research. Waller *et al* (2016) describe research design as the great thinking deal with regard to the essence of the enquiry as per the sense of ontology, epistemology and the manner in which the research question will be coherently and

sensibly formulated. Some scholars define research design as the blue-print or a detailed plan on how the research has to be conducted (Mouton, 2014).

In a nutshell, the research design depends on the kind of study being planned and the type of results that are aimed at as per the research problem which is regarded as the study's point of departure. Lastly, the research design focuses on the logic of research as informed by the information required to address the research question (Mouton, 2014).

3.3.1 Relationship Between Research Design and Research Methodology

In this study, the research design is related to the research methodology from the following premise:

The unit of study for this research is faecal sludge production and management. From this unit of study, a **unit of observation** was established as there are various technologies used in faecal sludge management and water preservation in the Polokwane Municipality. For this study, the **unit of analysis** is Polokwane Municipality. From the premise of this unit of analysis, the research focuses on the relationship between water usage in disposing faecal sludge against other applicable alternatives.

3.3.2 The Importance of the Mixed Method Research Design

The mixed method has in recent times improved and evolved to a point where it is now a separate methodology in the world and it has developed its own techniques as well as vocabulary. Furthermore, the design clearly specifies the sequence and gives priority to the elements of data collection and analysis. It also provides a clear and explicit account of the research aspect on how the two methods relate to each other (Denscombe, 2008).

It is believed that some researchers use this method to improve their data accuracy as they combine information from the data sources in a more comprehensive way and create a better picture with unbiased results as compared to a single method. Lastly, it helps in sampling as potential participants will be screened for inclusion in the interview programme through questionnaires (Densecome, 2008).

3.3.3 Quantitative Research Approach

This approach can be defined as the focus and understanding of reality by discovering general laws while manipulating some variables which are unimportant and irrelevant. Furthermore, quantitative research uses the statistical technique for a population in an objective or measurable sense as it focuses on the cause as well as effect and testing of the hypothesis (Hancock, Ockleford & Windridge, 2009).

Quantitative descriptive data according to Hancock *et al* (2009) is used to solely describe a phenomenon in order to arrive at a universal statement through the use of data obtained from a census. The data will help project the amount of faecal sludge to be produced in future and the amount of water to be required if the waterborne faecal sludge management programme is used for disposing human waste.

3.3.4 Qualitative Research Approach

This approach can be defined as a research method which can be applied to a number of systematic reviews that give answers to questions about people's perspectives and experiences. It is further valued to have good potential in informing policy and practice as it is not generalised but it is specific to a particular context, time and participants in the group (Thomas & Harden, 2008).

Qualitative data collection involves the setting of boundaries for the study; collecting information using tools such as interviews, observing protocols by recording audios or videos, reviewing primary and secondary data; providing the researcher with the skill to gauge words as well as the language of the informants. The acquired information can be accessed by the researcher at his or her own convenience with informants having an opportunity to share the reality as attention was fully paid during data collection. Data collected is then transcribed for further analysis (Ivankova, Creswell & Plano Clark, 2014).

This study is based on the mixed method research design encompassing the quantitative research approach and qualitative research approaches. The mixed method research design is defined by Leech and Onwuegezie (2007) as well as

Creswell (2015) as the collection and the analysis of both qualitative and quantitative data in a single study or in a series of studies. The definition is further expantiated by Heyvaet, Maes and Onghena (2011) as a method which the researcher will use at a primary level to collect qualitative and quantitative data directly from research participants utilising either interviews, observations or questionnaires and combine them into a single study.

3.4 Data Collection

Data collection is described as a valuable guide for gathering information, facts and observation. It adequately measures information on variables of interest and in a systematic way in order to answer queries in quantity and quality for the sake of producing a complete and credible analysis of a stated research question. Data collection also tests hypothesis and evaluates the outcomes without compromising the integrity, accuracy and reliability of data using appropriate sources, tools and methods. Collection of inaccurate and misleading information will lead to poor research results (Murgan, 2015).

Data collection is further described by Moyo (2017), as a tool designed to enable the researcher to collect comprehensive and relevant data for analysis, inference and contributes to knowledge production. Furthermore, it is a mode of helping the society to know what was not known before and leads to new knowledge creation. The researcher collected data using two formats namely: Primary data and Secondary data.

3.4.1 Primary Data

Primary data collection is described as an involvement of closer and deeper interaction between the researcher and the respondent in addressing the inquiry (Auriacombe & Mouton, 2007). Auriacombe (2007) further describes primary data collection as data obtained through means of communication and association or evidence of human behaviour which has to be investigated.

Primary data in qualitative study is original data gathered through a research study. This implies that the focus is not only on generalising a specified population but the reason is to uncover new ideas and hidden feelings from the respondents. In collecting

this type of data, a small number of respondents is required using unstructured interviews in order to get in-depth information. The second form of primary data in quantitative study is aimed at generalising a specific population as a sample is chosen and estimates are done to generalise on the studied phenomenon (Auriacombe, 2005).

The researcher collected primary data through the use of an interview guide from the municipal officials and from the politician responsible for sanitation so that first-hand information with regard to sanitation in the Municipality of Polokwane is acquired. The method gave insight into the depth of the study through the exploratory data that is solicited from the opinions and perceptions of the participants with regard to the faecal sludge management in the city of Polokwane. On average, ten respondents were be interviewed and their information will be recorded with the intention of reaching a saturation point.

In acquiring data, the semi-structured interview was applied as it is one of the empirical study methods that permits the individual respondents' latitude and freedom to talk about what is of interest or importance to them. The interviews conducted involve using semi-structured personal contact with the participants who answered the research question relating to the research problem.

Qualitative interviews are an interaction between an interviewer and a respondent. the interviewer has a general plan of inquiry and mainly uses the interview guide but is not restricted to specific questions asked in a particular order. It is also specified that the main aim of qualitative research is to acquire as much information as possible and interrogate all the information being obtained to the saturation point in order to understand the actual meaning of information and reach conclusions (Kgalane, 2015).

3.4.2 Self-administered Questionnaire / Interview Schedule

An interview schedule was used to ask questions to the targeted and the identified population for this study. The researcher used both open-ended and closed-ended questions in no particular order.

3.4.2.1 Importance of the Interview Guide

The interview questions were based on the research questions stated in Chapter one. The guide assisted the research and the researcher to maintain consistency and the logical flow of questions.

3.4.3 Interviews

Semi-structured face-to-face interviews were conducted with other municipal officials that deal with water and sanitation within the Municipality of Polokwane and the councillors responsible for water and sanitation. Open-ended questions were asked so that the study can obtain rich and complex data which is not possible to obtain from a closed-response question. However, close-ended questions were also used to avoid monotony.

In this regard, the researcher must supply the response options to the person. Each interview took approximately 20 - 50 minutes for each interviewee and the whole process was expected to take a month to complete and ten interviews were meant to be conducted.

3.4.4 Secondary Data

This is the type of data already collected by others on the research. It is used when there is no need to conduct another research to answer the research questions. It provides literature which shows the existing gaps in the studies that have been done already and helps to identify important definitions, variables, point out a trial of development, latest trends as well as the current state of practice in the field of study. Lastly, it helps to formulate the research questions (Burian, Rogerson & Francis, 2010).

In this study, the secondary data that was used included the national census data between 2001 to 2011 (Stats SA, 2011) and the worldwide standardised sludge production figures developed by Sustainable Sanitation and Waste Water Management (SSWM) for projecting the sludge production and water usage (Condradin, Kropac and University of Limpopo, 2012).

3.4.5 Population

Population is defined as a small group, portion, objects and phenomenon for the study purpose which remains the representative of the larger group which the researcher wishes to research in order to establish new knowledge. Population is also defined as the total collection of individuals from which the units of the study are chosen and the sets of elements on which the research has focused on and to which they obtain results that should be generalised (Kgalane 2015).

The population for this study comprise the following:

a. Municipal Population Census Data (1996, 2001 and 2011) for quantifying sludge production and sludge- water usage Statistics SA (2011);
b. Municipal officials working with sanitation to address the qualitative questions on sludge management. The total number of municipal officials in the City of Polokwane is 1 556 as per the Municipal structure Polokwane Municipality (2017/8).

3.5 Sampling

Sample is defined as the segment of the population to be studied representing the entire population to participate in the study. It also refers to the process that is being used in selecting a portion of the population that has to be studied (Nieuwenhuis, 2014). A sample is when a single member from the population known as elements is selected to participate in the study. Collis and Hussey (2009) state that a research sample should be made of members of the population instead of the whole population because the cost of conducting research on a sampled population is lower than researching the whole population like in census (Hanlon & Larget, 2011).

3.5.1 Sampling Method

For the purpose of this study, the researcher utilised amongst others the Census Data of the Polokwane Municipality population to determine the processes that the Polokwane Municipality apply on faecal sludge management in order to ascertain how water conservation can be applied in faecal sludge management in Polokwane Municipality. The data was also used to evaluate the cost management system which the Polokwane Municipality applied on faecal sludge management to investigate the faecal sludge management approaches/plans applied by the Polokwane Municipality.

It was also utilised to examine how the faecal sludge production and management system has to be improved in the Municipality of Polokwane.

In addition**,** the researcher applied the purposive sampling method in the project as that helped to select relevant municipal officials for participation in interviews. The reason for choosing this method was that the focus is on special situations dealing mainly with sanitation in the municipality. Furthermore, the study also considered the issues of gender and age because their impact is based on the experience and expertise of each respondent.

Furthermore, sampling is purposive in that one is looking for particular types of participants, according to what one already knows about the field with the intention of having those participants give more information and data (Ritchie, Lewis, Nicholls & Ormston, 2014; Blanche, Durrheim & Painter, 2006).

3.5.2 Sample size

The researcher targeted to have a maximum of ten individuals who included six officials and four politicians as they possess the data needed for the study until such a time when there would be no themes emerging from the data being gathered. The process is known as the saturation point (Nieuwenhuis, 2014).

The researcher could only manage to interview seven individuals as some targeted positions were not occupied in the municipality.

3.6 Data Analysis

Welman, Kruger and Mitchell (2011) describe data analysis as a process of bringing order, structure and meaning to the collected data and helping to investigate effects, relationship and involvement of variables within the world. The process of data analysis can take different forms but it depends upon the nature of the research and the design and the nature of the data itself. Qualitative and quantitative (mix-methods) data was used in the study.

3.6.1 Quantitative Data Analysis

Quantitative data was analysed using content/phenomenon logical analysis which is defined as a set of procedures meant to describe a large amount of content communication by reducing it into parts and checking their relations towards each other in the whole study. It is also referred to as breaking concepts into small components of data for analysis purposes (Bardenhost, 2008).

In this study, the numerical data collected from the secondary data sources which include population figures, number of households using different types of toilets and data on water statistics was presented using bar graphs, line graphs, pie charts and tables.

3.6.2 Qualitative Data Analysis

Qualitative data analysis is a systematic process of selecting, categorising, comparing, synthesising and interpreting acquired information to provide explanations of the phenomenon of interest. This involved the analysis of the data collected, the process of inspecting, cleaning, transforming, and modelling data with the goal of highlighting useful information, suggesting conclusions and supporting decision making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science and social science domains (Kgalane, 2015).

In a qualitative research, the information obtained from participants is not expressed in numerical form but on the stated experiences of the participants and on the stated meanings attached to themselves, other people and the environment. In analysing the responses, the researcher will identify questions and statements in the interview guide which are related and grouped together in discussing the findings in relation to the research questions. Data collected during the study was classified and categorised in order to attain the logical connections between categories and in order to create a pattern that establishes connections (Doyle, Brady & Byrne, 2016).

In applying the inductive analysis of data in qualitative research, the results will involve the extensive condensation of raw data into a brief and summary format as well as through establishing clear links between the research objectives and the summary

findings. A model will be developed on the underlying structure of experiences or processes that are evident in the text data (Mabona, 2016).

In this study, qualitative data was analysed using thematic analysis which is defined as a sequential explanatory design helping to ensure that questions raised in the qualitative phase are answered.

According to Anderson (2007), the Thematic Content Analysis (TAC) process involves:

Making multiple copies of interview transcripts of the exact text of the post-interview notes; Highlighting all descriptions that are relevant to the topic of inquiry; marking each distinct unit of meaning and separating by a break or change in meaning through retaining all information relevant to understanding a meaning of the unit, so that the relevant information needs not be disconnected from the source as the TCA continues.

The researcher further grouped the extracted texts into common themes so that expressions of the common voices from the population could be identified with minimal interpretation of naming.

3.7 Ethical Considerations

Babbie and Mouton (2010:520) state "*that ethical issues arise out of interaction with people, other beings and the environment".* In conducting this study, there was interaction with people and the researcher had to respect the participants and sites of research. Amongst others, the ethical consideration involves the informed consent, research misconduct, conflict of interest and authorship.

Ethics in research means doing good and avoiding harm. In doing good the researcher protects the participant's identity when interpreting results and the information acquired from the participants is done without coercing anybody. The manner in which the researcher gains access to the study group and the effects he/she has on the participants should be of acceptable standards (Mfuwane, 2012).

For the purpose of this study, the researcher has acquired ethical clearance from the Turfloop Research Ethics Committee and a letter from the Municipality of Polokwane allowing research to be conducted amongst its subjects.

3.7.1 Ethical Principles

The ethical principles to be considered are amongst others: *autonomy, beneficence and justic*e.

Autonomy: Implies that research should recognise the participants' rights such as being informed about the study, having the right to freely decide whether to participate in a study and having the right to withdraw any time without penalty (Beauchamp & Childress, 2009). The researcher approached the municipality manager and informed her on the manner in which the research will be conducted and requested that the people who deal with sanitation be informed about the researcher's request to interview them. The people were informed that it should be on a voluntary basis.

Beneficence: According to Mfuwane (2012), beneficence implies doing well to others and preventing harm, some regarded it as paternalism because the researcher is morally obliged not to reveal the participant's identities. In so doing the use of pseudonyms should be applied to really secure the identities when publishing the research finding. The researcher ensured that the participants were given alphabetical names so that their identity could be hidden when interviewed. The same names were used when analysing data.

Justice: The principle implies that there should be equal share and fairness. The main intention is to avoid exploitation and abuse of participants. For example, when the researcher finds that during data analysis one of the headings/concepts to be used belongs to a particular participant, the researcher should request permission from that participant (Butts & Rich, 2008). The researcher requested that all participants' inputs be used in the research in the manner in which it will be for academic purpose only. A guarantee was made to all participants that if there are changes on the information given, a prior concern will be requested from the respondent.

The important implication to the researcher's work is validity, reliability and meaningfulness of the data (Mabona, 2016).

- ✓ In conducting this study, the researcher safeguarded the respondent's emotions and physical feelings so that they would not be harmed;

- ✓ Furthermore, the researcher informed the respondents that if there is any possibility of any harm through the use of words, it was absolutely unintentional as the researcher intended to avoid such at all costs during the study;
- ✓ Approval was sought by the researcher from relevant institutions in order to get permission to interview the water providing officials and the politicians;
- ✓ The respondents were given reasons for conducting the research and were promised to never to be deceived;
- ✓ The privacy of the respondents was never violated and the research was conducted with anonymity regulation and confidentiality.

3.7.2 Validity

Validity in mixed methods research relates to the type of strategies discussed, sample size, contradicting results follow up, data collection biasness and the use of rich descriptions to deliver the findings and provide the readers with the real setting as well as the accuracy of the findings as they determine the accuracy of the findings. If validity is compromised, objectivity and credibility of the social research will be compromised (Mdluli, 2017).

In this study, the researcher validated the information by using census data and the measure of faeces in the Polokwane Municipality's University of Limpopo (Turfloop).

The census was further used to do the calculations of what is existing, what will be needed in the near future to sustain the delivery of this vital resources which is water and improve on the existing infrastructure at the sewage plants.

3.7.3 Reliability

Reliability is described as the consistency of measurement and ensuring that the information provided is credible in nature (Bless, Higson-Smith & Sithole, 2013). According to Terreblanche, Durrenheim and Painter (2006), reliability is also referred to as dependability of how the researcher has ensured that the results happened as stated in the study.

The data collected from both interviews and census data was made reliable as a thorough or extensive review of the literature was considered regarding faecal sludge

management in both South Africa and the other countries. A comparison was also done on the measurement of faeces produced by a South African in Limpopo, Polokwane Municipality with those of other countries in terms of mass and volume.

CHAPTER 4:
RESULTS, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents and analyses the data collected from the officials and politicians of Polokwane Municipality who are in control of the town/city's Seshego Sewage Plant and Mankweng Sewage Plant as well as the municipality's rural areas. The research respondents in this chapter answered the following research questions:

i. What processes do the Polokwane Municipality apply on faecal sludge management?
ii. How is water conservation applied in faecal sludge management in Polokwane Municipality?
iii. What cost management system does Polokwane Municipality apply on faecal sludge management?
iv. What are the faecal sludge management approaches/plans applied by Polokwane Municipality?
v. How can the faecal sludge production and management system be improved in the Municipality of Polokwane?

The empirical study obtained more information/data through the use of an interview guide on a purposeful sampled population of Polokwane Municipality who are directly involved with faecal sludge management on administrative practice and political execution of activities. The research design presented in Chapter 3 is the applied case study method which indicates that data was collected using both literature review and empirical study. The literature review in chapter 2 shows that the study's conceptual framework originated from the theory of the world's actual happenings. The presentation of data resumes with the presentation of interview guide questions, the response from the respondents and a discussion on the response. The interviews were conducted face to face with all the respondents from the municipality.

4.2 Qualitative Data Presentation and Analysis

The research obtained a total of seven respondents instead of ten and it was based on purposive sampling method as some targeted positions were not occupied in the municipality. The presentation of data in this section is done in accordance with the investigative sub-questions and the research objective.

4.2.1 Given the high rural-urban migration and population growth in Polokwane, what are the plans of managing faecal sludge produced in both rural and urban areas

Five officials and one politician stated that in the rural areas, faecal sludge is managed by lined VIP pit toilets which will prevent contamination of ground water in future.

a. Respondent A, in verbatim, said: “The municipality is busy with ventilated pit latrines or toilets in the **rural areas** which are **lined** for the purpose of avoiding ground water contamination and for future maintenance and emptying them”.
b. Respondent C, said: “In the **rural areas** sludge is managed by construction of l**ined** VIP pit latrines as there are no sewage network systems currently”.
c. A different response was found when responded D indicated that the municipality has constructed a toilet with a vacuum opening at the back for the truck to suck the sludge and dump it at the sewage plant and such are found in Mentz and Ga – Mothapo. The advantage with this toilet is that they take time to fill up.
d. Respondent B and G indicated that there is no method used to control it except just to keep it in a toilet pit when the pit is full it was to be abandoned and a new pit is dug for the new toilet.
e. Respondent F and G, indicated that in some areas of the municipality, septic tanks are used and when sludge is full it is emptied by honey sucker trucks which ultimately dump it in the sewage plants.

In the urban areas, it was indicated by all the seven respondents that the only method used is the waterborne system and sewage network that transports all faeces to the waste water treatment works.

a. In their own words Respondent A, said: “In the urban areas waste water treatment works is being used so that sewage can be treated before it is

released to the environment. Currently, there are systems in place to accumulate the sludge and allow it to dry in the drying beds then it can be deposited to the designated area of disposal".

b. Respondent C, indicated that: In the urban areas, the network system is already in existence and the flush toilets are in existence, as a result, sewage plants are sources of managing sludge and wastewater treatment works are being used so that sewage can be treated before it can be discharged to the river. There are systems in place to accumulate the sludge and allow it to dry in the drying beds then it can be exposed / can be deposited to the designated area of disposal.
c. A different answer was provided by Respondent G, who indicated that more sludge comes in daily, as a result, it is difficult to have sludge drying properly as the existing infrastructure is limited to give it time to dry fully.
d. Respondent G, further indicated that, currently, there is a problem of space to store sludge as it is composed of things that can be harmful such as bacteria. You cannot just throw it (dump) it anywhere. Now it is piled at the treatment works.
e. Respondent C indicated that wastewater treatment plants are operated by the municipality to try and manage sludge which is being produced, though the plants are currently overloaded. Mankweng is still within its capacity of 8ml/day. The Seshego and Town plants are operating beyond capacity. The sewage plant is where the sludge is separated from the inlet works. The first is the raw sludge from the Primary Segmentation Tank (PST's) that will be pumped to the digesters 1 – 5 whereby one will have the primary sludge, secondary sludge and tertiary sludge.

   Secondary sludge is collected from Digester 4 and 5 and it would have spent about 25 – 30 days. This sludge is well stabilised, then it is pumped to the drying beds without causing any nuisance. At the drying beds, it will be kept for 3 – 4 weeks so that it can be dry.

According to the 2010 / 11 Green Drop certification it was pointed out that in South Africa the sewage plant infrastructure is poorly managed. The national green drop

analysis further indicated that out of 824 waste water plants, only 60 are in excellent condition. The 284 plants are in critical conditions and 161 are in poor conditions. This implies that 409 which translates to 49.6% of the plants are failing (Savides, 2018).

The other contributing factor of the deteriorating infrastructure is instead of solving the deteriorating problem, the DWS spends billions of Rands in excessive project management and professional fees. This instead placed the department in financial distress and the leadership's inability and skills crisis also exercebate the situation (Savides, 2018).

4.2.2 Since 1994 Government provided houses to the people and increased the usage of existing sewage plants. Are those plants coping with the high incidence of more sewage networks being connected?

In answering this question, all the respondents indicated that the Polokwane and Seshego wastewater treatment plants are not coping, the only one that is coping is the Mankweng waste water treatment plant as it is capacitated to 8ml per day and the income is 6Ml per day.

The Polokwane wastewater treatment plant is equipped to take in 25ml per day, but the inflow is around 32ml per day. The Seshego Plant is capacitated to take in 7.4ml per day while the daily intake is roughly 10 ml per day.

The respondents indicated that:

a. Respondent A, said: **"**Generally, no**"**. The two plants of Polokwane Municipality, namely, Seshego and Town are above capacity due to the increase of people who are discharging to the plants, Mankweng is the only one which is still save. I can agree that they are no longer coping because of population growth and there has never been any upgrade, Polokwane sewage is only being upgraded now for 6Ml with the help of Anglo Platinum. The wastewater treatment plants are at the worst stage now.
b. Respondent B, indicated that: No, existing plants were not upgraded in a long time. Currently, Polokwane capacity is 25Ml but it is operating around 32Ml, at pick it can get up to 50Ml/day more specifically when it is heavily raining. The plants are not coping currently because the inflow

is too much. The new development taking place within the city makes it difficult for the plant to operate. Seshego capacity is 7.4Ml/day but it is operating beyond 10Ml. In Polokwane, the inflow is measured properly with new metres from both domestic and industrial.

c. According to the by laws, the industries are supposed to pump effluent with less than 500Mlg of Chemical Oxygen Demand (COD). The plant is 3 in 1. 1st Activated sludge plant, 2nd Bio–filter plant and 3rd Brewery. Seshego capacity is 7.4ml per day but it is operating beyond 10ml per day. In Polokwane, the inflow is measured properly with new metres from both domestic and industrial. Before this effluent is released they are combined in the contact tank then discharged into the ponds.
d. The sentiments were further comprehended by Respondent C, who indicated that: The population in town increased and the sewage plant indicate on the flow metres that the intake is high since 1994. The performance of the plant deteriorated due to high intake until now. Even if you check at the outflow you will see that the sludge does not conform with the standard, but before 1994 the final effluent released into the river was 100%. Mankweng is coping despite the new extensions done. The problem is in the rural areas where majority of toilets in the old settlements are not lined.
e. Respondent F, indicated that the plants are not coping because the plants in Polokwane are running above capacity. It should be 28Ml/day. The highest problem is when it is raining because we go above 30Ml/day. When the sewage is overloaded the storm water by-pass valve is opened and goes straight into the river. To avoid damaging motors in the plant, blocking of pipes you have to open storm water by-pass valve knowing that you are contaminating the environment temporarily in order to avoid major disaster.
f. Respondent F, said: No, the plants are not coping, there is serious overload on the plants and that creates the final effluent not to be properly treated to the required standard. As such the Municipality is polluting the rivers. When there is any problem the ***by-pass is released to the maturation ponds not direct to the river***. Seshego is 7.5ml as per documents but it can take 11.7ml. The flow metres in Seshego

shows that the operation is above capacity. Currently, the intake is between 8 – 9ml per day. Even if rains we do not have serious problems as there is a by-pass line. The problem is people who divert their house water into the sewage pipe as that increase the plant intake. In Polokwane, there is a dam which was built to receive water from the by-pass. The water will be directed back for processing before it is released to the natural environment.

g. Respondent E, simply said: “Polokwane and Seshego plants are running on the danger zone while Mankweng is still safe”.

According to Dr. Anthony Turon who is regarded as the water expert due to his extensive training as a scientist specialising in water resources management and strong strategic publications record indicated that, the situation in South African waste water treatment plants is not improving but getting worse as there is lack of capacity beyond the inability to produce reports. Furthermore, the expert indicated that the reports show that measuring systems and gauging stations are also failing (Savides, 2018).

4.2.3 Emanating from the above question, can you describe the challenges faced by the Municipality in the management of faecal sludge at the sewerage plants?

In answering this follow up question the respondents highlighted different views which were mainly focusing on the over capacitated plants with lack of properly trained human resources.

In their own words the respondents stated the following:

a. Respondent A, indicated that the main challenge is that “over capacitated plant makes it difficult to handle sludge properly and you cannot throw it everywhere as you are compelled to have a designated area to dump”. Currently, it is just kept in the plant as hips or piled up. That on its own has an impact because when it rains water carry it into the river / wash away.
b. Respondent B, stated that adequate capacity is a problem because the more intake the more sludge is produced that need to be addressed, as

there is no enough capacity to treat the sludge fully. This implies that, sludge is partially treated, by right sludge has to be classified after treatment for use and Sludge cannot be disposed because it does not meet the requirements of water and sanitation. Furthermore, Sludge is produced daily and is just heaped no use. This need capacity of infrastructure needed to treat sludge to the required standard.

c. Respondent C, substantiated the previous answers by stating that: The main challenges are due to high sludge production, we are unable to withdraw / dis-sludge some of the PST on time due to blocked PST 's, which is caused by too much sludge or too much sand or creed that came into the system with rain. This creates a high risk to the Municipality waste water treatment plant as the first tank used to separate sludge and settle the switch becomes overloaded with foreign objects mainly when it is raining as we will be forced to open the overflow valve to by-pass the diluted sewage direct to the maturation pond. (only when it is raining heavily). Once you open the storm water overflow valve it implies that you by-pass the whole process then it will get into the ponds 1, 2 & 3. The role of the ponds is for final purification of the water. In Polokwane, the capacity is standing at 28ml but documented measure is 25ml, the flow fluctuates between 24 – 32ml per day. When it is raining it goes up to 40 – 50 ml per day, if the storm water overflow and the valve is not opened it will reach 60ml per day.
d. Respondent D, indicated that: The problem is people who use hired toilets and dispose sludge anywhere without dumping it at the municipal facilities. This creates pollution in the rivers, "we are experiencing pollution in the rivers from the private trucks". which extract sludge from the septic tanks. In Mankweng the other problem experienced is deposits from garages, Mankweng hospital, the University of Limpopo and the abattoir in Nobody as the deposits from their septic tanks become difficult to purify with the biological process due to oil contamination when brought to the plant for purification.

These sentiments are supported by the study done by Morris, Harris, Morris, Cummin and Cormican (2008), stating that the release of hospital effluent may encourage and preserve resistance within the environment in which it is discharged because of the antimicrobials bacteria. It is, therefore, advisable to have hospital effluent which has to be released to the municipal waste water system be treated separately or be treated with specified methods because the new antimicrobials bacteria vary in resistance.

Boshego (2018), further indicated that hospital effluent does not only put the lives of the community in danger, risk and jeopardy but the entire ecology of the river system if the hospital effluent is released to the river untreated because, the effluent consists of human faeces, blood, toxic waste and other dangerous medical waste.

e. Respondent D, further indicated that: The abattoir needs a separate purification dam. Fat suffocates the bacteria on the biological filter, as a result, it is unable to denitrify the water and the sewage plant finds it difficult as there is no fat trap. The other problem is the community which opens the main hole in the urban areas and let water, sand and bricks which blocks the system and damage the pumps. This water gets into the main sewage and overload the inflow and exceed 8ml and it pushes buggering objects into the main hole and we are using mechanical screen and that mechanical screen cannot cope up. This implies that when it rains we will have to open the main hole to lift up the mechanical screen. Thus, everything is being by–passed from the plant and raw sewage gets into the natural environment. After it rains the PST have big objects and block the discharge valve.
f. Respondent G, stated that, the challenge with faecal sludge is that due to overload more faecal sludge is produced which will have to be added to the one in the drying bed from the digester. No time for sludge to dry properly, it had to be piled. If it is not piled the entire plant will block. Sometimes the new Sludge is added to the old one.

4.2.4 Can you elaborate to us what methods are used in urban and rural areas for managing the produced faecal sludge?

The respondents indicated that there is no concrete programme or methods used to manage the produced sludge. Instead, it is just piled as it is not graded for use by either the municipality or individuals.

The respondents indicated that:

a. Respondent A indicated that in the urban areas, there is an obligation to hip the sludge / dump it as per the regulations. In the other areas sludge is dumped at their landfill sites, but the site must be classified/graded and have an approval to take the sludge. With Polokwane, it cannot be taken there. In the past, there were people who used to collect sludge at their own risk for use. That was stopped because it was putting the Municipality at risk as it was not classified or graded for use. If something could happen it will be traced back to the Municipality and that will jeopardise the institution as it will be the one who provided the untreated/ungraded sludge.
b. Respondent B, indicated that: Communities use sludge for composting but lately there are some people who are using it for brick manufacturing/making. The process is still in the research stage as the people come and request samples for their project.
c. Respondent C indicated that during the construction of the Polokwane Golf Course the construction company purchased faecal sludge for roughly R 210.00 a tonne. In the Municipality, the sludge is used on the municipal lawn for manure. The nursery came collected it and mixed with saw dust for their products.
d. Respondent D, indicated that currently at the sewage works sludge is dried and piled up because it is not in use due to the fact that the law does not allow it to be used as it is not tested for use / classified. In the past University, experimental farm used to collect the sludge and utilise it as manure mixed with lime. Future plan is to incinerate the sludge or recycle it.

e. Respondent F, stated that: Faecal sludge is just piled, there is no actual method used.
f. Respondent G, indicated that, in the urban areas sludge produced is just piled, while in the rural areas they keep it in lined VIP toilet which is either emptied by removing the top or close it when it is full and dig a new pit for the new toilet.

4.2.5 Is the municipality considering applying any alternative methods in faecal sludge management such as implementing toilets that will separate urine and faeces or dry toilet methods?

Generally, any method that might be introduced in the Municipality of Polokwane will be in the rural areas, as in towns and cities the only system to be applied is the waterborne toilets connected to the sewage network.

a. Respondent A, indicated that: In the rural areas, the municipality is installing urine diversions VIP's, which could take an estimate of 5 years to empty. The toilet has a soak way for urine diversion to avoid odour like in the septic tank / French drain. The soak way has rocks to filter in a lined toilet. Individuals are now responsible for emptying as there was no sense of responsibility by users and council ordered that the Municipality should stop emptying toilets as foreign objects such as clothes, stones, pampers were thrown into the facility. That created problems for draining/vacuum machines.
b. Furthermore, in the urban areas, no consideration/plan is done for dry toilets only water borne. To save water from the old cistern, the department introduced a block which had to be kept in the cistern so that the amount/volume of water used be reduced.
c. Respondent B, indicated that, the dry toilets are only applied in the rural areas. In the urban areas, it is 100% water borne. Currently no plans for dry toilets in the urban areas of Polokwane.
d. These were complimented by respondent C, who stated that, the alternatives are implemented only in rural areas with the projects identified in the IDP as a priority.
e. Three of the respondents namely, D, F and G clearly stated that it was for the first time hearing of such a toilet. They never heard of such and

they do not know what that is and it will be good to have as that will remove the smell. But, consideration will be in the rural areas because in towns and cities only network/water borne is considered. The plan like this one will be good for boreholes as they will never be contaminated.

4.2.6 In your opinion, how will people perceive Faecal Sludge Management if the business advantages are explored, for example, the use of faecal sludge in producing fertilisers, biogas and fuel.

There is a general agreement from all the respondents that if people could be taught about the opportunities of faecal sludge or the Municipality use it for boilers there will be a saving in the use of electricity.

a. According to Respondent A, sludge advantages are not known to the people, they just think faecal sludge is just dirt. Furthermore, it really has the potential for generating income or exploring business opportunities like the person who approached the municipality requesting faecal sludge samples for Masters Research in brick making project using sludge.
b. Respondent B, stated that for business purposes, it will work as there are people already coming for sludge to use as fertilisers and bio-gas. Currently, other municipalities take sludge and produce methane gas which is used to run some processes in the plant and reduce usage of your energy/electricity to run the plant.

   Respondent E, further stated that, in one Cape Town plant they reduced electricity utilisation by applying this method. In Polokwane, the problem is infrastructure to do it. Currently, there is a plan for the new plant to use some gas from sludge for energy purposes.

c. Respondent F and G, indicated that, If the municipality can adopt a system of biogas which is from digesters there can be saving on electricity as there will be enough methane to be used in driving the boilers. The process was abandoned almost 5 – 10 years ago in the Municipality of Polokwane after the boiler was broken and never repaired. If the boiler is repaired it could be used to heat the sludge. Once you boil the sludge it will provide co2 gas / Methane for heating the boilers.

d. Responded D, indicated that there is a person who collects sludge for coal making research and the research has yielded positive results. The respondent further indicated that at a course in Durban they were told that, they recycle the sludge and convert it to polish. Others extract methane gas and use it as fuel for the municipal buses in countries like France in some areas, they use sludge to provide electricity.
e. Respondent F, stated that, it will help but education need to be taken to the people. On the other hand, there is a need for bio-gas and fuel for to the communities in rural areas and if people are taught about this project they will obviously explore it for commercial reasons either on a small scale or big scale. Currently, the Municipality need to consider using methane gas and run boilers as that will save energy and diesel. Now the Municipality has abandoned raw material which is not being used.

In addressing Objective 3 which needs to determine the amount of water utilised by residents of Polokwane in faecal sludge management and Research Question 2 which states how water conservation applied in faecal sludge management in Polokwane Municipality, the study posed the following questions and responses.

4.2.7 It is said that South Africa is a water scarce country; recently Polokwane Municipality passed by-laws putting stringent measures onto household water use. Are there any plans to introduce new technologies that will save water when disposing of faeces?

The respondents indicated that there are no specific technologies that were introduced except the brick which was introduced by the municipality to insert in the old cistern which utilises more water when flushing faeces.

a. Respondent E, stated that, presently there is no technology planned. The use of water will just continue for sewage based ablution facilities but, as the Municipality, we purify the water and put it back on the circulation for re-use in the form recycling. The only plan which could be said to be in the pipeline is with the regional water treatment plant which will be able to provide for this purpose.
b. The plan is to bring waste water treatment plants to their optimum functionality accompanied by proper maintenance on a daily basis.

Furthermore, the intention is to have water cleaned to meet the requirements of being consumed by people (drinkable) as per the class after scientific tests.

4.2.8 How do you think the municipality and the community can play a role towards the implementation of the alternative faecal sludge management in the municipal area?

It became very clear from the respondents that no other option of faecal sludge management will be easily accepted in the areas declared urban within the Municipality of Polokwane. The only acceptable method is the water borne sewage based system.

a. Respondent A and E, indicated that: People do not understand any other method of faecal sludge management, if you tell them about the bucket system as an alternative they haul at you and tell you direct that the bucket system is an apartheid method which is now faced out and people do not want it anyway. One politician indicated that when they were doing community consultation they had a serious challenge in explaining to the people of Solomondale about the non-use of existing ponds who wanted to know when will they be used. Not taking into consideration shortage of drinking / running water in the area.
b. Respondent E, further indicated that people need to be educated about the dry system as an alternative to waterborne network given the condition of water scarcity in our Municipality in particular and South Africa in General.

4.2.9 Streams and rivers around the municipality are polluted daily by releasing the faecal sludge that is not properly treated; this causes strain as water usage is increasing in the community. What are the plans to rectify this problem?

The respondents indicated that the problem is a lack of capacity in the plants. The human resources that were knowledgeable have either retired or moved to other areas of work.

a. Respondent E, indicated that the plan is to bring waste water treatment plants to their optimum functionality and develop a maintenance plan not wait for disaster to happen to the plant before attention is given. The fact that the plant is now being refurbished shows that somewhere there was no proper

maintenance done. This in a way is an intervention strategy to have the plant operate properly.

b. Furthermore, there is a need to computerise the plant so that all the dangers could be detected and monitored from the computer room. This brings to play the issue of well-trained human resources as there is a need of enough human resources at the drying beds for sludge and avoid just employing unskilled people with the perception that this is not an important job. In some cases, the problem of poor sewage system is fuelled by the reports which goes to management not reflecting the real conditions on the plant as officials report to their seniors what will impress them.
c. Respondent A and C stated that the other solution which the Municipality brought forth is the plan to construct the regional sewage plant which will take 100ml per day, though the plant will be constructed in phases. The first project will take 40ml per day, then add 20ml in the additional three phases.
d. Respondents G, indicated that, the plan to rectify the pollution of rivers by waste treatment plants is to avoid high intake which is above capacity, the operators should be trained so that they should know exactly what they are doing so that they can ensure that all the plants comply with the standards as laid by the DWA and ensure that faecal sludge is properly managed from water.

4.2.10 It is said that by 2015 governments around the world would have met sanitation requirements including faecal sludge management. What is the current status in the Municipality of Polokwane?

The municipality is currently not complying with this requirement as it is known as the millennium goal.

a. Respondent E, indicated that currently, with sanitation, in general, we are far as we did not meet the targets we set for ourselves, The Municipality is overtaken by population growth as it is growing fast and if we do not put an effort we are in danger. For example, sewage line from extension 44 is always over flowing and the size of pipe to be used is not known as it is not clear as to how many people are residing in that area not only the number of houses. The area is occupied mainly by foreign nationals who are more than required for one yard.

b. Furthermore, it should be noted that the systems were initiated by whites pre-1994 democratic state based on their growth rate. They knew that in the long run, the sewage system will suffice as there was no plan to have all residing in towns and cities and it should be noted that when municipalities were incepted the sewage system was run by the central government through the DWA. The last transfer to the municipalities was around 2007 / 2009 that was packaged with the takeover of employees to the Municipality, who were not trained. Section 78 of the transfer stipulated that the department must (make sure) of guiding the Municipality until you are sure that the Municipality can do the work. thus, the Municipality can perform the function before completing the transfer.
c. Respondent A, indicated that, the Municipality of Polokwane is still behind because the requirements are not met due to population growth both in rural areas and the city. Plans are there to eradicate unlined toilets and replace them with VIP. The problem is budget; though yearly implementation is done in all the clusters as per priority list. The other problem is that no priority given to sludge management as it does not have direct impact. “The political will is not on it, only when there is a problem or outcry it is then considered”.

The issue of population growth in Polokwane is supported by literature, which states that the total number of households living in formal housing which include houses, flats and town houses has increased by 462 000 between 2001 and 2011. The number of shacks not in backyards went down by 16, 276 but dwellings that contain more than two individuals per room which is regarded as overcrowding has gone up (HDA Research Report, 2013).

4.3 Quantitative Data Presentation and Analysis

The study used numerical data and population figures from Statistics South Africa.

Table 4.1: Showing population of Polokwane Municipality (5 – 24 years) attending school from 1996 to 2011.

1996		2001		2011.	
Male	**Female**	**Male**	**Female**	**Male**	**Female**
93 485	97 945	116681	120 718	123 633	120 835

Source: Stats SA, 2011

The table presents a growing population in both the male and female population in the three-year period. In both 1996 and 2001, the female population was growing more than the male population. 2011 experienced a high male population growth.

The trend shows population growth because most of the young people came to the city with their parents with the intention of accessing better schools. This in a way increased the demand for more sanitation facilities and faecal sludge management programmes within the areas in which people live in.

The statement above is corroborated by the sentiments found in the Census (2011) release statement P0301.4 which states that, “Access to education is a human right and it is Goal 2 of the Millennium Development Goals (MDGs) which aims to achieve universal primary education and ensure that by 2015, children everywhere, enrol a full course of primary schooling as quality education encourages technology shifts and innovation that are necessary to solve present day challenges”.

Table 4.2: Showing population of Polokwane Municipality (25 – 85 years) from 1996 to 2011.

1996		2001		2011.	
Male	**Female**	**Male**	**Male**	**Female**	**Female**
72 063	82 413	92520	100 974	136 289	163 815

Source: Stats SA, 2011

In this table, there was a consistent growth in female population. Both 1996 and 2001 had an average of 9 000 growth. A higher female population growth of more than 20 000 was experienced in 2011.

The municipality inherited the dormitory Location of Seshego, Mankweng and some rural areas which had people residing as families and the community started to age with no other alternative homes. The sanitation / faecal sludge management programme was not much of a priority in the pre – 1994 municipal administration. The faecal sludge management system was meant for the few who reside in locations with the Group Areas Act, 41 of 1 950 not allowing blacks to reside in towns, Indians located in their own place as well as coloureds. The only people who were allowed to reside in towns were whites / Europeans or British settlers only.

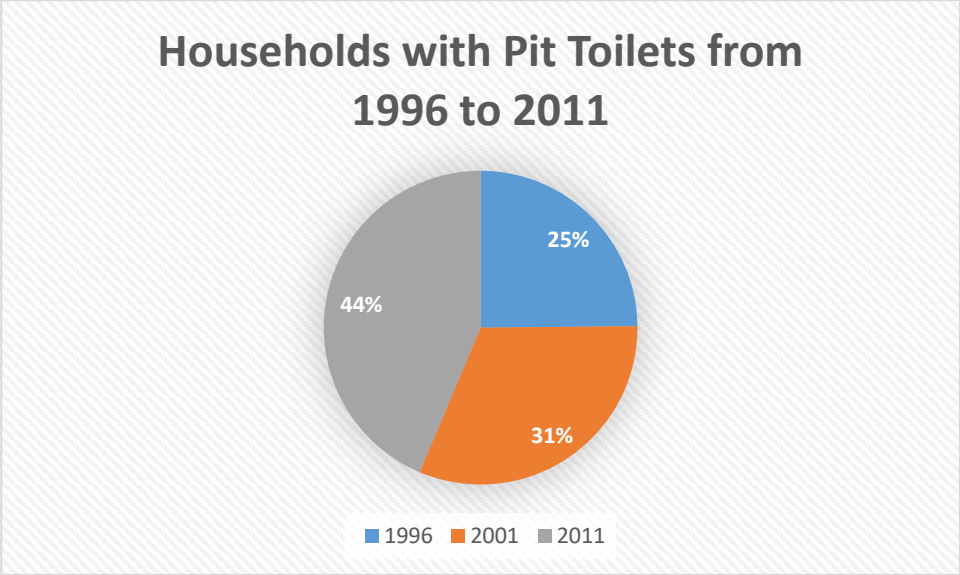
The other contributing factor of increasing population in Polokwane Municipality was the movement of many government officials who came to Polokwane from Lebowakgomo, Thohoyandou and Giyani (administration centres of the previous homelands). The other contributing factor is the young adults who prefer an urban environment to a small and remote rural settlement and stay next to their work places (SA Cities Network, 2014).

Table 4.3: Showing population growth rates of Polokwane Municipality from 1996 to 2011.

	1996	2001	Change	2011	Change
Lim 354: Polokwane	**424 835**	**508 277**	**3.6**	**628 999**	**2.1**

Source: Stats SA, 2011

The population shows a rapid growth rate between 1996 and 2001 due to rural urban migration which took place in the city of Polokwane due to the people's expectations that they would get better jobs as the RDP houses were given to people free of charge. Squatter camps were also a means of accessing the resources. The growth was almost 3.6% and it dropped to 2.1% in 2011.



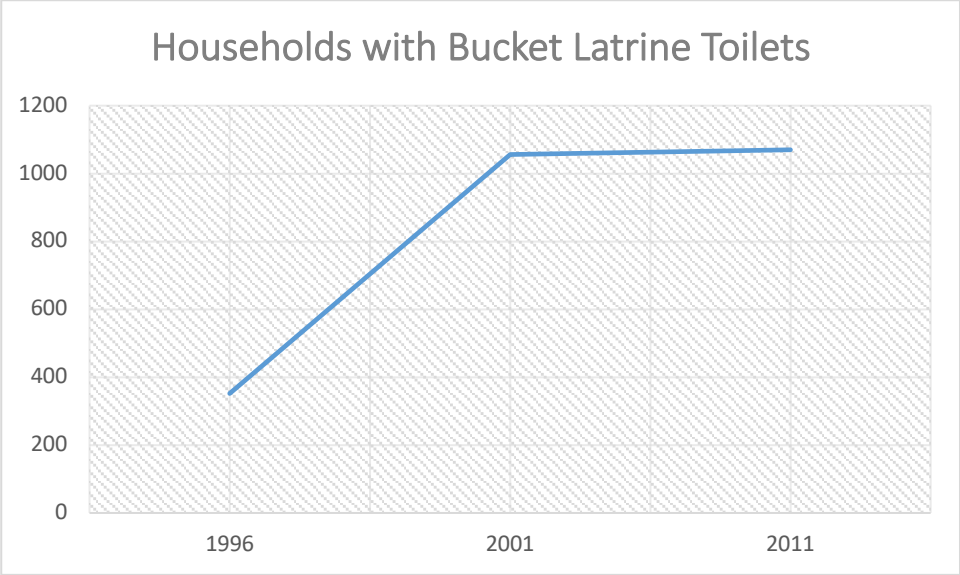
Source: Author ‘s own work

Figure 4. 1: Showing households who use pit toilets from 1996 to 2011 in Polokwane Municipality

The pie chart above illustrates the households who made use of pit toilets from 1996 to 2011 in the Polokwane Municipality. In 1991, the households which utilised pit toilets were 25% and they increased to 31% by 2001. A significant rise in households with pit toilets was further recorded in 2011 when it was determined to be 44%.

When the Municipal boundaries were realigned to become ward based some rural areas which were not part of the former Polokwane Municipality were incorporated into the Polokwane Municipality and water borne toilet network services were not available. People in those areas depended on pit toilets for defecation.

This was supported by the census (2011) findings which indicated that municipalities adopted more rural areas and land changed to 125 754 in 2011 from 122 816 square kilometres as some municipalities decreased their geographical areas while others increased during the realignment and reduction of municipalities from 262 to 234 in 2011. Furthermore, households having access to pit toilets without ventilation declined from 22.8% according to the 2001 Census results to 19,3% in Census 2011.



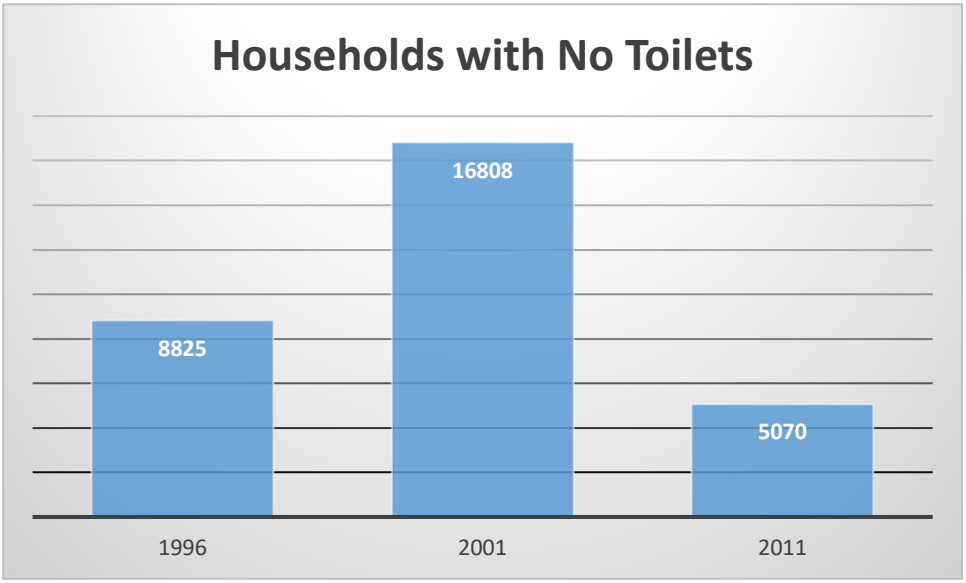
Source: Author ‘s own work

Figure 4.2: Showing households who use bucket latrine toilets from 1996 to 2011 in Polokwane Municipality

A growth in bucket latrine toilets was experienced between 1996 to 2001. The growth moved from about 380 to 1100. The bucket latrine per household stabilised from 2001 up to 2011 and remained at an average of 1 100.

Given the high rural-urban migration, most people resided in areas which did not have proper faecal sludge management accessories and the supply of water was not sufficient, mostly in informal settlements around the city of Polokwane. The toilet which was used was the bucket system as there was no place to dig for pit latrines due to high population density in such areas.

According to the national statistics, the proportion of households using the bucket toilet system declined by half between 2001–2011. Thus, in 2001 it was 4,1% and during the 2007 review, it was found to be 2,2% and 2,1% in 2011. The DWS planned that by the end of 2015, households still using the bucket toilet system in informal areas should be replaced with the waterborne system.



Source: Author ‘s own work

Figure 4.3: Showing households who have no toilets from 1996 to 2011 in Polokwane Municipality

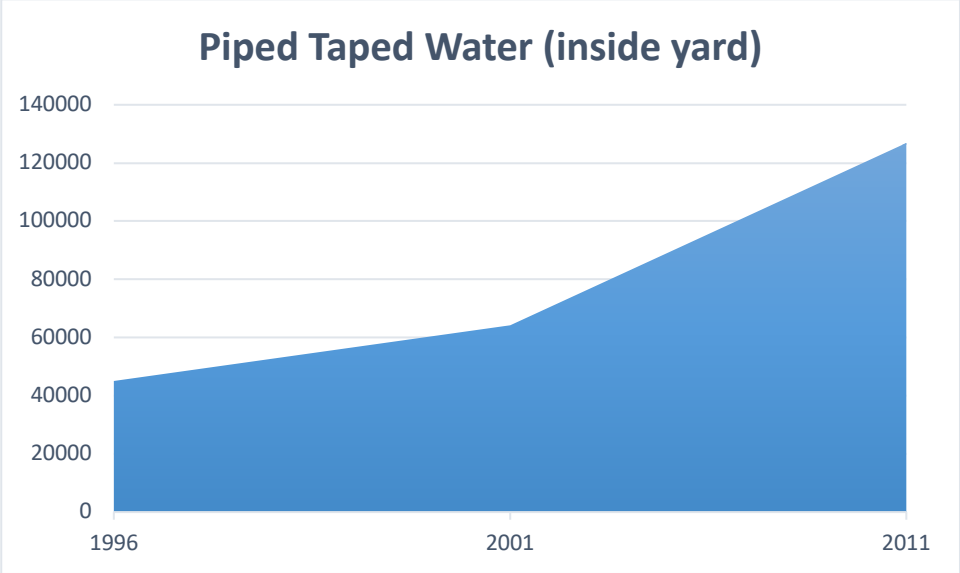
The graph shows that in 2001, 16 808 people in the Polokwane Municipality did not have toilets. By 2011, only 5 070 households did not have toilets. The 16 808 was reduced by 10 000.

The above graph shows the number of houses which did not have toilets within the Municipality of Polokwane. This came as a result of population growth of between 1996 – 2001 of about 16.39% at an average annual growth of 3.27% due to an influx from the rural areas.

The other reason for the major hike of lack of toilets was the concentration of all the housing developments in the municipality’s urban areas and the rural villages were neglected as there was the fear of investing resources in the depopulated areas. Secondly,70% of the Polokwane Municipality is rural. Those rural areas were not falling under any municipality pre-1994 general elections.

This problem was noted by the municipality and it indicated that there is a serious need to develop interventions which will address the scattered settlements which make it difficult to provide services and ensure the quality of life to areas with no basic amenities or those below the RDP. Nationally, the percentage of households that were

without toilets declined tremendously from 13,6% as per the 2001 Census to 8,3% and 5,2% in 2011 (Blukes, 2010).



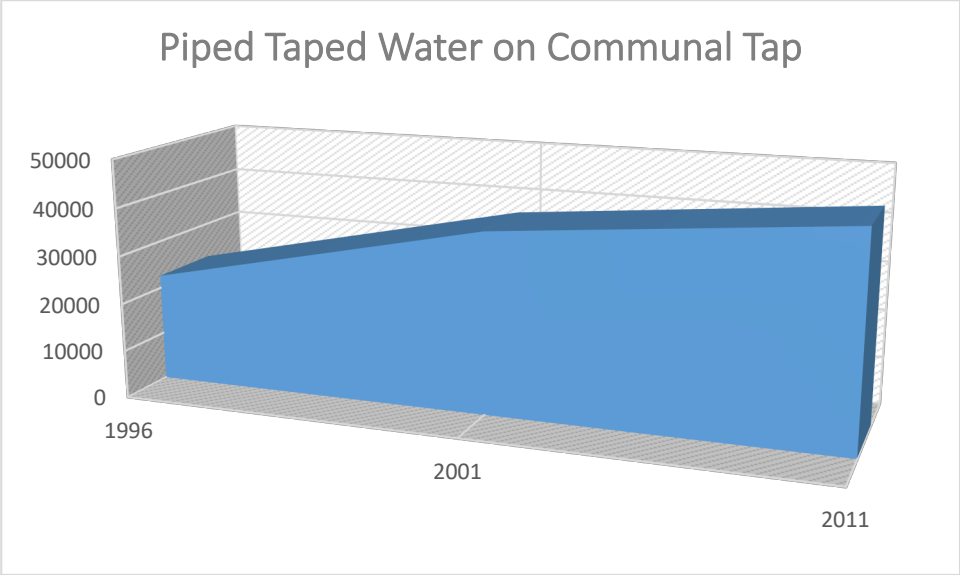
Source: Author ‘s own work

Figure 4.4: Showing households who use piped taped water inside the yard from 1996 to 2011 in Polokwane Municipality

The graph shows the rapid growth of people receiving piped portable water within their yards. From 1996 only 40 000 houses had piped water and they grew rapidly to 120 000 by 2011. This shows a growth of 80 000 houses thereby ensuring piped water to the people within the Municipality of Polokwane. Furthermore, the graph above shows the requirement as per the RDP water supply in communities. 64% of the supply is below the standard as they had pit latrines, bucket system and no services were provided as there are no sewage network services in the areas.

The Mayor of Polokwane Municipality, Councillor Thembi Nkadimeng indicated that the municipality is working around the clock to install water taps in almost all the yards. The problem is with the areas with rocky terrains like Moletjie, Segwashi, Mankweng, Boyne and Ga-Mamabolo (Frankson, 2015).

The problem is not mainly found in urban towns as per settlement hierarchy, but rural is in towns, large villages and small villages (Blukes, 2010).

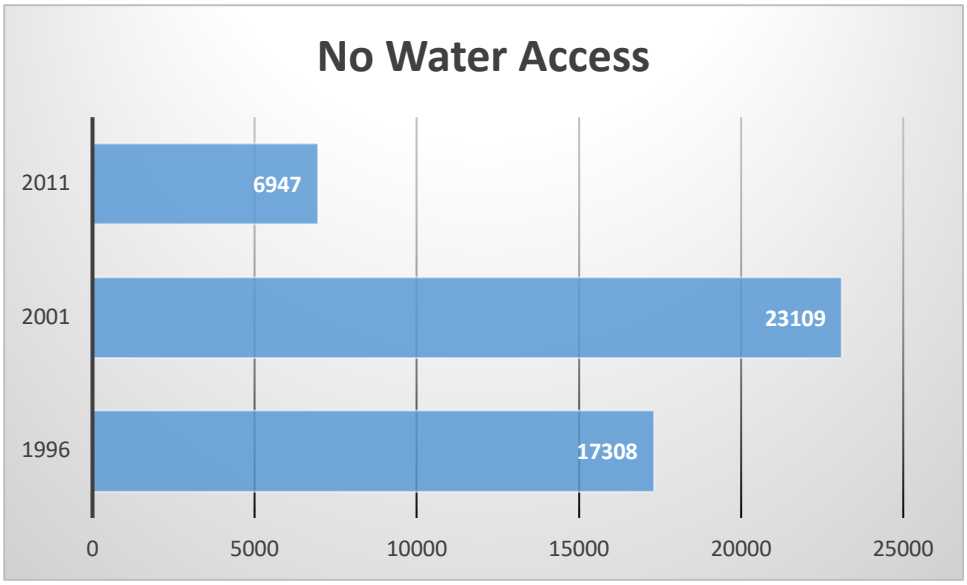


Source: Author ‘s own work

Figure 4.5: Showing households who use piped taped water on communal taps

The graph shows the improvement in some municipal areas which did not have portable piped water and their improvement from 20 000 to 50 000 by 2011. This shows a 30 000 increase in service delivery.

As it was shown in the above population, the municipality grew tremendously around the city with the informal settlement acting as “arrival cities” for accommodation. The only way to provide such people with the social right to basic amenity was to provide them with water at a communal tap. The same approach was used in the rural areas which were scattered and it was difficult to provide services.



Source: Author ‘s own work

Figure 4. 6: Showing households who have no access to piped tap water from 1996 to 2011 in Polokwane Municipality

The graph illustrates the manner in which most areas of the Municipality were under serviced before the re-demarcation of the wall to wall municipalities. In 1996, almost 17 308 households did not have access to water. In 2001, when the demarcation was done, the Polokwane Municipality covered more rural areas with 23 109 houses who did not have water. In 2011 only 6 947 houses did not have access to water.

Some rural areas did not have reservoirs and lined pipe water infrastructure when they were adopted by the Municipality of Polokwane, as such from 2001 the figure started going down as the municipality started to provide the social needs to the people.

4.4 Overall Discussion of Results (Qualitative and Quantitative)

This study based its empirical data as presented in this chapter from the respondent’s perspective of the phenomena and the data was analysed as per the response to the questions that were asked utilising the interview guide as the research instrument and contrasting it with information derived from the literature.

When looking at the Stats SA figures from 1996 – 2011, the trends show that the population of (5 – 24 years and 25 – 85 years) has been going up on an average of 9 000 growths. This resulted in more people needing water supply and ablution facilities which culminated into a high demand of faecal sludge management facilities. This

factor was supported by the respondents who indicated that houses were built and new establishments were constructed, informal settlements or back rooms were being occupied by people but the sewage systems were constructed to cater for people under the Group Areas Act, 41 of 1950. This was supported by Hedden and Cilliers (2014) who state that, since 2004 the demand for water and sanitation has gone up and South Africa is presently exploiting the renewable water resources nationally. The study also stated that rural-urban migration, as well as expected income levels, will ultimately fuel up the residential consumption of water as the gap between demand-supply increases daily in South Africa.

This is evident in the three sewage plants in Seshego and Mankweng which were for blacks and town sewage plant which was for people of colour. The challenge for the town sewage was created when the homelands were abolished and the government administration was located in the city of Polokwane. The infrastructure started to be in high demand as people moved with their families to be closer to their work places, RDP houses and squatter camps also came into the picture with no expansion on the existing sewage infrastructure. This created an overload on the current faecal sludge management systems within the Municipality of Polokwane and water supply became under pressure as more water was needed.

When the municipal land occupation increased from 122 816 square kilometres in 1996 to 125 254 in 2011. The Municipality adopted more rural areas which did not have access to running water and sewage network. The faecal sludge management technology used was the pit toilets though most were not lined to protect contamination of ground water as indicated by the respondents when interviewed. The other method that was utilised was the bucket toilets which were mostly used in informal settlements as there was no place to dig due to high population density. The infrastructure also did not provide for the supply of water. The water supply and faecal sludge is still a challenge even today according to the respondents because there is data that shows how many people live in backrooms in some yards around the Municipality.

Managing faecal sludge in both the rural and urban areas of Polokwane is a challenging factor as the rural areas which were not within the borders did not have toilets which were friendly to the environment as they were not lined. Currently, the municipality provides lined VIP toilets in the rural areas. In the urban areas, there is

no other method except the sewage network system which is waterborne. This finding correlates with the sentiments of Dodane *et al* (2012) when they indicate that South African people are conflicting with the United Nations and the World Health Organisation which considers the onsite septic tanks, onsite VIP to be equivalent to improved sanitation systems in the MDG. This was further evident by the people of Tokologo Municipality who rejected the 270 VIP lined toilets in the rural areas when the municipality was eradicating the bucket system

Polokwane Municipality has three sewage plants namely: Mankweng, Seshego and Polokwane. Of the three plants, the only one which is currently coping is Mankweng which is having challenges of hospital effluent and abattoirs which bring a lot of oil to the ponds and that affects the natural process as it blocks the PSTs and suffocates the bacteria. The other problem is people who open main holes in their homes and allow sand and stones to runoff to the plants. This problem is also experienced in Klerksdorp as specified by Mjoli (2012) where High Biological Oxygen demand (BOD) became septic in the inlet screens and caused blockages from clots of abattoir wastewater. The other problem is the uncontrolled release of wastewater from chicken processing factories as there was high BOD waste water flowing to the plant. The chicken feathers were also blocking the system and impacting negatively on the treatment process. Lastly, fat deposits increased the concentration of suspended solids mainly in winter.

The Polokwane Plant and Seshego plants have deteriorated in performance due to a high intake and are above capacity due to high rural-urban migration which took place after the 1994 democratic elections. The other problem is caused by high housing infrastructure which has been constructed around the city and no extension was done to the sewage plants. Mjoli (2012) indicates that when experiencing this problem, the Matlosana City invested in the expansion and upgrading of sewage networks and wastewater treatment plants. This according to the findings is the route the Municipality of Polokwane is following in erecting the regional sewage plant which will be done in phases which will have higher intake capacity.

The problem that is currently being experienced is that the water levels are low and the people only perceive good sanitation as waterborne toilet systems. This was evident as the people of Sol Plaatjie Municipality were not satisfied with the urine

diversion sanitation as they regarded it as inferior. The lesson learnt at Tokologo Municipality was to conduct workshops before implementing sanitation projects to people if they are not waterborne systems so that an explanation can be provided as to why a different technology has to be implemented. The people in that municipality accepted the closed circuit wastewater treatment and recycling sanitation system because they understood the complication the waterborne sanitation system will bring to the township due to insufficient water supply.

The chapter that follows will present a summary of the pertinent aspects that respond to the research objectives, questions and draw recommendations to the conclusions derived at in accordance with the relevant sectors aligned to the research objectives.

CHAPTER 5: CONCLUSION

5.1 Introduction

The supra chapter presented the outcomes of the empirical study and indicated the variances, correlations amongst the units of analysis, explanation of the way in which data was presented, interpreted and analysed. This chapter discusses a summary of findings from literature and empirical study. It will further draw attention to the general conclusion of the study. The chapter draws attention to the general conclusion of the study, what has been achieved through research objectives and the contributions towards knowledge. Lastly, the chapter makes recommendations to the various stakeholders.

5.2 Summary of Findings

This section of the study provides a reflection of the complete research study by ensuring that the research aims and objectives are achieved and realised. Furthermore, the section looks into whether the literature collected for this study was relevant and useful in addressing the research questions and tests if the methodologies applied are relevant to the study.

The study conducted an investigation on faecal sludge production and management projections in the city of Polokwane so that the city can understand the current levels of sewage plants, estimate future faecal sludge production and water demand for sludge disposal.

Objective 1: To analyse whether the processes that the Polokwane Municipality apply on faecal sludge management are appropriate to present day situation.

In responding to this objective, the Polokwane Municipality manages its faecal sludge in rural and urban areas. In the rural areas, the municipality solved the problem by installing ventilated pit latrines which are lined so that the ground water cannot be contaminated. In some areas, the municipality provided a vacuum opening toilet at the back so that trucks can easily empty the pit. Unfortunately, this project was made in a few yards.

When coming to the emptying of the toilets and the vacuum pits, the dumping happens at the municipal sewage plants. In the urban areas, only one method is applied that of waterborne toilets with the sewage network wherein on receiving sludge it is dried up and stored as there are no places to take it and the problem with the Polokwane and Seshego Plants is that the intake is higher than the required intake as per the original plans. Consequently, this poses threats to the treated water that has to be released to the environment. Furthermore, it is difficult to have the sludge dry fully as the infrastructure does not permit to have sludge to fully dry as the process take 3 - 4 weeks and the space to keep it for drying is limited. The challenge is that, sludge cannot be dumped everywhere as it contains harmful things such as bacteria and bad odour if not well managed. Literature as provided by Green Drop analysis shows that this is a general problem in South Africa as most of the waste water treatment plants are not meeting the requirements of the Green Drop and Blue Drop.

This objective was also addressed by the question which stated that since 1994, the government provided houses and increased the usage of sewage plants.

These developments pose a serious overload on the existing infrastructure, especially in the urban areas wherein the demand for more water is high and the usage of the existing sewage network is high. The impact is negative on both the Seshego Sewage Plant which is capacitated to receive 7.4 ml but is receiving around 10ml a day and Polokwane which is capacitated to receive 25ml a day but receives around 32ml a day. This, therefore, implies that the faecal sludge management process is overburdened and overloaded to an extent that not all processes are followed from intake, processing and drying, which is the reason which shows why some respondents said the plants are at their worst stage now.

The other challenge received is on the COD which is supposed to be pumped by industries to the plant with less than 500mlg. Secondly, in Mankweng, the problem of COD is a problem as an abattoir, hospital and garages provide sludge to the plant. People also create more problems as they open manholes and let sand and stones run into the sewage system. The respondents indicated that the outflow does not always conform with the required standards but before 1994 the released effluent used to meet the required standard. The fact that Polokwane and Seshego are running on danger level implies that the natural environment is not safe or protected from the

released effluent. One of the factors which causes the problems is human resources as some people are not qualified to run the plants. Some people who are knowledgeable are either retired or have moved to other areas of work.

Through the research outcomes, this objective was achieved.

Objective 2: To appraise and ascertain if water conservation can be applied in faecal sludge management in Polokwane Municipality.

The municipality has introduced a block which has to be placed in the old cistern as it is used to demand more water to flush the toilets. With that block in the cistern, less water will fill it and the quantity found is sufficient to wash away the faeces. This is supported by literature **as *indicated on page 17 of this study.*** Cymru (2015) indicates that the old cistern was taking nine litres of water while the new one takes six litres to transport faeces or urine to the sewage network.

Other options such as dry toilets and lined VIP toilets are only considered in the rural areas of the municipality. The towns and urban areas only consider the flush toilets as the only means of ablution. The best way for the municipality to conserve water in faecal sludge is to install smart metres which will be able to detect where the leakages are between the supply and the households as the current system is not fully reliable.

The respondent through the responses of the research has managed to prove that there is water conservation in the application of faecal sludge management.

Objective 3: To analyse and evaluate the cost management system which the municipality applies on faecal sludge management.

There is no cost management system that is applied by the Polokwane Municipality in the management of faecal sludge and this was supported by one of the respondents who indicated that there is a need to develop proper Operation and Maintenance (O & M) at all times on the sewage plant. The fact that the plant is refurbished shows that things were not done properly from an operational level. Furthermore, the reporting system which the senior manager gets from their subordinates creates a problem as some reports are just to please the top officials and do not reflect the real situation on the municipal sewage system. The municipality should consider utilising sludge in its operations as part of minimising the running costs especially on heating the boilers

rather than use electricity or fuel based generators. As some respondents indicated, in countries such as France, faecal sludge is used as methane gas which is utilised for running municipal buses and the same could be explored in Polokwane. Further engagement should be done with the farmers and other users of faecal sludge to buy and move sludge from the plant as that will contribute to the municipal's income and assist in maintenance.

The research could not analyse or evaluate the cost management system because Polokwane Municipality does not have such systems in place.

Objective 4: To determine and investigate the faecal sludge management approaches and plans applied by the Municipality of Polokwane.

It was clear from the respondents that; the municipality is not meeting the targets set on faecal sludge management in particular and sanitation in general. A good example is the continuous bursting pipe of Extension 44, due to an unknown number of people in one house using limited wastewater pipes. When planning, the network system should be in accordance to the number of houses and expected occupants of those houses. Instead, those yards have extra extensions of rooms and it is not known how many people live in the yard. Census 2011, shows that the population in the rural areas is deteriorating as most people are moving towards the urban centres in search of better living conditions and job opportunities. It is, therefore, difficult for the municipality to invest in expensive sewage network in areas which are cheaper to utilise the VIP lined toilets.

The research has managed to investigate the approaches and found that in the rural areas the plan can easily meet the challenge as in the urban areas more people make it difficult to achieve the objective by overloading the sewage network systems.

Objective 5: To examine how the faecal sludge production and management system can be improved by the city of Polokwane.

It is a common fact that the faecal sludge produced is high in the urban areas and suburbs as the Department of Housing used to provide houses without considering human settlements. This implies that before people could be placed in a particular area, all social services or amenities need to be provided for instance, water, sewage, sports grounds and church areas. Given the advanced technology, the respondents

indicated that there is a need to computerise the system so that all shortfalls can be picked up from the screen in and around the sewage plant.

Currently, the municipality is releasing effluent to the environment as per the respondents who indicated that the release is used to recharge the 37 boreholes around the river which are used to supply water to the city and some suburbs. Currently, Anglo America is assisting the municipality to expand the sewage plant with 6ml per day which will help with the grey water to be used at the mines. The same should apply to the hospitals and abattoirs in implementing fat traps and reduce chemicals as they have a bad influence of BOD. The respondents further indicated that the problems will be solved when the regional sewage plant is constructed.

The research through the respondents' analysis has managed to achieve the objective as the new sewage plant will assist solve the overload which is pumped to the sewage plant daily.

5.3 Recommendations of the Study.

Emanating from this study, there will be two types of recommendations namely: Recommendations for practical interventions and recommendations for policy formulation or review.

5.3.1 Recommendations for Practical Interventions

- ✓ The community should be involved in faecal sludge management programmes and other technologies since the municipality is continuously experiencing a problem of water shortages;
- ✓ Provide lessons and training to both the formal and informal dwellers about various technological methods to be applied in urban areas and proper use of sewage networks in order to avoid foreign objects from entering the system;
- ✓ Economic spinoffs of faecal sludge should be explored and farmers must be taught how to best use the faecal sludge like it used to be done in Mankweng by the University of Limpopo at the experimental farm;
- ✓ Encourage organic farming so that piled faecal sludge at sewage plants can be properly treated and graded for secondary use as that will make a space for the incoming sludge to dry properly;

- ✓ The findings need to be used as a point of departure in the projects administration during the Integrated Development Planning consultations;
- ✓ Develop a proper maintenance plan and programme for the sewage plants as well as properly trained staff to avoid environmental degradation due to spill offs and release of less quality effluent;
- ✓ Managers to conduct regular visits to the plants with the aim of ensuring that reports provided by the subordinates reflect the real situation on the ground.

5.3.2 Recommendation on Policy Formulation

- ✓ Noting that the faecal sludge that is produced in the Municipality of Polokwane is just piled as there is no zoned dumping site for it, the study therefore, recommends that the policy makers should encourage farmers who received government grants to utilise the sludge as manure in their farms as that will help alleviate heaps of sludge which are not drying properly due to high volumes;
- ✓ Policy makers should also ensure that sludge is graded and they should also encourage those who maintain the municipal parks to utilise the product on the grass as well as stadiums so that the lawn can be of good quality and standards as that will also help relieve the piled faecal from the sewage plants;
- ✓ The gap between the supply of water and sanitation use does not get bridged as a result other forms of faecal sludge management need to be explored as the supply of water does not change for the better but the demand of water required for flushing is high;
- ✓ Need to develop water conservation and water demand management programmes for human consumption and use of greywater;
- ✓ Develop better monitoring of municipal and industrial water supply in lowering and reducing lost water;
- ✓ In Polokwane Municipality, waste water is not fully utilised as there is a need to explore means of re-use as it will reduce the use of clean water to flush toilets;
- ✓ Upgrade water services development plan as required by the Water Service Act of 1997 and the national sanitation strategy;

- ✓ Need to upgrade sanitation in general and faecal sludge management in particular to be a basic service with quality assurance for faecal sludge management facilities, proper monitoring and evaluation;
- ✓ Need to have qualified management and technically competent plant operators of wastewater treatment plants.
- ✓ Future studies can also look at comparing how cities are managing this issue, both at national or international levels.

5.3.3 Future Research

Given the shortage of clean water, poor maintenance of sewage plants, lack of understanding of the economic opportunities associated with faecal sludge management and lack of understanding of other technologies and faecal sludge management, the study encourages researchers to look at various faecal sludge methods that should be adopted and encouraged within the residents of the Polokwane Local Municipality in both rural and urban areas. The future studies should focus on the benefits and costs to the community. There is a need to explore the dry toilet systems within the municipality and consider urine diversion toilets from faeces with the focus of recycling and re-use in agriculture. Further studies need to focus on the re-use of faeces in energy production in the Polokwane Local Municipality. Future studies can also look at comparing how cities are managing faecal sludge management both at national or international levels.

5.4 Conclusion

The study focused on faecal sludge production and management in Polokwane Municipality with an emphasis on the existing technologies which are mainly sewer plants and pit latrines both lined and unlined as both have an adverse effect on the quality of water provision. If the sewer systems are not well managed they pollute the rivers while the pit latrines pollute the underground water. The continuous expansion of these two faecal sludge management methods has huge long-term effects on the quality and volume of water provisioning for human consumption. The municipality is

operating on the Seshego, Mankweng and City sewage systems which have the conventional sewer network infrastructure which was never expanded since 1994. Consequently, the wastewater treatment plant ended up not keeping pace with the growing urban population especially with the illegal extension of houses for backrooms, lack of maintenance plans for sewer infrastructure, low budget allocation for operation and maintenance of plants.

In collecting data, the researcher had targeted to have a maximum of ten individuals composing of six officials and four politicians in the project as that would give specific defining character as they possess the data needed for the study. The research collected primary data through the use of an interview guide from the municipal officials and from the politician responsible for sanitation so that first-hand information with regard to sanitation in the Municipality of Polokwane be acquired. The method gave insight into the depth of the study through exploratory data solicited from the opinions and perceptions of the participants with regard to the faecal sludge management in the city of Polokwane. Statistics SA figures were used to quantify the findings from primary data with regard to average usage of facilities of water and sanitation within the Municipality of Polokwane.

5.5 Limitations of the study

The target population of the researcher was ten but seven respondents based on the purposive sampling method took part as some targeted positions were not occupied in the municipality and there are no people acting in the positions.

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Appendix A

Interview Guide for the officials

Topic: Faecal Sludge production and management projections in the city of Polokwane, South Africa

1. Given the high rural – urban migration and population growth in Polokwane, what are the plans of managing faecal sludge produced in both rural, urban and semi – urban areas.

2. Since 1994 Government provided houses to the people and increased the usage of sewage plants that exist. Are those plants coping with the high incidence of more sewage networks being connected?

3. Emanating from the above question, can you describe the challenges faced by the Municipality in the management of faecal sludge at the sewerage plants?

4. Can you elaborate to us what methods are used in urban and rural areas for managing the produced faecal sludge?

5. Is the municipality considering applying any alternative methods in faecal sludge management such as implementing toilets that will separate urine and faeces or Dry toilet methods?

6. In your opinion how will people perceive Faecal Sludge Management if the business advantages are explored, for example the use of faecal sludge in producing fertilizers, bio – gas and fuel.

7. Can you outline to us who is currently responsible to design methods for the management of faecal sludge in towns and villages, except the current sewage network system?

Appendix B

Interview Guide for the Politicians

Topic: Faecal Sludge production and management projections in the city of Polokwane, South Africa

1. It is said that South Africa is a water scarce country; recently Polokwane Municipality passed Bylaws putting stringent measures onto household water use. Are there any plans to introduce new technologies that will save water when disposing of faeces?

2. How do you think the municipality and the community can play a role towards the implementation of the alternative faecal sludge management in the municipal area?

3. Streams and rivers around the municipality are polluted daily by releasing the faecal sludge that is not properly treated; this causes strain as water usage is increasing in the community. What are the plans to rectify this problem?

4. It is said that by 2015 governments around the world would have met sanitation requirements including Faecal Sludge Management. What is the current status in the Municipality of Polokwane?

Appendix C

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	02 November 2017
PROJECT NUMBER:	TREC/310/2017: PG
PROJECT:	
Title:	Faecal sludge production and management projections in the City of Polokwane, South Africa
Researcher:	PPA Mabotha
Supervisor:	Dr F Ganda
Co-Supervisor:	N/A
School:	Turfloop Graduate School of Leadership
Degree:	Masters in Public Administration

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:
i) Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.
ii) The budget for the research will be considered separately from the protocol.
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

Finding solutions for Africa

Appendix D

REPORT CONTROL SHEET

SUBJECT: Request to conduct Research for Mr P.A Mabokela

DOCS NUMBER#

SECTION A: SUBMISSION BY SBU MANAGER

SBU: HR NAME (AUTHOR): Ms

SIGNATURE / SBU MANAGER: DATE: 29/09/2017

POLOKWANE MUNICIPALITY
OFFICE OF THE MUNICIPAL MANAGER
2017 -09- 27
P.O. BOX 111, POLOKWANE 0700

SECTION B: AUTHORISATION / SUBMISSION BY

DIRECTORATE: Corporate & Shared Services

SIGNATURE / DIRECTOR: DATE:

SECTION C: COMMENTS REQUIRED FROM: (TICK IN APPLICABLE BLOCK)

DIRECTOR: ENGINEERING SERVICES		SIGNATURE:	DATE:
DIRECTOR: DEVELOPMENT & ECON. PLAN		SIGNATURE:	DATE:
DIRECTOR: COMMUNITY SERVICES		SIGNATURE:	DATE:
DIRECTOR: CORP. AND SHARED SERV.		SIGNATURE:	DATE:
CHIEF FINANCIAL OFFICER		SIGNATURE:	DATE:
DIRECTOR: COMMUNITY DEVELOPMENT		SIGNATURE:	DATE:
DIRECTOR: STRAT PLAN, MONITOR, & EVAL		SIGNATURE:	DATE:
MAN: COMMUNICATION AND PUBLIC PART.		SIGNATURE:	DATE:

SECTION D: SECRETARIAT & ADMINISTRATION

REG. NO: REG. DATE: COMMITTEE CLERK:

SECTION E: MUNICIPAL MANAGER

APPROVED FOR SUBMISSION: DATE: 29/09/2017

REMARKS:

ALLOCATION TO COMMITTEES

FINANCE & LED	ENERGY	HOUSING	CULTURE, SPORTS, REC & SPEC. FOCUS	ADMIN & GOV.
WATER & SANITATION	COMMUNITY SAFETY	ROADS, S/WATER & TRANSPORT	WASTE & ENVIRON.	SPATIAL PLAN & DEV
LAND USE MAN.	LOCAL LABOUR FORUM	COUNCIL	MAYORAL COMMITTEE	

APPROVED ITO DELEGATED POWERS DATE

MM/ NUMBER ALLOCATED BY CAO – SECRETARIAT MM/

APPROVAL OF EXECUTIVE MAYOR IN TERMS OF DELEGATED POWERS

APPROVED ITO DELEGATED POWERS DATE:

EM/ NUMBER ALLOCATED BY CAO – SECRETARIAT EM/

515559
MS. R.E RAMELA (26/09/2017)

DIRECTORATE: CORPORATE AND SHARED SERVICES

ITEM:

FILE REF:

REQUEST TO GRANT MR.PA MABOTHA PERMISSION TO CONDUCT HIS RESEARCH WITHIN POLOKWANE MUNICIPALITY

Report of the Acting Director: Corporate and Shared Services

Purpose of the Report

To request approval from the Municipal Manager to give permission to Mr. PA Mabotha to conduct his research within Polokwane Municipality.

Background and Discussion

Mr. PA Mabotha is a student at University of Limpopo studying MPA, request a permission to conduct his research within the Municipality and his topic of research is:" Faecal Sludge Production and Management Projections in the City of Polokwane, South Africa".

Financial Implication

There is no financial implication.

Recommend

1. That approval is granted for Mr. P.A Mabotha to conduct his research within Polokwane Municipality.
2. That the findings emanating from the research study be shared with the Municipality before they are published.

Appendix E

LoveToEdit

You Write. We Edit. You Love it.

8 August 2018

TO WHOM IT MAY CONCERN

RE: CONFIRMATION OF LANGUAGE EDITING SERVICES: PHUTI ALFRED PATRICK MABOTHA.

I confirm that I have done Language Editing for Phuti Alfred Patrick Mabotha's dissertation titled:

FAECAL SLUDGE PRODUCTION AND MANAGEMENT PROJECTIONS IN THE CITY OF POLOKWANE, SOUTH AFRICA

The Dissertation now conforms to the University of Limpopo's language editing standards.

Yours sincerely

Lynn N Sibanda

Tel: 011 050 0376

Mobile: 071 989 0983

Email: lynn@lovetoedit.co.za

Member of the Professional Editors Guild

Professional EDITORS Guild

Address: 16 Countesses Ave, Randburg, South Africa, 2194 | **Telephone:** +27 11 050 0376 | **Email:** info@lovetoedit.co.za
Website: www.lovetoedit.co.za | **Registration Number:** 2016/ 425723/ 07