Factors influencing compliance with waste management licence at selected wastewater treatment plants

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DECLARATION

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ABSTRACT

Studies show that in developing countries the concentrations of pollutants discharged into water bodies are still very high; thus, several attempts have been made to address this phenomenon and eventually achieve compliance. South Africa made it mandatory for wastewater treatment plants to be licenced and thus achieve compliance in terms of the National Environment Management: Waste Act (Act no 59 of 2008). Compliance to regulations are spelt out under section 24(5) of the NEMA. This compliance is critical for wastewater entities to operate. Thus municipalities are mandated to comply with the waste management licence requirements. This study aimed to evaluate factors that influence compliance with waste management licenses in selected wastewater treatment plants in Chris Hani District Municipality. This was achieved through a combination of literature review, document analysis and semi-structured interviews with 19 municipal employees comprised of process controllers, environmental control officers, engineers, and managers. Data were analysed using thematic analysis, which is a qualitative data analysis procedure that identifies key themes in an attempt to answer research questions posed by the study. Results shows that factors affecting compliance with waste management licence by wastewater treatment plants are population growth, design capacity, discharge effluent flow, human resource factors (management, recruitment, and capacity building), site security, budget, infrastructure (ageing infrastructure, outsourcing of municipal service, lack of scheduled maintenance) and resources. Most respondents cited budget as one of the main factors impacting negatively on the ability to comply with waste management licences. This may impact on the effectiveness of the wastewater treatment plant operations.

Key words: Compliance, Waste Management License, Wastewater Treatment plants, South Africa.

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ABBREVIATIONS

BEE	Black Economic Empowerment
CHDM	Chris Hani District Municipality
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DG	Director-General
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GG	Government Gazette
GN	Government Notice
IDP	Integrated Development Plan
ISO	International Organisation for Standardisation
MFMA	Local Government: Municipal Finance Management Act 56 of
NEMA	National Environmental Management Act 107 of 1998
NEMWA	National Environmental Management: Waste Act 59 of 2008
NWA	National Water Act 36 of 1998
WA	Water Act 54 of 1958
W2RAP	Water Risk Abatement Plan
WSA	Water Services Act 108 of 1997
WSSA	Water Services South Africa
WML	Waste Management License
WWTPs	Wastewater Treatment Plants
WWTW	Wastewater Treatment Works

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CHAPTER 1: INTRODUCTION

1.1 Background

Despite the fact that the Public health Act (36 of 1919) that prohibits discharge of wastewater into the streams as well as the National Water Act (56 of 1956) which aims to control the discharge of effluent into the water streams were introduced, water pollution is still a major challenge in South Africa (Ntombela *et al*., 2016). Poor and inadequate wastewater treatment processes increase the incidents of non-compliance with national water resources management legislation, policies, norms and standards designed to protect South Africa's water resources (Ntombela *et al.,* 2016). A number of guideline documents have become available to provide an opportunity for integrating legislation and best practice into useable tools for implementation (Ntombela *et al.,* 2016). These guidelines provide an opportunity to minimise contamination of the environment through the discharge of wastewater (Ntombela *et al.,* 2016).

In order to reduce water contamination and thus protect the environment, the South African government introduced several legislations which include the South African constitution (107 of 1996) which is a cornerstone for community involvement and ensures that the environment is protected for the benefit of the present generation as well as future generations (Du Plesis, 2013). The constitution is important due to the fact that it assigns functions to different spheres of government which includes wastewater disposal.

Furthermore, the Environment Consevation Act (73 of 1989) made it a mandatory for authorization of listed activites. This means that the licencing of wastewater treatment plants is compulsory for organisations and complicance with licencing requirements prior release of effluents into the environment (South Africa, Western Cape Government, 2017). This requirement was introduced to ensure that the performance of Wastewater Treatment Plants (WWTPs) is monitored (Morris *et al.,* 2017). Licencing is a command-and-control tool used by the government to enforce compliance with legal requirements and environmental standards (Morris *et al.,* 2017). In this way, it assists in enforcing the reduction of polluting activities and associated environmental impacts. Complex developments require Environmental Impact Assessment (EIA) to analyse the potential effects of the proposed projects on the environment (South Africa, Western Cape Government, 2017). Lastly, licences are used by government as a tool to authorise implementation of projects and activities with respect to their potential to negatively impact on the environment (Morris *et al*., 2017). Licences thus form the basis for compliance monitoring by the South African government (Morris *et al.,* 2017).

As part of licencing requirements, organisations undertaking specified activities as described in the National Environmental Management Waste Act (59 of 2008) and National Conservation Act (73 of 1989) section 20 and 21 should conduct an environmental impact assessment. The National Environmental Management Act (107 of 1998) was adapted from the National Environmental Policy Act promulgated in the United States of America in 1969, with the aim of identifying and mitigating the potential effects of a project on the environment (Broderick & Durning, 2007; Chang *et al*., 2018). Projects with the potential to cause adverse environmental impact include WWTPs due to potentially negative impacts of released waste on the environment. The waste management activities commonly referred to as listed waste management activities are listed in Government Notices No. 718 of 03 July 2009 (GN. No 718), which was promulgated in terms of the National Environmental Management Act: Waste Act 2008 (59 of 2008).

Wastewater treatment plants are listed in GN. No 718 as activities with associated licensing requirements in accordance with section 20b of National Environmental Act: Waste Act 2008 (59 of 2008). Of the categories A and B, wastewater treatment plants fall under category B, which require an Environmental Impact Assessment process as stipulated under section 24 (5) of the National Environmental Management Act (107 of 1998) to be undertaken as a requirement for the issuing of a Waste Management Licence (South Africa, Western Cape Government, 2017).

The environmental impact assessment process comprises several steps. EIA starts with screening the project proposal to determine whether an EIA is necessary (South Africa, Department of Environmental Affairs and Tourism, 2004). Following the screening of the proposal is the scoping phase. Scoping is the first interaction of the planned development with all relevant stakeholders and includes all interested and affected parties and the relevant competent authority (Broderick & Durning, 2007). The next phase is public participation**.** Public participation can be defined as a mechanism used to involve the public or their representatives in the decision-making (Andre *et al.,* 2006). The public is introduced to the project and is requested to provide suggestions to the environmental impact assessment so that developers can incorporate them into the final EIA report**.** The public can submit their feedback or suggestions on the EIA report after the public participation meeting (Abebe *et al.,* 2007). The next step of the EIA process is undertaking an environmental impact study. Environmental impact studies involve impact prediction, impact analysis, consideration of alternatives and environmental management plan preparation (Abebe *et al.,* 2007). Finally, reviewing, decision making, and implementation of the Environmental Impact Assessment Report is done (Abebe *et al.,* 2007).

Following approval of the development by the competent authority, issues raised during the EIA process are addressed to ensure compliance with all the legislations before the licence is issued (Abebe *et al.,* 2007). Waste management licences are part of the EIA follow-up as their goal is to

provide information about the consequences of activity and check compliance with the implementation requirements (Morris *et al.,* 2018)**.** Waste Management Licences (WML) for wastewater treatment plants are issued by the Department of Environmental Affairs (South Africa, Western Cape Government, 2017). The WML has requirements including site security and access control, management, designation of waste management control officer, impact management, monitoring, investigations, and records. Section 34 of the EIA regulations (2014) requires that an environmental audit report is submitted by the holder of the WML to the competent authority for the duration in which the WML remains valid (South Africa, Western Cape Government, 2017).

The treatment of wastewater and discharge effluent is regulated by the National Water Act (36 of 1998). The National Water Standards limits the direct discharge of wastewater into water resources and the Water Service Act (108 of 1998) is assigned a responsibility for provision of wastewater to municipalities. As a result some municipalities have been classified as waster service authorities (Ntombela *et al.,* 2016). The Water Service Authorities are responsible for the collection, treatment and discharge of wastewater and are required to ensure that WWTPs comply with compulsory national standards relating to the construction and functioning of WWTPs (du Plesis, 2013) .

Very little information is known about factors influencing compliance with the WML specifically related to wastewater. This research aims to critically analyse the factors that influence compliance with waste management licences in selected Wastewater Treatment Plants in Chris Hani District Municipality.

1.2 Problem statement and rationale for the study

One of the main causes of water pollution problems in South Africa is poor and insufficient wastewater treatment (Moyo, 2014)). A number of municipalities in South Africa are having challenges in complying with waste management licenses despite the fact that management programmes which include environmental management plans were introduced to assist. Environmental management plans are sector-specific and are developed as part of the EIA process; they also assist with complying with the WML requirements. Following approval of the EIA, the WML should be issued as part of regulatory compliance. Then the project can commence (in case of a new project). Despite the abundance of information on environmental governance mechanisms as a way for effective regulatory compliance, literature is silent on factors affecting the organizations compliance with WML requirements (South Africa, Western Cape government, 2017; Gopo, 2013; Ntombela *et al.,* 2016; South Africa, National Waste Act (59 of 2008); Moyo, 2014).

Little information is available on factors influencing compliance with WML requirements which may result in non-compliance. According to Ndlovu (2015) monitoring compliance to the WML is still lacking and is one of the weakest links in the EIA process worldwide. Compliance monitoring, enforcement, and authorization have been identified as the major challenges facing the South African EIA system (Wessels & Morrison-Saunders, 2011). The current study will however, not focus on factors affecting enforcement. Still, it will attempt to understand factors influencing those being regulated, specifically to understand factors influencing implementation of WML conditions by selected municipalities.

Several cases of water resources pollution results from inadequately treated effluent from municipal wastewater treatment plants (Fatoki *et al*., 2003). According to Mazwi, (2014), in September 2007 cases of cholera outbreak were reported in Queenstown, a town located in Chris Hani District Municipality. These five cases reported presented a mild diarrheal symptom which is a symptom of cholera. A report by Department of Water Affairs (DWA, 2009) confirmed that the Queenstown and Whittlesea wastewater treatment plants fall short in meeting the required standards for *E. coli.* In 2015 the Department of Water and Sanitation reported that Middleburg and Cradock communities raised several complaints about polluted water resources, drinking water quality and bad odour from treatment plants. These towns are both situated in Chris Hani District Municipality. Chris Hani District Municipality was reported as one of the municipalities with poor operational state and inadequate maintanance, which has resulted in major pollution problems and impacts on water quality resources with water quality consequently not meeting standards.

Little information is available on WWTPs and their challenges in complying with WML requirements in the Chris Hani District. Knowledge on factors affecting compliance with WWTPs is important in CHDM as this municipality is the 2nd largest municipality in the Eastern Cape Province and a majority of the people reside in rural areas and depend on river water. Challenges faced by organizations in implementing WML requirements may result in non-compliance to environmental regulations, specifically, the WML may lead to poor health problems in communities as can be evidenced by outbreaks of chorela (Mema, 2010). As far as this study is concerned, very little is known about factors influencing compliance to WML requirements and consequences of non-compliance at Chris Hani District Municipality; this study will attempt to fill up this gap using a combination of semi-structured interviews and document review.

1.3 Research question

What factors influence compliance with waste management licences in selected Wastewater Treatment Plants in the Chris Hani District?

1.4 Scope of research

This study focused on 10 wastewater treatment plants in CHDM that were are authorized under waste management licences. Table 2.1 shows that eight waste management licences are valid for a period of 20 years and are reviewed in every 10 years. The other two waste management licences are valid for a period of 10 years and are reviewed every 5 years. All of these waste management licence were registered between the period of 2011 and 2015, this means that they are stilll valid.

1.5 Structure and outline of the dissertation

The dissertation is organized 5 into five chapters.

Chapter 1 provides a brief introductory background of the study, problem statement and it also addresses the research question.

Chapter 2 provides the research approach and paradigms, study sites, sampling strategies, sample size, data collection strategy, data quality control, data analysis, and ethical considerations.

Chapter 3 reviews available literature, policies, acts and legislations applicable to wastewater treatment plants and waste management licences.

Chapter 4 provides results and findings of the study based on collected data; followed by an analysis of the study results as informed by codes, themes, and categories generated.

Chapter 5 Provides concluding remarks and provides suggestions on how compliance to the waste management licence conditions in wastewater treatment plants can be improved.

CHAPTER 2: RESEARCH METHODOLOGY

2.1 Introduction

This Chapter provides the research methodology the study followed in the collection and analysis of research data. Maguire and Delahunt (2017) define research methodology as *"a strategy or architectural design by which the researcher maps out an approach to problem-finding or problem solving".* This entails all efforts aimed at finding answers to the research question. This Chapter starts with the research design and the research approach followed in the study. This is then followed by a description of the various methods of data collection and analysis. The chapter ends with a conclusion.

2.2 Research design

A qualitative research approach was used in this study. Unlike the quantitative approach, which is based on numerical data, the qualitative data used words (Given, 2008). The qualitative approach is used when little is known about the study phenomenon (Given, 2008). There is little information on factors influencing compliance with WML requirements in wastewater treatment plants in the Chris Hani District. Qualitative data was thus seen as the appropriate approach to be followed given the nature of the research question and can be described as data that captures the ways people make meaning of their experiences (Rabionet, 2009). This approach uses rigorous data collection procedures to influence the results quality and reliability (Nowell *et al.,* 2017). Qualitative data aims to describe and understand the topics and occurrences from the participant's viewpoint (Given, 2008).

2.3 Study site

This study was based in Chris Hani District Municipality. Figure 2.1 shows that the Chris Hani District Municipality is situated in the north-eastern part of the Eastern Cape Province and is a linking node to all regions in the province. Chris Hani District Municipality is the second-largest district in the Province, making up almost a third of the Eastern Cape's geographical area. As can be seen in Figure 2.2 the Chris Hani District municipality comprises of six local municipalities, namely: Inxuba Yethemba, Enoch Mgijima, Intsika Yethu, Engcobo, Sakhisizwe and Emalahleni.

Figure 2.1: Districts in the Eastern Cape

(https://en.wikipedia.org/wiki/List_of_municipalities_in_the_Eastern_Cape)

Figure 2.2: Chris Hani District Municipality, 2020

(https://municipalities.co.za/map/104/chris-hani-district-municipality)

Chris Hani District Municipality consists of 18 WWTPs. Out of these, there are only ten WWTPs that are authorized (CHDM IDP, 2019-20). Wastewater treatment plants must be granted authorization through the WML to function properly (South Africa, Western Cape government, 2017). This study focused only on the ten WWTPs that are authorized by the waste management licence as listed in Table 2.1.

Table 2.1: List of wastewater treatment plants included in the study

Works name	Status & Date of Authorization	Waste classification	Validity period	Review	Capacity size (Ml/day)	No. of employees
Old Elliot	Authorized (2021/11/21)	Hazardous	20 years	Every 10 years	1.6	2
Cradock	Authorized (2014/05/01)	Hazardous	20 years	Every 10 years	4.2	4
Sterkstroom	Authorized (2015/11/01)	Hazardous	20 years	Every 10 years	1.1	3
Cofimvaba	Authorized (2013/02/20)	General waste	20 years	Every 10 years	1.3	2
Engcobo	Authorized (2011/03/23)	Hazardous	20 years	Every 10 years	0.75	2
Queenstown	Authorized (2012/03/27)	Hazardous	20 years	Every 10 years	17.5	4
Dordrecht	Authorized (2021/10/10)	Hazardous	20 years	Every 10 years	1.0	3
Whittlesea	Authorized (2013/02/11)	Hazardous	20 years	Every 10 years	5.0	4
Tarkastaad	Authorized (2014/10/11)	Hazardous	10 years	Every 5 years	0.8	3
Lady frere	Authorized (2013/02/20)	Hazardous waste	10 years	Every 5 years	0.8	3

Chris Hani District Municipality applied and was granted the WML for ten treatment plants by the Deputy Director-General: Environmental quality and Protection (CHDM IDP, 2019-20). Of the ten WMLs which were used in this study, six were issued for waste treatment plant facilities that require expansion of facilities and changes to existing facilities which release the effluent of waste to the environment (CHDM IDP, 2019-20). The other four WWTPs were issued WMLs prior the construction of the treatment of effluent with annual capacity of 15000 cubic meters. This means that these wastewater treatment plants were constructed after the governement notice was issued.

2.3.1 Population

The Chris Hani District Municipality population is 840055, which is 12.0 percent of the total population in the Eastern Cape Province, with a population growth of 0.96 % per annum (Stats SA, 2017). Only 35% of the population of the Chris Hani District Municipality use flush toilets connected to the sewerage system (Stats SA, 2017).

2.3.2 Employment rate

Unemployment, inequality, and poverty are significant challenges currently facing the country. Due to high unemployment rate, most people in the District depend on social grants as the main source of household income (http://www.chrishanidm.gov.za 02/06/2020). The majority of the communities

in Chris Hani District Municipality depend on household employment (domestic help), and others are primarily self-employed through casual jobs (http://www.chrishanidm.gov.za 02/06/2021).

The economic situation results in lack of income due to unemployment (CHDM IDP, 2019-20). The Chris Hani Municipality's economy is dominated by the public sector, which indicates the challenge of a limited production base in the area and little private investment growth into the CHDM economy (http://www.chrishanidm.gov.za 02/06/2021). Human development across the district in the local municipalities is very low (http://www.chrishanidm.gov.za 02/06/2021).

2.3.3 Water access

The District is challenged with a higher demand for basic services, including shelter, roads, water, and sanitation services (CHDM IDP, 2019-20). The Water and Sanitation Services are provided through a contract between the CHDM and its eight local municipalities (CHDM IDP, 2019-20).

2.4 Data collection methods

This section will explain the different methods used to collect data in the study. These methods include document review, literature review as well as semi-structured interviews.

2.4.1 Document review

The secondary data that was reviewed in the study includes documents such as waste management licences, and various guidelines concerning wastewater treatment plants. The advantage of using document review methods is that the documents were not created for this study, they are specific and they can be reviewed more than once.

Documents that were reviewed in this study include internal documents such as operation and maintenance manuals – that were issued with wastewater treatment plants, and IDP-2015. The purpose of document review in this study is to understand CHDM wastewater treatment plants, which assisted in formulating questions for interviews. The criteria that was used to evaluate these documents was determing that the documents that exist and are relevant to this study., Lastly summarize the information from the documents reviewed was summarized and the findings evaluated.

2.4.2 Literature review

Literature review is used in research to understand what is already done and identify what is unknown (gaps) (Given, 2008). The purpose of literature review for this study was to find out the factors influencing compliance to WML requirements and consequences of non-compliance.

Relevant international, national and local literature was reviewed, together with applicable legislations, acts and policies inclusive of the South African constitution No 107 of 1996, Public Health Act No 36 of 1919, Water Act No 54 of 1956, National Environmental Management Act No 107 of 1998, Water Act No 36 of 1998, Waste Act No 59 of 2008, and the National Conservation Act No 73 of 1989.

The literature reviewed was from scholary articles that were retrieved through the efundi website (the University of North West website) using the following databases: Google Scholar and Science Direct. The following words were used to search for articles to be reviewed: Compliance, Waste Management License, Wastewater Treatment plants, South Africa.

2.4.3 Sampling

A purposive sampling strategy was used in the study. Nineteen participants were interviewed in the study. The selection of these participants was because of their particular experience and expertise. The study sample included ten wastewater treatment plant process controllers, four environmental control officers (ECOs), two technical managers, and three engineers. The ten wastewater treatment plant process controllers were from the different local municipality (one controller per plant), Environmental officers were working for the district municipality and they work as a team to perform their duties. The two technical managers as well as engineers that were interviewed are managing all the treatment plants of CHDM.

Two technical managers and three engineers were interviewed; technical managers ensure that the WWTP functions smoothly (CHDM IDP, 2017-18). In the municipalities, managers are responsible for allocating funds and recruiting new personal (CHDM IDP, 2017-18). These are 2 important factors because they contribute to the proper functioning of the WWTP. Ten WWTP controllers were also interviewed. Wastewater treatment plant process controllers maintain a variety of plant equipment connected with operation of a WWTP. They also direct lower level operators to perform related work as required (South Africa, Department of Public Works, 2012). The wastewater treatment plant process controllers' duties include adding chemicals such as ammonia and chlorine, disinfect water, inspecting equipment on a regular basis, and collecting water and sewage samples (South Africa, Department of Public Works, 2012).

Lastly, four environmental control officers (ECOs) were also interviewed. The ECOs inspect wastewater treatment plant facilities and ensure adherence to relevant legislations which include water quality guidelines (CHDM IDP, 2017-18). They also check compliance with the WML and perform general inspections for escaping effluent, spills, pre-treatment of industrial waste, site fencing, and provision of safety equipment for workers. The sample size was determined by data

saturation (Given, 2008). The interviews were discontinued as soon as data saturation was reached (Given, 2008). Data was collected over a two month period.

2.4.3 Data collection strategy

The primary data was collected through semi-structured interviews. As previously stated purpose sampling is important and it is essential to use in semi- structured interview research to improve results (McIntosh *et al*., 2015). Semi-structured interviews are used when the type of information necessary to answer research questions is already known; the researcher has control over the topics (Given, 2008). The semi-structured interviews can be conducted with individuals or as groups (Maguire & Delahunt**,** 2017). The interviews were chosen for this study because they focus on this study and individuals provide explanations. They were also conducted facialy and the advatange is that the interviewer could also see the body language and attitude of interviwees on the matter.

The benefit of semi-structured interviews includes that the researcher designs the questions, and the respondents have to answer open-ended question (Given, 2008). Furthermore, they have the advantage of giving structure to the data collection strategy while providing an opportunity to probe the participant's responses further (Kallio *et al.,* 2016). Thus, semi-structured interviews are time and cost saving compared to unstructured interviews (Kallio *et al*., 2016). Interviews were used to generate research data and were conducted in respective municipal offices and through telephone conversations. Research Participants were asked the questions displayed in Table 2.2. below. These questions relate to the research question.

Table 2.2: Interview guide

Question No	
1	In your opinion, what are the factors that influence compliance with waste management license requirements in waste water treatment plants?
2	What are some of the steps you would usually undertake to ensure the waste water treatment plant remains effective and complies with the waste management licence?

2.5 Data Analysis

The methods used to analyse research data in this study were thematic and document analyses. A brief discussion of these strategies follows.

2.5.1 Documentary analysis

According to Patton (2002) documentary analysis involves the analysis of texts the researcher has produced herself. Depending on the nature of the cultural group being examined, this involves reports, official publications, and written responses to interviews.

2.5.2 Thematic analysis

Thematic analysis can be defined as a procedure of classifying patterns or themes in qualitative data (Braun & Clarke, 2006). According to Braun & Clarke (2006), this procedure is used as the foundational method for qualitative data analysis as it provides essential skills for conducting other forms of qualitative analysis. The main aim of thematic analysis is to identify themes and to use them in answering research questions (Braun & Clark, 2006)**.**

Thematic analysis is much more than summarizing the data; it interprets and makes sense of collected research data (Nowell *et al.,* 2017). Even though thematic analysis is not complex, there are advantages and disadvantages of using the method (Nowell *et al.,* 2017). Braun & Clarke (2006) argued that thematic analysis helps examine different participants' views who have a different understanding of the topics and show similarities and differences. One of thematic analysis advantage is that it is well structured and includes the ability when working with large data set to produce a clear and organized report (Nowell *et al.,* 2017).

According to Nowell *et al.* (2017) thematic analysis has less literature than other qualitative data analysis methodologies such as grounded theory and ethnography. As a result, the insufficiency of literature limits the theoretical base on which a qualitative researcher can draw knowledge (Nowell *et al.,* 2017).

Six steps developed by Braun and Clark in 2006 were used when conducting thematic analysis in this study. The steps for analyzing data in this study, included: becoming familiar with the data, generating initial codes, searching for themes, reviewing themes, defining themes & writing-up (Braun & Clark, 2006).

The first step of thematic analysis involved reading the scripts and writing down the transcribed audio interview to be familiar with the data (Maguire & Delahunt, 2017). The second step involved structuring the data in a meaningful manner and creating new codes; this was done using excel (Nowell *et al.,* 2017). The third step involved searching for themes. *"A theme can be defined as the pattern that captures important data that relates to the research question, themes are characterised by their significance"* (Maguire & Delahunt, 2017). Themes were developed using colour coding and were reviewed and improved (Maguire & Delahunt, 2017). The final step for thematic analysis comprises improving the themes through classifying an extract of what each theme is about and writing reports (Braun & Clarke, 2006; Maguire & Delahunt, 2017).

2.6 Ethical Consideration

Researchers, in the performance of their research work, are required not to abuse participants in the process of conducting research, hence the need for ethical consideration. The student attended the online ethics course and applied for ethics clearance in March 2020. The ethics approval for the study was granted as it was low risk and the ethics number is NWU-01314-20-A9.

Informed consent was obtained from all participants. Informed consent is a necessary research pre-condition for this study. Emphasis was placed on accurate and complete information so that the subjects fully comprehended the investigation and were able to make a voluntary, informed decision about their participation. Informed consent has three major elements: the type of information needed from the research subject; the degree of understanding that the subject must have in order to give consent; and the fact that the subject has the choice of whether or not to give consent. All participants must understand that information. The information was provided in the participants' own language, at their level of understanding and in simple vocabulary, not in technical language or professional jargon.

2.7 Limitations of the study

One of the limitations in this study was in data collection. It was not easy to get participants due to the pandemic. Due to Covid-19 pandemic personnel in CHDM were working in shifts and it was not easy to get them schedule appointment with personnel were made though managers. Then one-on one appointment were arranged with individuals via emails and telephones. At first people who are not working in the municipal buildings so the study was delayed for a month.

2.8 Conclusion

This Chapter presented the research design, research approach, sampling strategies, data collection strategies, and data analysis strategies. The study was conducted in Chris Hani District Municipality; which has a population of 840055 with a population growth of 0.96 % per annum (Stats SA, 2017). It has a high unemployment rate (CHDM IDP, 2019-20). Due to the little information on factors influencing compliance with licencing requirements in waste water treatment plants qualitative data approach was used as it was seen as being suitable to answer the research question.

The primary data was collected through semi-structured interviews, and the sampling strategy which was used was the purposive strategy. The study included nineteen research participants including wastewater treatment plant process controllers, environmental Control officers (ECOs),

engineers, and technical managers. This study has used document and thematic analysis to analyse research data. The following chapter will discuss the literature reviewed in the study.

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

Environmental problems concerning wastewater treatment plants have increased over the years internationally. Wastewater treatment plants are essential as they release effluent back to water resources or near water resources which affects water quality (Renou, 2008). All communities depend on water for their daily activities and livelihood (Gopo, 2013). Even though the importance of smooth operation in treatment plants is recognised, municipal treatment plants still dispose wastewater into the environment inappropriately. This is believed to be the leading cause for water pollution that also causes great concern to the environment in developing countries (Hounkpe *et al.,* 2014). According to Hounkpe *et al.,* (2014), the major part of the illnessess in developing countries are caused by water and sanitation problems. "*It is estimated that 1.5 million deaths among children under five each year are due to diarrhoea, mostly in developing countries; this is equivalent to "a child dies every 21 seconds".* Appropriate methods for discarding are therefore obligated to protect the environment and health and also to avoid unpleasant smells (Hounkpe *et al.,* 2014).

Compliance with waste management licence criteria is crucial to the South African government as they have a sound legislative framework, which is seen as addressing the need to comply with environmental legislation (Jones, 2011). This chapter will review literature on legislation governing WWTPs in South Africa. It will start by explaining the following terms; wastewater, wastewater treatment plant, and compliance. It will then proceed to give an overview of wastewater governance within the South African context. Thirdly, it will critically review the factors affecting compliance with waste management licence in wastewater treatment plants. Finally, the Chapter will provide a summary of various aspects discussed.

3.2 Defining wastewater

River pollution has many sources, with diverse strengths and sizes (Von Sperling & Chernicharo, 2002). One of the main sources of water pollution locally, regionally and globally is untreated wastewater discharge (Von Sperling & Chernicharo, 2002). This wastewater discharge can be from a point or nonpoint source (King *et al*., 2018). Point source means that the pollution is from a single direct source such as a factory or sewage treatment plant (EPA, 2018). In contrast, a non-point source is a pollution resulting from indirect sources such as drainage, fertilizers from agricultural activities and atmospheric deposition (EPA, 2018).

Wastewater is considered as any water that has been unpleasantly affected in quality by human-made impacts such as liquid waste discharged by homes, industries, businesses and agriculture, and can contain a variety of potential contaminants and concentrations (Gopo, 2013). The

wastewater is composed of a complex combination of organic and inorganic constituents and man-made compounds (Ntombela *et al*., 2016). Table 3. 1 presents the list of organic and inorganic compounds present in sewage waste; these nutrient contents often impact the receiving waters. As can be seen in Table 3.1 the microbes and chemicals found in wastewater are a threat to human health and the environment (Morris *et al.,* 2017). For this study, "*wastewater will be defined as any water which has been adversely affected in quality by human activities and may include Domestic and industrial effluent"* (Gopo, 2013).

Table 3.1: Composition of raw sewage (Gopo, 2013)

Nutrient	
Suspended Solids	250-400mg/l
Ammonium salts	25-50mg/l
Chloride	60-100mg/l
Phosphates	12-25mg/l
Fats	100-200mg/l
Chronium	0.1-0.5
Copper	0.2-0.5
Lead	0,08-0,4
Zinc	0.4007
Faecal Coliforms	2-30x10/100ml

3.3. Waste Water Treatment Plants

Von Sperling and Chernicharo (2002) define a wastewater treatment plant as a facility that is *"important and compulsory to improve the quality of wastewater before it is discharged back to the surface, rivers or groundwater worldwide."* In WWTPs, the quality of wastewater is enhanced by using various methods that include biological, physical, and chemical methods to meet the regulatory standards regarding effluent discharges (Von Sperling & Chernicharo, 2002). The effectiveness of wastewater treatment plants is assessed regularly to ensure proper maintenance and sustainable management (Gomez-Llanos, 2018; Morris *et al*., 2018). WWTPs vary in size and irrespective of their extent, they have to comply with legal requirements (Snyman *et al.,* 2004).

Research shows that in South Africa, only 4 percent of treatment plants are complying with the legal requirements i.e. regulatory standards and are adequately operated and maintained (Snyman

et al., 2004). Facing the high frequency of non- compliance of WWTPs, stakeholders have made reliable decisions and support tools to measure treatment plants' environmental performance (Renou, 2008). One of these tools is licencing. The goal of licencing in WWTPs is to improve their performance (Morris *et al*., 2017). Therefore licencing assists in managing WWTPs effectively as they have a huge impact on water quality (Gopo, 2013). Compliance with waste management licence is compulsory in the WWTPs. WWTPs are regulated by the National Water Act, Section 21(f)-(h), which emphases the requirements for the discharge of wastewater into water resources by WWTPs (Gopo, 2013).

3.4 Compliance

Compliance can be explained as an act of conforming, complying or yielding (Jones, 2011). The term compliance in wastewater governance conforms to the legislated standards, laws and other requirements such as licence, permit, etc. set by the government, company (internal standards), or other organisations (Jones, 2011). This compliance adherence is done in the form of Environmental Compliance Auditing, in which the project proponent is required to appoint an Environmental Control Officer (ECO). The ECO's role is to ensure that the general conditions of the WML are implemented and monitored throughout the phases of development and operational phase (Wessel & Morrison-Saunders, 2011).

South African legislation regarding WWTPs has been established and is used as a mechanism that determines whether compliance concerning the standards has been accomplished (Nhapi, 2002). Waste management licence, constitution, guidelines, acts and policies are legal documents that are used to determine compliance in wastewater treatment plants (Jones, 2011). Failure to meet requirements in the regulations specified in a WML will lead to non-compliance that will require improvement in developing control routines and instrumentation (Jacobsen, 1999). In a case where there is continued non-compliance with the WML, it licence can be revoked (Owens &Burke, 2009).

3.5 Waste management licences

Wastewater treatment plants are highly regulated both internationally and nationally (Gomez-lianos, 2018). An important component of this regulation includes the WML (Doherty *et al*., 2018). In South Africa, the government stipulates conditions for a WWTP in the WML (Gomez-lianos, 2018). The development of sewage discharge standards and the implementation of licencing in wastewater treatment plants helped developed countries improve the standard of wastewater and control discharge (Zhang *et al.,* 2016). Hence even in developing countries like South Africa, waste management licences are compulsory for every waste water treatment plant (King *et al.,* 2018).

Wastewater treatment plants are recognized as effective when their performance is according to the required standard (as accepted by the waste management licence) (Morris *et al.,* 2017). The discharges are usually monitored to determine waste water quality to ensure compliance with the conditions stated in the WML (Morris *et al.,* 2017). A waste management licence requires influent and effluent to be analysed at intervals during the requested times. The licence determines frequency for audit reports (Morris *et al.,* 2017). Detailed information about South African legislation on WWTPs will be discussed in the next paragraph.

3.6 South African Legislation in respect to Wastewater Treatment Plants

Wastewater treatment plants have been regulated for decades. The Public Health Act (36 of 1919) prohibits discharge of sewage into streams due to increasing population and urbanisation. Environmental complexities and wastewater concerns have increased over the years. As a result in 1956 the Water Act (54 of 1956) was introduced with the aim to enforce and tighter changes. The Water Act brought major changes on how wastewater was observed. Basically this Act prohibits wastewater plants from discharging effluents into the river and made it compulsory to discharge only purified effluents into watercourses (rivers and streams or, in the case of coastal areas into the sea). Discharging purified effluents into the water course also required permits that showed that it complied with the standards.

Section 24 of the constitution of South Africa (107 of 1996) declares that everyone has the right to an environment that is not harmful to their health or wellbeing. To achieve the constitutional mandate the National Environmental Management (108 of 1998) was introduced as the umbrella of regulations that are regulating WWTPs. These include the National Water Act, Waste Management Act, Conservation Act as well as.

The Conservation Act (73 of 1989) section 20 states that no person shall start, provide or operate any disposal site without a permit issued by the minister of Water Affairs and this includes wastewater treatment plants. The Conservation Act (73 of 1989) also assists in controlling activities which may have detrimental effects on the environment by identifying those activities which may have a substantial detrimental effect on the environment. These include waste and sewage disposal.

Waste management activities were published in schedule 1 of the NEMWA under Government Notice 718 that came into effect in 2009 as part of activities (Category B) that require a person who wishes to construct them undergo an environmental impact assessment. The regulations made under section 24(5) of the National Environmental Management Act, 1998 (Act no 107 of 1998) stipulate an EIA as part of the waste management licence application (South Africa, Department of Environmental Affairs, 2013).

Before constructing a wastewater treatment facility that has the potential of causing harm to the environment, an EIA is conducted to evaluate the potential impacts that will occur during the construction and operation phases of a WWTP; to provide mitigation measures (King *et al.,* 2018). After the approval of the EIA the waste management licence, which can also be called Environmental Authorisation, is required before constructing the WWTP, which is issued in terms of the National Environmental Management Act (NEMA) EIA Regulations. The Wastewater Treatment plants are regulated by the National Water Act (36 of 1998).

The National Water Act (36 of 1998) recognised that water is a scarce and unequally distributed national resource that need to be conserved, protected managed and controlled in a sustainable and equitable manner for benefit of all citizens. The National Water Act is a primary legislation regulating the management of water resources in South Africa, including effluent quality. Section 21 (f)-(h) of this act emphasises the responsibilities and conditions for discharge of wastewater into water resource by WWTPs.

WWTPs are also regulated by the Water Service Act (108 of 1997). The District Municipalities are categorized as water service authorities meaning that they are in charge of providing water services within the authority (Gopo, 2013). These regulations guide how to construct and operate a WWTP legally. The Water Service Act (108 of 1997), National Waste Act (59 of 2008), municipal governance policies and procedures ensures an environment in which section 24 of the constitution is achieved. This is supported by chapter 7 of the Constitution, which states that Local Government has the duty to provide a safe and healthy environment to its community in a sustainable manner (Gopo, 2013). All the conditions for managing, operating and maintenance of WWTPs are provided in the WML, and the waste management licence holders are responsible for ensuring compliance with the requirements (South Africa, Western Cape Government, 2017). The following section will discuss the factors affecting compliance with waste management licence in wastewater treatment plants.

3.7 Factors affecting compliance with waste management licence in waste water treatment plants.

There are several factors affecting compliance with the WML in WWTPs. According to Morris *et al.* (2017) compliance with the WML in WWTPs is not only affected by urbanization, industrialisation and population growth; it is also affected by factors such as infrastructure, financial, technical, administrative, operational and regulatory aspects (Johnson, 2010).

Infrastructure in most WWTP facilities can also influence compliance with the WML (Snyman *et al*., 2004). Aging infrastructure in WWTPs that is not maintained regularly for smooth operation results in complications such as faulty equipment that will result in disposing of water that is not adequately treated (Ntombela *et al*., 2016).

Although WWTPs are highly legislated in South Africa, there are many treatment plants that were reported to be non-compliant to regulations. As a result, the Government has introduced several programs and/or management plans which include the Green Drop Programme, wastewater management plan, and Environmental Management Plans (Ntombela *et al.,* 2016). The Green Drop Programme is a programme that assists with improving wastewater management in South Africa through identifying and developing the essential competencies required to achieve this for this generation and furture generations (Ntombela *et al,* 2016). Despite all initiatives by the Government, compliance with wastewater licences remains a challenge. Problematic organizational procedures, complex relationships between sectors (different departments), stealing, damage and mismanagement of WWTP infrastructure and transparency are other factors that influence WWTPs compliance with waste management licences (Ntombela *et al*., 2016*).*

3.7.1 Regulatory factors

The first regulatory factor that significantly influences compliance with the WML in WWTPs is the ever-changing legislation. Legislations concerning wastewater governance change over the years due to various reasons (Morris *et al.,* 2017). For example, one of the largest treatment plants in the United Kingdom was not complaint due to the several changes undergone on the original licence agreement granted (Morris *et al*., 2017). The original licence was issued in 1989 under the Control of Pollution Act 1974. Changes in legislation have resulted in strict conditions to ensure that WWTP conforms with the licence conditions (Morris *et al.,* 2017). The main challenge of changing the legislation is that the original plant's design and its functions, which include the requirement of tertiary treatment primarily to reduce nutrients in the effluent being discharged, do not meet the latest legislation requirements (Morris *et al*., 2017).

Furthermore, guidelines that are directly taken from worldwide standards specifically from the developed countries influence compliance with the WML in developing countries (Von Sperling & Chernicharo, 2002). Standards from developed countries require expensive technology, which becomes an issue in developing countries (Von Sperling & Chernicharo, 2002), either because the expertise and equipment are unsuitable or mitigation measures are not applied. According to Von Sperling and Chernicharo (2002), discharge standards are not based on existing capable and affordable wastewater treatment technologies. They are more theoretical and not practical as they play the role of a tool for environmental and public health protection (Von Sperling & Chernicharo, 2002). This approach will lead to a lack of enforcement of the standards. Enforcement also influences compliance with waste management license in wastewater treatment plants (Von Sperling & Chernicharo, 2002). Lack of enforcement in standards results in measures being theoretical and the culture of standards being only on paper (Von Sperling & Chernicharo, 2002).

3.7.2 Management of waste water treatment plants

The majority of WWTP are managed and thus maintained by municipalities nationally. According to Morris *et al*. (2017), the management and ownership of WWTPs can influence compliance with the WML. According to Morris *et al.* (2017), private companies are more concerned with profit-making and continued operations and are less concerned with environmental pollution and public health protection. For example, there was a private company that owned and managed a WWTP.The government was only involved in the construction of the plant (Morris *et al*., 2017). The audit findings showed that the effect of wastewater treatment plants being managed by private companies resulted in non-compliance with regulations (Morris *et al*., 2017; Hounkpe, 2014).

3.7.3 Personnel issues and impact on waste water treatment plants

According to Johnson (2010) shortage of trained, skilled and experienced process controllers, mechanical and electrical maintenance staff in WWTPs influences compliance with the WML. These are significant problems in municipalities (Heymans & Parkison, 2004; Ntombela *et al*., 2016). All the skills mentioned above are required for the WWTP to function properly and are crucial for the effectiveness of the treatment plant (Snyman *et al.*, 2004).

Doherty *et al*., 2017 argues that WWTPs that lack experienced operators may be negatively affected when it comes to reporting and as such, the municipality might have limited data availability. In addition to personnel needs, most plants operate with insufficient information to guide optimised operations. Snyman *et al*. (2004), suggests that plants poor performance is caused not only by the need for new or upgraded infrastructure or the need for funding but by the absence of standard procedures to conduct an audit in conforming to the requirement of the waste management plans.

Compliance with WML is also related to other factors such as lack of budget for personnel to attend training on how to use new equipment or how to keep up with the latest technology (Johnson, 2010). One of the WML conditions is the designation of a waste control officer; however, there is little literature on the involvement and importance of Environmental Control Officers in WWTPs.

3.7.4 Financial management

Of many financial aspects available and impacting WWTP, this study will focus on financial management, capital funding and operation maintenance funding for WWTPs, which all play a role in ensuring smooth operations (Johnson, 2010; Ntombela *et al.,* 2016). The study views the above financial aspects as being crucial to effective functioning of the WWTP.

According to Johnson (2010) lack of planning in South African municipalities affects compliance with the WML. The budget that is allocated for maintaining WWTPs is usually insufficient. When the funding for maintaining and servicing treatment plants is allocated, factors like increased

urbanisation are sometimes considered. A study shows nearly 1 of every 5 WWTPs need extra funding to fix the existing equipment to consistently treat the influent flow (Ntombela *et al.,* 2016). Due to this, the national grant funding mechanisms funding in most instances, municipalities choose to build new infrastructure rather than maintain existing infrastructure (Ntombela *et al.,* 2016). Besides, internal procedures such as processes in local sphere are sometimes complicated and affect decision making; for example managers cannot respond effectively to the need to provide reliable wastewater treatment services (Johnson, 2010).

3.7.5 Infrastructure

One of the reasons for that causes WWTPs not to function as they should is overloading and lack of maintenance (Hounkpe, 2014). According to Hounkpe (2014) lack of maintenance in WWTPs could result to effluent going back to the environment without meeting the required discharge standards. Evidence shows that only 10% of WWTPs in South Africa are maintained to ensure effective functioning within the known plan and to guarantee the instruments' reliability and accuracy (Snyman *et al.,* 2004). Johnson (2010) believes that faults in infrastructure could result in non-compliance with the WML due to resource unavailability. Maintenance of the treatment plants depends on process controllers' availability, skilled mechanical and electrical maintenance personnel (Ntombela *et al.,* 2016).

Lack of planning in the municipalities does not only affect budgeting; it remains a problem that also affects the infrastructure (Ntombela *et al.,* 2016). Maintenance of the plants' infrastructure is required to take place without delay for effective functioning (Snyman *et al.,* 2004).It is encouraged that the maintenance of a WWTP should be conducted on a reactive basis rather than a preventative basis (Ntombela *et al.,* 2016).

3.8 Conclusion

South Africa is a highly legislated country, especially in the field of Environmental Management. Waste water treatment plants are governed by Section 24 of the constitution, NEMA (Act No 107 of 1998), National Water Act (36 of 1998), National Waste (59 of 2008) permits and waste management licences. One of the requirements for wastewater treatment plants is possession of the WML, which details the conditions that the licence holder (municipality) needs to comply with. Even though WWTPs are legislated, it has been mentioned above that there are factors that influence compliance with the WML in WWTPs. Regulatory factors have been identified as factors that influence compliance with the WML and these include changing legislation and guidelines taken from worldwide standards as well as lack of enforcement. Management of WWTPs influence compliance with the WML, as literature shows that plants managed by private companies lack compliance. Trained, skilled and experienced personnel were identified as factors influencing WWTPs in compliance with the WML. Infrastructure is also essential for successful functioning of

WWTPs and lack of proper infrastructure can influence compliance with the WML in WWTPs. These factors will be compared to factors that influence compliance with waste management licence in 10 WWTPs in Chris Hani District Municipality, Eastern Cape in the next chapter.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents an analysis of the data collected through semi-structured interviews from research participants, which included WWTP process controllers, environmental control officers, technical managers and engineers working in Chris Hani District Municipality. In attempting to put the perspective of respondents in context and understand their relevance to this study, scholarly literature and various documentation informing local government of their job roles were reviewed. The research data was analysed using thematic analysis. The key findings of the semi-structured interviews and documentation review as it relates to each of the research questions are presented.

Table 4.1 below shows the factors influencing compliance with the WML in selected WWTPs in Chris Hani District Municipality. As can be seen in Table 4.1, the factors influencing compliance with the WML are categorized into 3 groups. Each group has different factors.

Table 4.1: Factors influencing compliance with waste management licences in wastewater treatment plants in Chris Hani District Municipality

Category	**Factors influencing compliance with the WML IN CHDM WWTPs**	**Frequency**	**Respondents**
Inputs to watewater treatment works (WWTWs)	Population growth	21%	4
	Design Capacity	36.3%	7
	Discharge effluent flow	42%	8
Personnel related factors	Management	26.3%	5
	Recruitment of personnel	26.3%	5
	Capacity building	52.6%	10
Resource related factors	Aging infrastructure	42%	8
	Lack of scheduled maintenance	68%	13
	Outsourcing of repairing of WWTPs equipment	15.8%	3
	Budget	58%	11
	Theft of equipment in WWTWs	15.8%	3
	Shortage Water and chemicals	26.3%	5

4.2 Inputs to wastewater treatment works

Inputs in wastewater treatment are categorized as factors that affect the operations of the treatment plants. The research finds that the population growth, design capacity and discharge effluent flow influence compliance with waste management licence in the Chris Hani District Municipality.

4.2.1 Population Growth

As shown in Table 4.1, research participants (21%) indicated that the growth in population size of the Chris Hani District Municipality (CHDM) does not only influence compliance with WML but also affects the effectiveness of the WWTP. Respondents mentioned the following treatment plants: Rathwick Queenstown Wastewater Treatment Work, All saint Wastewater Treatment Work, Cradock Wastewater Treatment work and Cofimvaba Wastewater Treatment Work, which were constructed 30 years ago. Some of these treatment plants have not been upgraded. Figure 4.1 below shows that for the past 20 years, the population has increased and this negatively affected compliance with the WML.

The population growth in CHDM urban areas is mainly caused by the increase in birth rate and urbanization. Urbanisation is driven by individuals looking for employment as well as better education opportunities.

One of the ECO's mentioned that

> *"When the plant is designed, the estimated number of people who will be utilizing it was less but the population has now increased by 8 per household; population growth has exceeded the estimated waste load."*

According to Teklehaimanot *et al*. (2014) there has been a rapid population growth in South Africa, especially between 1985 and 2005. As it has been mentioned in Chapter 2 that Chris Hani District Municipality is the primary secondmost dense municipality in East Cape (Stats SA, 2011). During the beginning of the 21st century, the CHDM population was 756 432 (Stats SA, 2011). In 2007 the CHDM population size was 801407 but reached 816266 in 2012 (CHDM IDP, 2019). CHDM population size is currently estimated to be 849 231 (CHDM IDP, 2019-20). The increase in population has led to an increase in the volume of wastewater the WWTPs receives. The increase in the population size puts a strain on WWTPs infrastructure and this could result to treatment plants not functioning properly.

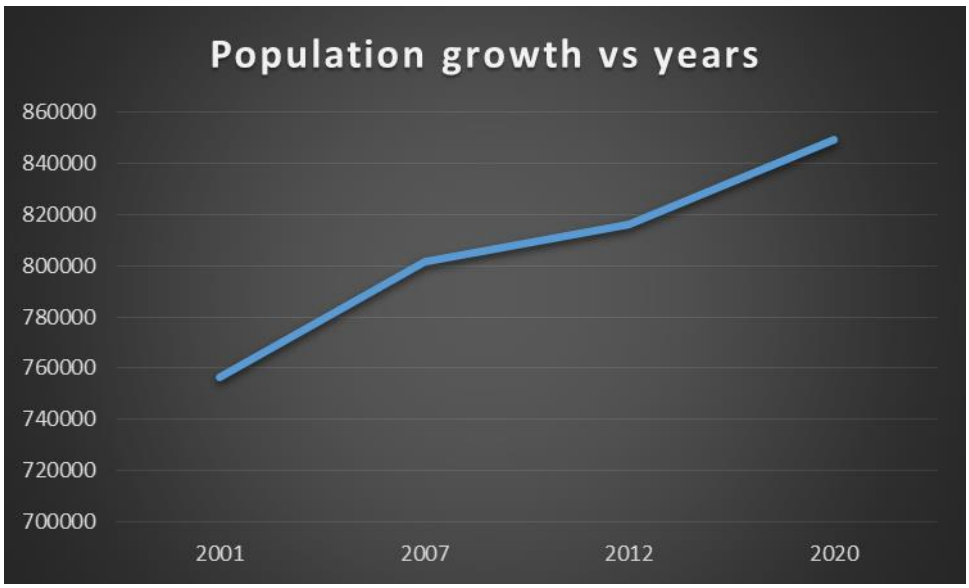

Figure 4.1: Population of Chris Hani District Municipality from the 21st century-2020

(Stats SA, 2017)

The increase in CHDM population has increased the number of households connected to the sewage system. As can be seen in Figure 4.1, the population in CHDM increased from 730236 in 2001 to 756432 in 2011. This represents a 3.5 % increase over a period of 10 years. This has resulted in an increase in number of houses connected in sewage system. In Inxuba Yethemba Local Municipality, the numbers of households connected to sewage system have increased from 65.8% in 2001 to 87.3 % in 2011. This represents a 21.5% increase over 10 years. In Enoch Mgijima Municipality, the numbers of households connected to the sewage system have increased from 49.4 % to 64.9% (as shown in Figure 4.2). This represents an increase of 15.5 %. Between the year 2001 and 2011 the numbers of households connected to the sewage system have increased from 3.5% to 3.8% in Engcobo local municipality (see Figure 4.2). Figure 4.2 shows that Emalahleni local municipality households connected to sewage system have increased from 17.3% in 2001 to 20.2% in 2011.

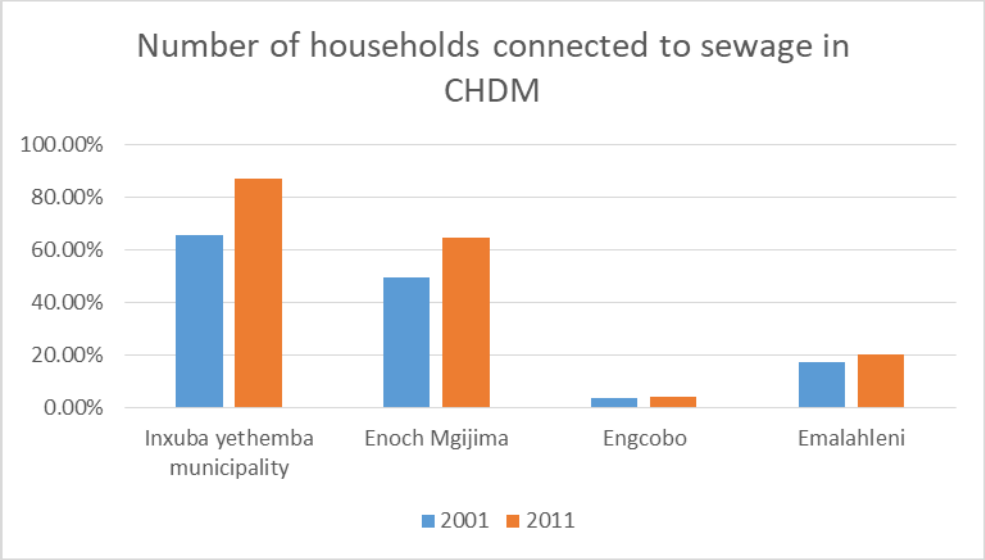

Figure 4.2: Number of households connected to sewage system in local municipalities of Chris Hani District

(Stats SA, 2017)

The increase in numbers of households connected to sewage system in CHDM has affected design capacity of the treatment plant. This means that the wastewater input into the treatment plant has exceeded the design capacity. The impact of this includes overflowing of wastewater in treatment plants and sewer lines, thus this can influence compliance with the WML.

4.2.2 Design Capacity

Design capacity in the treatment facilities can be explained as the amount of wastewater a WWTP can hold, receive, store or treat in a period of time under ideal conditions (South Africa, Department of Public Works, 2012). Based on Table 4.1, 36.3% of the respondents noted that design capacity had exceeded the operational capacity of CHDM WWTPs. The capacity of the plant measures the volume of effluent (measured in Ml/d) that a WWTP is able to treat (South Africa, Department of Public Works, 2011).

In general, the operational capacity has to be less than or equal to the design capacity (South Africa, Department of Public Works, 2012). Evidence from this study shows that in five WWTPs the operational capacity is more than the design capacity. Table 4.2 shows that in Queenstown treatment works, the design capacity is 17.5Ml/day and the plant is currently operating at 22Ml/day; this means that the design capacity has been exceeded. Dordrecht's design capacity is 1Ml/day and operational capacity 1.26Ml/day; the design capacity has also been exceeded. Table 4.2 shows that in Cradock WWTPs, the design capacity is 4.2Ml/day and the plant currently operates at 8.34Ml/day. Cofimvaba WTTP has also exceeded the design capacity by 0.9 Ml/day.

The implications of the operational capacity exceeding the design capacity include overflowing of untreated wastewater in treatment plants and sewer lines to water bodies due to insufficient capacity to hold, receive, store and treat wastewater. This could result in ground water and river pollution. This is one of the factors that influence compliance with the WML in WWTPs. One of the participants indicated that the reason several WWTPs have exceeded design capacity is

> *"In Qamata, WWTP was designed to cater for the hospital only, then when the village developed and most people could afford to have sewer connections, there are more connections to the sewer lines, which resulted in the overflow of the treatment plant waste."*

Elliot WWTP and Sterkstroom WWTP are currently operating at full capacity of the design capacity; this means that the design capacity is equal to operational capacity. Table 4.2 shows that in CHDM, there are only three WWTWs (Engcobo, Whittlesea, and Tarkastaad) whose operating capacity is less than the design capacity. In affirming this, the respondent states that

> *"There is no over flooding in the treatment plant that is caused by the plants being overloaded. All the treatment plants are still operating on a capacity that is less than the design capacity*."

This statement was based on the few plants in which the operational capacity is still less than the design capacity. The above statement was mentioned by the ECO, who is allocated to inspect a few selected WWTPs. Hence, the information mentioned disagrees with the one mentioned by other participants.

Table 4.2: Design capacity versus current capacity of wastewater treatment plants in the Chris Hani District Municipality

Item No	**Local municipality**	**Works Name**	**Design Capacity (Ml/day)**	**Current Capacity (Ml/day)**
1.	Enoch Mgijima	Queenstown	17.5	22
2..	Inxuba Yethemba	Cradock	4.2	8.34
3.	Intsika Yethu	Cofimvaba	1.3	2.2
4.	Emalahleni	Dordrecht	1	1.26
5.	Enoch Mgijima	Whittleasea	5	3.8
6.	Sakhisizwe	Old Elliot	1.61	1.6
7.	Engcobo	All saint	0.75	0.25

8.	Enoch Mgijima	Tarkastaad	0.8	0.67
9.	Enoch Mgijima	Sterkstroom	1.1	1.1
10.	Emalahleni	Lady frere	0.8	0.89

4.2.3 Discharge effluent flow

Municipal WWTPs are designed to receive discharge effluent from domestic sewage flow (South Africa, Department of Public Works, 2012). Despite that, CHDM WWTPs receive domestic sewage effluent as well as industrial sewage effluent. Forty-two percent of the respondents as shown in Table 4.1 indicates that the quality and quantity of discharge effluent that comes from the households and industries affects compliance with WML in WWTPs.

Domestic sewage effluent has less negative impacts on the WWTPs infrastructure because the WWTPs are designed for receiving it. Interviewees mentioned that one of the factors that influence compliance with the WML in WWTPs is industrial effluent. South Africa (2006) defines industrial effluent as "*any liquid comprising substance in solution or suspension as a result of any industrial trade, manufacturing, mining or chemical process or any laboratory, or agricultural activity, and includes matter discharged from a waste grinder*."

Industrial sewage effluent can also be referred to as foreign material in municipal WWTPs. According to the WWTP process controller, this includes the following foreign materials are some of the major causes of failing infrastructure: blood clots, oil chemicals, petrol and aborted foetus. These have damaged equipment and settling tanks and have caused blockages in the system. One of the research participants mentioned an example of how industrial effluent damages the system

> *"Raw wastewater comes in the treatment containing blood and blood-clots from the abattoir and blood takes oxygen in the WWTPs Treatment plant needs oxygen for bacteria's to survive, so lack of oxygen destroys bacteria."*

Blood has a negative impact in the treatment plants, it takes up all the oxygen in the WWTPs, resulting in the wastewater treatment plant having insufficient bacteria (Moyo, 2014). This has a negative impact in the WWTPs because bacteria are essential in the wastewater as they break down the organic matter found in wastewater and convert it to carbon dioxide and water (Moyo, 2014).

The other impact of disposal of foreign material in sewage systems is that these objects damage the WWTPs and also make it more labor-intensive for operators to manage the WWTW (Ntombela *et al*., 2016).

The next section focuses on personnel-related factors that influence compliance with the WML in CHDM WWTPs.

4.3 Personnel related factors

This study found that management and recruitment of personnel as well as capacity building are some of the factors that influence compliance with the WML in CHDM WWTPs,

4.3.1 Capacity building (staff knowledge and skills)

Research participants mentioned several negative impacts that could result when the knowledge and skills are lacking in personnel. According to research participants, untreated wastewater could negatively impact rivers, community and the environment. As shown in Table 4.3, majority of respondents (89.5%) mentioned that the community down the stream utilizes the water from the treatment plants for domestic and recreational purposes, therefore inadequately treated wastewater can lead to a water borne disease.

Furthermore, it has been reported that skilled personnel's unavailability is still critical and is one of the factors that affects compliance with the WML in WWTPs (South Africa, Department of Water Affairs, 2008; Du Plessis, 2014). As shown in Figure 4.1, fifty two percent of the research participants suggested that lack of skilled personnel in the WWTPs influences compliance with the WML. Lack of awareness and knowledge about WML requirements in personnel, communities and industries also affects WML compliance. Therefore, staff knowledge and skills are essential in the WWTP to ensure that the treatment plant remains effective and complies with WML requirements.

Table 4.3: Perspectives of research participants on Importance of Staff knowledge and skills (i.e. capacity) regarding waste management license requirements in achieving compliance.

Category	**Percentage**
Very important to employ personnel with qualifications and skills.	89,5%
Must have experience; no need for qualification.	10,5%

The majority of respondents agreed that skills and knowledge are essential when working in the WWTPs. Personnel must know about the WML, precisely its requirements. One respondent mentioned that

"Due to diseases like chlorella, hepatitis B in these days people working in the treatment plant need to be educated, unlike the olden days. In the olden days, we did not need to care about skills and knowledge."

This shows that to adhere to section 24 of the constitution of South Africa of (1996) that declares that everyone has a right to an environment that is not harmful to their wellbeing, the municipality must employ personnel with skills and knowledge, and this will ensure compliance with WML in WWTPs.

The other participants mentioned that

"The equipment at the treatment plants is expensive, so we cannot just expect anyone to work on a million-dollar equipment; that would be calling for disaster."

Due to the amount spent to purchase the equipment in the WWTPs, research participants (89,5%) suggested that employing personnel with skills and qualifications is critical. Although a majority of research participants agreed that knowledge, skills and capability are essential to have when working in the WWTPs, (10,5%) respondents stated that it is better to work with personnel with experience than a new graduate because graduates have more theory than practical knowledge. All employees working in the CHDM treatment plants are taken to training to ensure that they are competent to work in the WWTP. The training include in-house training and accredited external training.

4.3.2 Recruitment of personnel

As shown in Table 4.1, 26.3% of research participants mentioned that the shortage of personnel working in WWTP facilities is one factor that influences compliance with the WML. The effects of shortage of personnel working in the WWTPs results in personnel not paying attention to detail in their jobs due to work overload.

Research participants (73%), as shown in Table 4.4, raised sharply a shortage of personnel working in the WWTPs, especially process controllers, mechanical and electronics and civil engineers. Research participants mentioned that

"No, we do not have enough personnel currently. We have five operators, four general workers. These both work shifts, and its two people per shift. We work 12-hour shifts for eight days."

Twenty-seven percent of the respondents stated that the treatment plant personnel numbers are sufficient.

Table 4.4: Perspectives from research participants about sufficiency or the opposite personnel in Chris Hani District Municipality wastewater treatment plants (Compiled by author).

Personnel employed in CHDM WWTPs	**Percentage**
Not sufficient personal	73%
Sufficient personnel	27%

Nepotism in the institution was also identified as the factor that influences compliance with the WML in the WWTPs. Nepotism can be defined as favouritism resulting in granting jobs to relatives in the workplace whether they qualify or don't (Khumalo, 2016). Most of the wastewater treatment plant procedures require people with certain skills, qualifications, and experience. As mentioned by the Department of Water Affairs (2011), the technology used in the treatment plant is expensive and it requires high levels of technical knowledge, specialist plant operators and specific equipment.

The effect of nepotism in working in the wastewater treatment plant is that wastewater can end up not being treated effectively due to lack of competence by personnel.

4.3.3 Management of personnel

Research participants (26.3%), as shown in Table 4.1, indicated that one of the management's key responsibility areas is to manage personnel working in the treatment plant; thus ensuring that the wastewater treatment plant remains effective. The interviewees mentioned that senior management including municipal manager, mayors and directors, and middle management (supervisors and engineers) managing the treatment plant, lack technical experience.

One of the research participants commented that

> *"The majority (90%) of personnel in management positions never worked in the treatment plant, meaning that they do not have the experiences and do not know the processes taking place in the treatment plant."*

Research participants (26.3%) suggested that reporting to engineers and managers who lack experience on how to operate the treatment plant affects the effectiveness of the treatment plant. Senior management has little understanding of WWTPs personnel's challenges and the importance of successfully and effectively treating wastewater. This results in WWTPs being mismanaged. Having looked at personnel, the following section focuses on resource-related factors.

4.4 Resource-related factors

Resource-related factors that influence compliance with the WML in CHDM WWTPs include ageing infrastructure, lack of scheduled maintenance, outsourcing of repairing and servicing equipment in the WWTP, theft of equipment in the WWTWs, budget, chemicals and water scarcity.

4.4.1 Ageing infrastructure

As stated above, six WWTPs in the study were constructed 30 years ago. Even though the regulations for licensing the plants were established in 2008, both new and existing WWTPs applied for authorization. The WWTPs are listed activities under schedule 1 of the National Environmental Management Waste Act (59 of 2008). Ageing infrastructure in the treatment plants affects compliance with the WML. For example, one respondent stated that

> *"The main challenge faced concerning the infrastructure is that when there is malfunctioning equipment, it becomes difficult to repair it because some parts are out of the market."*

As shown in Table 4.1, research participants (42%) suggested that the infrastructure in the WWTPs is ageing, therefore maintaining and servicing equipment becomes difficult, and this affects the wastewater treatment process. As a result, water quality results become unsuitable for release into the rivers or streams.

4.4.2 Lack of scheduled maintenance

It is mentioned in the water research commission (2009) that wastewater treatment plant equipment must be serviced regularly. The majority of the research participants (68%) mentioned that due to lack of servicing and maintenance of the infrastructure in WWTWs, the WWTPs face several challenges which include unreliable meter readings, blockages in the infrastructure, and failure of sewer pumps.

According to the standard operating procedures, the municipality shall have a planned maintenance schedule of equipment to ensure the proper functioning and prevent contamination or deterioration of the plant (South Africa, Water Research Commission, 2009). Research participants (68%) (See Table 4.1) mentioned that the CHDM does not conform to the above directive, it was also noted that CHDM does not have a planned maintenance plan for WWTPs.

One participant mentioned that:

> *"Servicing of equipment has to be done in a certain period; it could be after a year, two years or more; depending on the type of equipment; in our municipality, there is no scheduled service. We have no Scheduled service documents in our municipality, which is supposed to give details on the equipment's service status and the next service. The last*

time the infrastructure was serviced was 3 years ago when a private company managed treatment plants."

Lack of service on equipment results in equipment not functioning properly. Results from this study show that the municipality works on a reactive basis than a preventative basis. This means that the municipality only reacts when there is a problem in the WWTPs but does not anticipate challenges by putting a maintenance plan in place. These challenges cause plants to be ineffective and release poorly treated water into the natural system due to WWTPs not being serviced regularly.

4.4.3 Outsourcing of repairing wastewater treatment plant equipment

Outsourcing of municipal services includes contract service arrangements with private and public service providers (Johnson, 2005). According to Johnson (2005), outsourcing can be defined as using external service providers' through different contractual agreements.

In CHDM, maintenance and repairing of equipment, equipment calibration, purchasing of chemicals & personal protective equipment are outsourced. The reasons for the outsourcing of these services differ; it may be because the institution does not have the capacity to perform the job or the municipality wants to promote the Black Economic Empowerment business.

Service providers that are allocated for servicing of equipment at CHDM are rotated to promote impartiality. Service providers for maintenance of the WWTPs infrastructure are given a contract for 2 years and are selected based on pricing, not on competence. One participant mentioned that

"One of the main problems is that these companies are given jobs according to who quoted the cheapest or the popularity. Quality does not matter in the municipality. Sometimes, the jobs or tenders are given to unqualified people because they are well known."

The respondent points out the challenges regarding selecting service providers. These challenges include selecting suppliers due to price or popularity. The respondents further state that the municipality does not consider the quality and that sometimes jobs are given to unqualified people. As shown in Table 4.1, research participants (15.3%) mentioned that changing service providers cause complications in the treatment plant due to different service providers that are unfamiliar with the system and end up creating problems that may affect compliance with the WML.

4.4.4 Theft of equipment in CHDM WWTP

According to CHDM IDP (2019-20), theft and vandalism cases that occurred in Inxuba Yethemba Local Municipality Wastewater Treatment plant and Queenstown Wastewater Treatment Plant were reported between 2018 and 2020. It was also reported that sewer pump stations were vandalized by criminals who caused massive damage to the infrastructure. Research participants

(15.8%) stated that the consequences of theft of stripped cables, float switches and copper equipment resulted in malfunctioning in the WWTP, which cause sewerage spillages and that influence compliance with the WML in WWTPs. One interviewee mentioned that

> *"Such acts negatively affect the institution's operations and maintenance budget and impact the livelihoods of the community, especially in areas affected by the spillages."*

The cases reported in the CHDM show that the municipality does not comply with the first condition of the WML; which states that the *"Licence holder must ensure effective access control of the waste management site to prevent unauthorized entry"* (South Africa, Department of Environmental Affairs, 2008). Complying with this condition will ensure limited access to the WWTWs and the budget is being utilized for replacing the stolen equipment instead of being used for purchasing new equipment or servicing the existing equipment.

4.4.5 Budget

Interviewees (58%) stated that budget plays a huge factor in ensuring that the WWTPs remain effective and comply with waste management licences. The maintenance of the treatment plant, ensuring that the WWTPs remain effective and compliant with WML requirements, depends on the budget. The budget affects many aspects of the wastewater treatment plant and one of them is the recruitment of specialists such as the auditors and maintenance team. Budget availability also ensures that the institution has the necessary resources. One participant indicated that

> *"If we do not have enough budget, how will we be able to recruit staff? Mostly we are guided by budget because if we have enough, we can get anyone to fill up those positions If there's not enough budget, there's nothing we can do, budget is a huge factor, and we can't move without the budget".*

This comment agrees strongly with international and national perspectives such as those of Bhagwan (2014) and Ntombela *et al.* (2016). They stated that lack of funding is a root cause of ineffective and non-functional WWTPs.

The budget seems to be a challenge in maintaining treatment plants. In affirming this, the respondent states that

> *"The problem which is common in wastewater treatment plants is that the budget allocated for the treatment plants is always shifted and utilized for other activities in the district; for example, during this pandemic, the budget for treatment plants have been taken and used as part of covid-19 relief initiative*.''

The shifting funds, insufficient budget to employ specialists, sharing of budget and utilizing budget for other activities show that the WWTWs are not treated as essential services and are not

prioritized by the institution's management. Government do not take WWTPs seriously because community do not consider it as service delivery, unlike RDP houses, roads and electricity, Wastewater treatment plants are not prioritized because people hardly go on strike because there is bad odour and flooding in the treatment plant.

Participants further gave their perspectives about the sufficiency of the budget allocated to maintain WWTPs to ensure compliance with the WML.

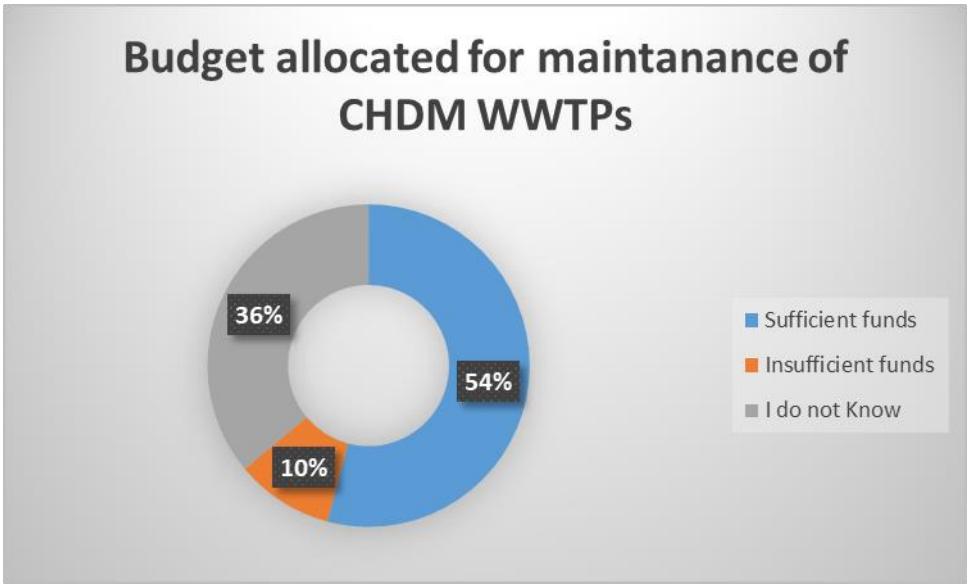

Figure 4.3: Perspectives from research participants about budget assigned for maintenance wastewater treatment plants

Findings show that a high percentage (54%) of research participants mentioned that the budget allocated for servicing and maintaining WWTPs to ensure compliance with WML is inadequate. One of the interviewees mentioned that

"'When purchasing chemicals, PPE and equipment it is usually first come first serve".

This is due to the fact that CHDM is the water service authority for all the local municipalities; the budget for all the treatment plants' maintenance and repairs is under one item, namely CHDM: wastewater treatment plants: maintenance and repairs.

As shown in Figure 4.3, the findings of this study show only 10% of the research participants suggested that the budget allocated for the maintenance of WWTPs is sufficient to ensure compliance with the WML.

The 10% were Environmental health practitioners who mentioned that the budget could only be known by personnel from technical service as they are the ones who are responsible for the maintenance of treatment plants.

Thirty-six percent of research participants (Figure 4.3) stated that they do not know if the budget allocated is sufficient or insufficient. Respondents indicated that there is no transparency when it comes to funding. Some were not comfortable and scared when answering this question.

The majority of research participants (90%) who responded that they do not know about the budget allocated to maintain the wastewater treatment plants were process controllers. The majority of personnel involved in budget allocation are managers; this is the reason process controllers do not have details regarding budget allocation.

4.4.6 Water shortage and chemicals

Resources are essential in the treatment plant and are used to ensure smooth operations in the WWTPs. According to interviewees (26.3%), the following resources, namely water, chemicals, and equipment, influence compliance with the WML in WWTPs. According to Adewumi *et al.* (2010) *''South Africa is a semi-arid country with high water stress (40–60%) due to the low volumes of rainfall (average of 500 mm per annum).”* The water scarcity in the country contributes to the challenges which result to WWTPs not being utilized.

Chemicals used in the WWTP to purify wastewater are one of the resources that affect the WWTPs. One participant mentioned that

> *“Due to long procurement processes followed, the chemical takes forever to be delivered, and not having chemical affect compliance with waste management license.”*

Furthermore, research participants mentioned that water scarcity and shortage of chemicals affect the treatment plants' primary function. This presents challenges in treating the raw wastewater from the community adequately before discharging it into the environment. Treatment of raw sewage is a requirement for meeting regulatory standards and legal obligations (Du Plessis, 2013).

In the next section, procedures used by personnel to ensure compliance with waste management licence will be discussed.

4.3 Procedures undertaken to ensure wastewater treatment plants remain effective and comply with waste management licence.

This section discusses procedures and methods undertaken in different sections ensuring that the WWTP remains effective.

4.3.1 Standard Operating Procedures

Documentation in the municipality involves establishing, documenting and maintaining policies which include standard operating procedures used to operate the WWTPs.

The respondents (42%) mentioned that to ensure that the treatment plant remains effective, the employees follow the standard operating procedure that are provided by the Water Services Act (108 of 1997) and National Water Act (36 of 1998). The standard operating procedure for all the treatment plants in different local municipalities differs and is drafted according to the type of facilities. Research participants (42%) noted that influent, screen, settling tanks and sludge are areas that are monitored every two hours to ensure compliance with the WML.

4.3.2 Inspection and monitoring

Wastewater treatment plant inspections and monitoring are conducted regularly to check if plants' equipment is functioning correctly. This ensures that the end product in the WWTP is up to the standard required by the National Water Act (36 of 1998) and Water Service Act (108 of 1997). The inspection of equipment aims to check what needs to be replaced or maintained to be included in the procurement plan for the next financial year.

Environmental Control Officers perform the general housekeeping in the WWTWs, including grass cutting, cleaning the yard, storage of chemicals, and health and safety measures. Research participants (37%) confirmed that their duty in the wastewater treatment plant is to ensure that the Water Servicers Act (108 of 1997) and National Water Act (36 of 1998) wastewater discharge standard are met. The ECOs collect water samples to be tested for the following water quality parameters: Physical, chemical and biological in accredited laboratories. The ECOs (37%) mentioned that they issue compliance notices when there is something wrong. One of the respondents states that

"We give notice to the technical service team to give them the hands up that there is something wrong in the plant. But with our compliance notice, we can't say that the plant must be closed."

The research participants further explained that the Department of Water and Sanitation is responsible for issuing the compliance notice as they are the regulating body for the wastewater treatment plants.

4.3.3. Wastewater treatment phases

Monitoring in the treatment plants occurs in different phases of the plant. The wastewater is treated in three stages, and they are explained below.

The initial treatment happens when the water enters through the treatment plant, a screen mesh size 6 mm or larger is used to eliminate big debris items. After the dissolved organic materials,

nutrients are removed and suspended to the aeration tanks in the settling tanks, and this is called the secondary treatment. The chemical dosing or disinfectant is also performed in secondary treatment. The aim of this is to ensure that treatment plants meet the specified minimum standards to protect human health and the environment. On the tertiary treatment, the separation of sewage sludge is encouraged by the flocculates and settling tanks from the effluents before any disinfection, before being discharged into a nearby waterbody (Mason *et al*., 2006).

These phases which are explained above, are used by CHDM WWTPs.

4.3.4 Risk abatement plan

The Risk abatement plan (W2RAP) is a direct instrument that Municipalities use to improve the management of their WWTPs (Gopo, 2013). The W2RAP identifies the key risks on the WWTPs and how to implement appropriate risk control measures (Gopo, 2013). The W2RAP is supported by legislative provisions and municipal business requirements such as the IDP and Quality Management Systems (QMS). The W2RAP has to comply with International Organization for Standardization (ISO) 9001 Quality Management System (Gopo, 2013). The QMS also includes standard operating procedures for data capturing, equipment malfunctioning, reporting, and preventative and mitigation factors.

The Department of Water and Sanitation embarked on a risk-based regulation that provides a practical plan to improve their wastewater services management by reducing identified risks. The ISO 14001 & 9001 requires that all risks are identified and monitored so that an action plan can be implemented to reduce high risks. One participant mentioned that

> *"CHDM uses the risk abatement plan to identify, quantify and manage risk according to the potential and probable impact of untreated effluents on the receiving water resources."*

This assists in minimizing the impacts of risks in the WWTPs. The factors that may influence compliance with the WML in WWTPs include personnel not implementing risk abatement plan it because of lack of training or shortage of personnel as mentioned above.

4.4 Discussion

The literature reviewed in this study shows that WWTPs managed by private companies fail to comply with legislation; this is primarily because private companies are mainly concerned about profit (Morris *et al.,* 2018). This contradicts the evidence gathered from this study which shows that CHDM WWTPs facilities were compliant with WML requirements when WWTPs were managed by a private company as compared to when WTPs are managed by the municipality. This shows that despite the fact that South African WWTPs are highly legislated, the South African government is

still lacking in implementing and enforcing these legislations. As a result, this affects the effectiveness of the WWTPs and compliance with the WML.

Research that was conducted by Moyo (2014) shows that South African municipality's budgets make provision for maintenance. However, most municipalities are only revamping damaged equipment and are not making lasting plans for the maintenance of their infrastructure (Moyo, 2014). Findings from previous study that was conducted by Padilla-Rivera *et al.* 2016 suggest that budget allocated to keep WWTPs operational is inadequate, funds are often spent on other activities which more noticeable by the community and are observed as having significant impacts on the quality of life, security and cleanliness. Results from this study shows that research participants (58%) suggested the budget allocated to maintain WWTP is insufficient; while 10% of research participants indicated that budget allocated for maintenance of WWTPs is sufficient. Research participants (36%) could not make up their mind regarding budget sufficiency; most of these participants are process controllers. The results from this study agrees with the study that was conducted by Padilla-Rivera *et al*. (2016), they show that funds allocated to maintain WWTP are the lowest , the importance of wastewater treatment and the associated health and environmental risks are ignored.

As previously stated, only 4% of the treatment plants in South Africa are maintained to ensure that they function effectively (Moyo, 2014). In this study, most research respondents (68%) mentioned the ageing infrastructure, lack of scheduled maintenance, and outsourcing of services for repairing WWTPs as some of the factors influencing compliance with the WML. This shows CHDM WWTPs are not part of the 4% of the treatment plants that are adequately maintained. Interviewees mentioned that utilization of different companies to repair the WWTPs damages the treatment plant equipment. Evidence from this study shows that it was reported that theft of equipment in the WWTP does not only affect the effectiveness of the WWTPs it also affects the budget of the institution. This is because the damaged or stolen equipment has to be repaired or replaced.

The perspectives from this study show that research participants (21%) indicated that population growth at CHDM influences compliance with the WML. The rapid population growth in the area resulted in an increase in the number of households connected to the sewage system. From 2001 to 2011, the number of households connected to the sewage system in CHDM showed a 3.5 % increase. Although there has been an increase in population, evidence shows that South Africa government did not respond to an increase in population as a result some treatment plants were not upgraded. This increase has put a strain on the WWTPs as it affects the design capacity. Research participants (36.3%) mentioned that the design capacity's exceeded the operational capacity in CHDM WWTWs; thus, there is an overflow of untreated water to waterbodies.

This study shows that in five WWTPs, the operational capacity has exceeded the design capacity while two WWTPs are operating at the expected capacity. There are only 3 WWTPs that have

operation capacity that is less than the design capacity. The quality of wastewater entering the WWTPs has been mentioned as another factor affecting compliance with the WML; for example, blood and blood clots released from abattoirs affect wastewater. The breakdown of blood increases the oxygen demand of the WWTPs, and the treatment plant needs oxygen for bacteria to survive.

Evidence from this study shows that results from this research agrees with South African literature. For example, previous studies show that the shortage of trained and skilled staff affects compliance with environmental legislations (Snyman *et al.,* 2004; Ntombela *et al.,* 2016)**.** Findings from this study show similar results that personnel shortage and the lack of skilled personnel are factors that influence compliance with the WML in WWTPs.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The purpose of this study was to examine the factors that influence compliance with the waste management licence in selected wastewater treatment plants in CHDM. The study design revolved around reviewing international and local literature in combination with semi-structured interviews for which participants were selected purposively. Data was analysed using document analysis as well as thematic methods of analyses.

As it has been stated previously that research that was conducted by Moyo (2014) shows that South African municipality's budgets make provision for maintenance. Evidence from this study shows that the budget allocated to maintain CHDM WWTPs is inadequate. A majority of participants suggested that resource related factors influence compliance with WML compliance requirements. Resource-related factors include the following: ageing infrastructure, lack of maintenance in WWTPs, outsourcing of repairing of WWTPs, theft of equipment in WWTPs, budget, and lack of resources. Budget is required for improving these factors.

Evidence gathered from this study shows that population growth, type of discharge effluent, and design capacity influence compliance with the WML in CHDM WWTPs. Findings from this study indicate that a number of CHDM WWTPs were erected 30 years ago during the apartheid era, when the population in the urban areas was smaller than today's population, and the large number of communities used pit hole toilets (King *et al.,* 2018). After 1994 when the South African government changed from apartheid to one of the majority rules, the number of people residing in urban areas increased. This migration to urban areas caused an increase in the number of households connected to the systems of the WWTPs. The problem is that WWTPs were not upgraded to accommodate the increase in population. As a result, population increase has affected the design capacity of the WWTPs.

Interviewees mentioned that industrial wastewater (specifically blood from abattoirs) influence compliance with WML by damaging the infrastructure of the WWTWs. Previous studies determined that shortage of trained and skilled staff affects compliance with WML in WWTPs (Snyman, 2004; Ntombela *et al*., 2016). This finding complements the results of this study. Evidence from this study shows no improvement in the recruitment and training of personnel for working in WWTPs. This is one of the main reasons impacting on the effectiveness of the WWTPs in the District. This study makes some contribution to understanding challenges faced by WWTPs in complying with water license requirements in the CHDM. It may also contribute to improved wastewater management and governance in the CHDM. Awareness of factors influencing compliance with WML can assist in improving compliance with WML requirements.

5.2 Recommendations

The following recommendations are informed by the literature review, document review and the analysis of data obtained from semi-structured interviews.

The budget for all of the CHDM WWTPs are managed by the District municipality. District Municipalities should consider decentralisation of the basic sanitation, which includes sewage treatment to Local Municipalities. This decentralisation should also have budget control. This will ensure that treatment works infrastructure is serviced, and that operation and maintenance functions are implemented as funds will be allocated for all plants.

Currently, the treatment plants are managed by CHDM. Making private companies manage the plants will increase compliance with the waste management license. Educational awareness campaigns and workshops could be conducted in the communities and industries on an ongoing basis to alert residents and owners about the risks of disposing of foreign material in the sewage system and the associated environmental impacts.

Despite the fact that the environmental management field is highly regulated, enforcement remains a challenge. To enforce the relevant legislations in WWTWs the South Africa government might need to consider adopting the incentive based approach.

Imposing of penalties for violation might be considered and might deter potential offenders. Lack of proper access control in the WWTWs results in theft of equipment and poses a risk to the community living in the area. The municipality should prioritise installing a fence in all the treatment plants to prevent unauthorized entry. Reliable security companies should be hired, and only trained security guards should be employed.

Lack of communication between officials delays progresses in improving the current situation in the WWTPs. More contact and regular feedback between the officials of the leadership of the Municipality includes management and process controllers, so that management can also have an idea of the state of the plant and what can be done to improve the WWTWs.

To improve the state of the infrastructure in the municipality, an asset register must be developed. The development of an asset register that will keep track of the infrastructure: how old it is, what needs to be done to improve its performance, and what long-term plans are to replace it with better technology.

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Annexure 1

Interview Guide

1. **In your opinion, what are the factors that influence compliance with waste management license requirements in waste water treatment plants?**

[*What are some of the '**good**' things (that influence compliance)? what are some of the **'bad'** things (that adversely affect compliance)? can you give examples?*]

2. What are some of the steps you would usually undertake to ensure the Waste Water Treatment Plant remains effective and comply with the waste management licence?

(Steps you **usually undertake" and are consistent with 'developed**

procedures/plans)

Can you provide me with examples*?*