



University of Venda

SCHOOL OF ENVIRONMENTAL SCIENCES

DEPARTMENT OF ECOLOGY AND RESOURCES MANAGEMENT

INVESTIGATION OF MUNICIPAL SOLID WASTE MANAGEMENT: A CASE STUDY  
OF VHEMBE DISTRICT MUNICIPALITY, SOUTH AFRICA

BY

MATHAKO KHODANI

STUDENT NO: 11633734

DISSERTATION SUBMITTED TO THE DEPARTMENT OF ECOLOGY AND  
RESOURCE MANAGEMENT, SCHOOL OF ENVIRONMENTAL SCIENCES,  
UNIVERSITY OF VENDA IN FULFILMENT OF THE REQUIREMENTS FOR THE  
DEGREE OF MASTERS OF ENVIRONMENTAL SCIENCES

SUPERVISOR: PROF. J.S. OGOLA

SCHOOL OF ENVIRONMENTAL SCIENCES, UNIVERSITY OF VENDA

CO-SUPERVISOR: MR. R. MULAUDZI

DEPARTMENT OF ECOLOGY AND RESOURCE MANAGEMENT,  
SCHOOL OF ENVIRONMENTAL SCIENCES, UNIVERSITY OF VENDA

AUGUST 2019

## DECLARATION

I **KHODANI MATHAKO** (student number: 11633734) hereby declare that this research for the degree of Masters of Environmental Sciences in Ecology and Resource Management at the University of Venda for Science and Technology has not previously been submitted for a degree at this or at any other university, and that it is my own work in design and execution and all sources have been accordingly acknowledged by means of complete references.

Signature..... Date.....

MR. K. MATHAKO

Signature..... Date.....

PROF. J.S OGOLA

Signature..... Date.....

MR. R. MULAUDZI

## DEDICATION

This work is dedicated to all Vhembe District Municipality Waste Management officials and without your support, this dissertation would not have been completed. It is also dedicated to my mother, Mathakho Agnes and Nyamande Ester for their guidance and prayers towards a successful completion of this mini-dissertation and all those who seek knowledge on how to contribute on managing waste and utilisation of available resources in a sustainable manner.

## ACKNOWLEDGEMENTS

Firstly, I would like to thank God who helped me to complete this project. I would like to give sincere thanks and appreciation to my supervisors, Prof. J.S. Ogola and Mr. R. Mulaudzi for guiding the work and providing valuable comments throughout the work. If it was not my supervisors, I was not going to complete this research project. I would like to thank my colleagues from the School of Environmental Sciences at the University of Venda. They encouraged me in my undertaking and gave me strong moral and intellectual upliftment, which was keeping me going through many difficult moments.

I also would like to thank all waste management officials from local municipalities who contributed in the study for the information that was useful for this dissertation. I would like to give sincere thanks to Mr. H Tshivhula, Mr. Ndwakhulu, Mrs. Rammuda, Mrs. V Ravele, Mrs. R Kutama, Ms. SN Mogano, Mrs. M Makheda, Mr. H Maseko, Tlomatsana ML, Dr. Maluleke and Mrs. T Ngobeni for assisting in the process of data collection. I am also grateful for the efficient administrative support and the useful documents that the municipalities availed to me for this study because the documents were of high significance.

## ABSTRACT

The main objective of the study was to investigate the effectiveness of municipal solid waste management system, its potential implication in Vhembe District Municipality, South Africa and to recommend strategies for effective management of municipal solid waste in the district. To achieve this, structured questionnaires, interviews, field observations and focus group discussions were used to collect primary data within the district. The study focused on the four local municipalities: Makhado, Thulamela, Musina and Collins Chabane. Desktop study was also undertaken to gather secondary data by reviewing journals, technical reports, books and articles. The study adopted a mixed method approach comprising of triangulation of qualitative and quantitative design. The target groups of the study were selected through purposive sampling. The respondents in the study were 21 officials from local municipalities including directors, waste managers, superintendents, landfill supervisor and interns. Data was collected using focus group interviews and questionnaires and analysed using descriptive statistics which involve the presentation of numerical facts, or data, in either tables or graphs form. Municipalities in the district are producing a considerable amount of solid waste. Municipalities do not adhere to the existing guidelines on waste minimization at source, for example; they do not have zero waste strategy (3R) reduce, reuse and recycle, which is the highest priority of the National Waste Management Policy. Lack of the application of existing waste management policy leads to large amount of solid waste eventually ending up in landfill sites. The study recommends to municipalities to develop operational and monitoring waste management plans which will create continuous improvement on waste management. In the district, it was observed that the bulk of waste generated per month within municipalities is general waste comprising 64%, as compared to garden waste and building rubbles. There are no equipment and programs in place by municipalities to encourage waste separation at source, for example, municipalities do not have household's recyclable receptacles to encourage separation at source. Municipalities do not have weighbridge to quantify waste entering the site. It was observed that Thulamela and Collins Chabane Local municipalities create compost from garden waste received at the landfill sites, whereas Musina and Makhado Local Municipalities do not create compost from garden waste. Garden waste is dumped and compacted with other waste materials in the landfills. All municipalities should create compost from garden waste received at the landfill sites as it helps to extend the life span of the landfills because it

reduces the amount of waste to the landfill. There is lack of prioritization within municipalities, for example, in Makhado Local Municipality, when the new financial start, budget is allocated to other proposed projects by councilors as they consider waste management projects not a priority. It was observed that within the district, there is high level of illegal dumping in catchment areas and open spaces especially at Musina Local Municipality. Musina Local Municipality is using a quarry as disposal site which was not lined and it has led to contamination of underground water by leachate, whereas Thulamela, Collins Chabane and Makhado Local Municipalities are using lined landfill sites to avoid contamination of underground water. The available vehicles within the municipalities are not enough to meet the demand and some of them are too old, for example, tractors and trucks used by Makhado Local Municipality are 20 years old and they often breakdown, whereas Thulamela, Collins Chabane and Musina Local Municipalities are not using old vehicles as they auctioned old vehicles and bought new ones. Vhembe District Municipality should manage waste in accordance to the new approach of source separation, waste reduction, reuse and recycling by developing environmental awareness programmes supported by the placement of the recyclable receptacles at strategic points to collect recyclable materials which will reduce large amount of waste which eventually ends up in landfills. The study recommends that municipalities should have law enforcement structure which will create and enforce the laws/policies as it helps municipalities to implement effective waste management system and monitoring structure to monitor prioritization and budget allocation to avoid any wastage. Municipalities should have landfill monitoring committees to facilitate the compliance on the development and operation of the landfills to avoid the use of quarry as landfill sites.

**Keywords:** *Vhembe District Municipality, waste management, potential implications and factors hindering solid waste management.*

## Table of Content

DECLARATION .....	i
DEDICATION .....	ii
ACKNOWLEDGEMENTS .....	iii
ABSTRACT .....	iv
LIST OF FIGURES .....	x
LIST OF TABLES .....	xii
LIST OF ABBREVIATIONS AND ACRONYMS .....	xiii
CHAPTER ONE: INTRODUCTION .....	1
1.1 Background .....	1
1.2 Study area .....	2
1.2.1 Location .....	2
1.2.2 Population .....	3
1.2.3 Climate .....	3
1.2.4 Topography and drainage .....	4
1.2.5 Soil and Vegetation .....	4
1.2.6 Land-use .....	4
1.3 Problem statement .....	5
1.4 Justification .....	6
1.5 Research questions .....	7
1.6 Objectives .....	7
CHAPTER TWO: LITERATURE REVIEW .....	8
2.1 Introduction .....	8
2.2 Legal Frameworks applicable to municipal solid waste management in South Africa .....	8
2.2 Sources of municipal solid waste .....	10
2.2.1 Residential waste .....	10
2.2.2 Commercial waste .....	10
2.2.3 Institutional waste .....	11
2.2.4 Municipal services .....	11
2.2.5 Industrial waste .....	11
2.2.6 Construction and demolition waste .....	11
2.3 Municipal solid waste management practices .....	11

2.3.1 Waste generation.....	11
2.3.2 Waste storage .....	13
2.3.3 Waste collection and transportation .....	15
2.3.4 Waste disposal .....	16
2.4 Integrated solid waste management practices .....	18
2.4.1 Waste reduction.....	18
2.4.2 Waste re-use and recycling .....	18
2.4.3 Incineration .....	21
2.4.4 Composting .....	22
2.4.5 Land filling.....	23
2.5 Factors affecting sustainable solid waste management system.....	24
2.5.1 Legal Policies and Strategies .....	24
2.5.2 Financial and economic aspects.....	25
2.5.3 Socio-cultural aspects .....	27
2.5.4 Institutional aspects.....	29
2.5.5 Technical aspects .....	31
2.6 Potential impacts of municipal solid waste on the environment.....	31
2.7 Summary of key findings .....	33
<b>CHAPTER THREE: METHODOLOGY .....</b>	<b>34</b>
3.1 Introduction.....	34
3.2 Desktop study.....	34
3.3 Research design .....	34
3.4 Site selection .....	36
3.5 Study population and Sample .....	36
3.6 Questionnaire survey .....	37
3.7 Interviews.....	38
3.8 Focus group discussion .....	38
3.9 Field observation.....	39
3.10 Limitation of the study .....	39
3.11 Ethical clearance certificate .....	40
<b>CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS .....</b>	<b>41</b>
4.1. Introduction.....	41
4.2 Demographic profile and educational qualification of the respondents.....	41
4.1.1 Gender and ages of the respondents.....	41

4.1.2. Educational qualification of the respondents .....	42
4.3 Solid Waste Management organizational structure in Vhembe District Municipality .....	44
4.4 Integrated Waste Management Plan and Integrated Development Plan .....	45
4.5. Municipal waste management practices/strategies in Vhembe District Municipality .....	46
4.5.1 Waste prevention and minimization .....	46
4.5.2. Waste generation.....	47
4.5.4. Collection and transportation .....	53
4.5.5. Recycling .....	59
4.5.6. Composting .....	70
4.5.7. Waste disposal .....	71
4.6 Factors affecting sustainable solid waste management strategies within a District.....	80
4.6.1. Legal Policies and Strategies .....	80
4.6.2. Technical aspects .....	82
4.6.3. Institutional aspects.....	83
4.6.4. Financial and economic aspects.....	84
4.6.5. Social and cultural aspects .....	86
4.7. Potential implications of municipal solid waste on the environment and human health .....	89
<b>CHAPTER FIVE: DISCUSSION OF RESULTS .....</b>	<b>92</b>
Introduction.....	92
Waste prevention and minimization .....	92
Waste generation.....	93
Waste storage .....	94
Recycling .....	98
Composting .....	99
Waste disposal .....	99
Legal Policies and Strategies .....	101
Technical Aspects .....	102
Institutional aspects.....	103
Financial and economic aspects.....	104
Social and cultural aspects .....	106
Potential implications of municipal solid waste on the environment and human health .....	107
<b>CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS .....</b>	<b>110</b>
6.1 Introduction.....	110
6.2 Conclusion .....	110

6.3 Recommendations.....	112
REFERENCES .....	114
APPENDICES .....	1

## LIST OF FIGURES

Figure 1. 1: Location map of the study area. ....	3
Figure 4. 1: Gender of the respondents on the study. ....	42
Figure 4. 2: Educational qualifications of the respondents. ....	42
Figure 4. 3: Job titles of the respondents. ....	43
Figure 4. 4: Solid Waste Management organizational structure in Vhembe District Municipality. ....	44
Figure 4. 5: Waste Management Personnel of Vhembe District Municipalities (%). ....	45
Figure 4. 6: Separated card boxes by Musina recyclers. ....	47
Figure 4. 7: Monthly waste generated in Vhembe District Municipality. ....	49
Figure 4. 8: Refuse plastic bags with domestic waste waiting for collection. ....	49
Figure 4. 9: Skip bins for commercial and institutional waste storage. ....	50
Figure 4. 10: Street litter bins for waste storage within towns and urban centres. ....	51
Figure 4. 11: CCTV storage facility used by some other municipalities in the District. ....	51
Figure 4. 12: Dzanani transfer station in Makhado Local Municipality. ....	52
Figure 4. 13: Notice board of Dzanani Transfer station in Makhado Local Municipality. ....	53
Figure 4. 14: Waste storage facilities used by University of Venda. ....	54
Figure 4. 15: Waste collection and transportation in Vhembe District Municipality. ....	54
Figure 4. 16: Bailing machine used by Matongoni recycling company at Makhado Landfill Site. ....	60
Figure 4. 17: Recycling facility at Makhado Landfill Site. ....	60
Figure 4. 18: Sacks of recycling materials separated by recyclers within the District. ....	60
Figure 4. 19: Kensha Mills recycled materials in percentage. ....	61
Figure 4. 20: Keep It Clean Environmental Solution recycled materials in percentage. ....	62
Figure 4. 21: LTT Algemene Handelaars recycled materials in percentage. ....	63
Figure 4. 22: Shumani Glass recycled materials in percentage. ....	64
Figure 4. 23: Matongoni General Trading recycled materials in percentage. ....	65
Figure 4. 24: Makhado Reclamation Group recycled materials in percentage. ....	66
Figure 4. 25: Messina Recycling recycled materials in percentage. ....	67
Figure 4. 26: Rehoboth recycling recycled materials in percentage. ....	68
Figure 4. 27: Materials recycled in Vhembe District Municipality per month (tons). ....	69
Figure 4. 28: Materials recycled in Vhembe District Municipality per month (%). ....	70
Figure 4. 29: Demarcated area for garden waste disposal in Thulamela and Makhado Landfill Sites. ....	70
Figure 4. 30: Makhado Landfill site weighbridge. ....	71
Figure 4. 31: Monthly waste received within Vhembe District Municipality landfills (%). ...	72
Figure 4. 32: Makhado and Thulamela Landfill site rule notice boards. ....	73
Figure 4. 33: Hazardous waste within Thulamela Landfill Site. ....	74
Figure 4. 34: Makhado Landfill Site bill board. ....	75
Figure 4. 35: Road signs within the Thulamela and Makhado Landfill Sites. ....	76
Figure 4. 36: Separation and collection of recyclable materials within the landfill sites. ....	76

Figure 4. 37: Landfill compactor machines. ....	77
Figure 4. 38: Vhembe District Municipality Landfill Sites. ....	77
Figure 4. 39: Musina old landfill site. ....	78
Figure 4. 40: Musina constructed disposal cell. ....	79
Figure 4. 41: Rehabilitation of Musina old landfill site. ....	79
Figure 4. 42: Makhado and Thulamela Landfill site leachate ponds. ....	80
Figure 4. 43: Makhado and Thulamela Landfill site water monitoring boreholes. ....	80
Figure 4. 44: Musina workshop facility for maintenance and repairing of equipment. ....	83
Figure 4. 45: Illegal dumping at Thulamela and Musina Local Municipalities. ....	87
Figure 4. 46: Illegal dumping at Musina Local Municipality. ....	87
Figure 4. 47: Vandalised street litter bins at Thulamela and Makhado Local Municipality. ..	88
Figure 4. 48: Waste which was not stored in litter bins in Musina and Thulamela Local Municipality. ....	89
Figure 4. 49: Illegal dumping of waste in catchment areas in Musina Local Municipality. ...	90

## LIST OF TABLES

Table 1. 1: Waste generation trends in Vhembe District Municipality. ....	6
Table 3. 1: Summary of qualitative and quantitative data. ....	36
Table 3. 2: Number of respondents participated on the study. ....	37
Table 4. 1: Gender and ages of the respondents. ....	41
Table 4. 2: Waste management personnel of Vhembe Local Municipalities. ....	45
Table 4. 3: Monthly waste generated within Vhembe District Municipality (tons). ....	48
Table 4. 4: Number of transfer stations and drop-off centre facilities within the District.....	53
Table 4. 5: Waste collection time table in Makhado Local Municipality.....	55
Table 4. 6: Waste collection time table in Collins Chabane Local Municipality. ....	56
Table 4. 7: Waste collection time table in Musina Local Municipality.....	57
Table 4. 8: Waste collection time table in Thulamela Local Municipality.....	57
Table 4. 9: Kensha Mills Recycled materials, equipment, workers and company sold to. ....	61
Table 4. 10: Keep it Clean Environmental Solution Recycled materials, equipment, workers and company sold to. ....	62
Table 4. 11: LTT algemene Handelaars recycled materials, equipment, workers and company sold to.....	63
Table 4. 12: Shumani Glass Recycling recycled materials, equipment, workers and company sold to.....	64
Table 4. 13: Matongoni General Trading recycled materials, equipment, workers and company sold to. ....	65
Table 4. 14: Makhado Reclaim Group recycled materials, equipment, workers and company sold to.....	66
Table 4. 15: Messina recycling recycled materials, equipment, workers and company sold to. ....	67
Table 4. 16: Rehoboth Recycling recycled materials, equipment, workers and company sold to. ....	68
Table 4. 17: Neo Scrap Metal recycled materials, equipment, workers and company sold to. ....	69
Table 4. 18: Tariff charged for waste disposal in Vhembe District Municipality Landfill sites. ....	75
Table 4. 19: Number of technicians and assistants within the District.....	82
Table 4. 20: Number of equipment within municipalities in the District. ....	84
Table 4. 21: Tariff charged for waste collection in Thulamela Local Municipality.....	86

## LIST OF ABBREVIATIONS AND ACRONYMS

MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
IWMP	Integrated Waste Management Plan
IDP	Integrated Development Plan
GNP	Growth national product
NWMS	National Waste Management Strategy
B-Tech	Bachelor of Technology
LLB	Literally Legum Baccalaureus
PhD	Doctor of Philosophy
NDEA	National Department of Environmental Affairs
CBD	Central Business District

## **CHAPTER ONE: INTRODUCTION**

### **1.1 Background**

Municipal solid waste is the waste generated in the daily life of people such as paper, plastic, textiles, glass, metal, wood, and residual food. This waste is generated from households, commercial activities, street-sweeping and construction and demolition activities (Bouanini, 2013). According to the National Environmental Management Waste Act (Act no 59 of 2008), waste refers to any materials, whether that materials can be utilised, re-used, recycled and recovered and that is surplus, unwanted, rejected, discarded, or disposed of materials that the producer has no additional use of that material in the production purpose and which can be treated and disposed.

Increasing population, thriving economy, rapid urbanization and improving standards of living have greatly speeded up the depletion of natural resources and waste generation, particularly in developing countries. Municipalities have responsibility for waste management and they are having a challenge to render a good waste management system to the communities. Urbanization is likely to aggravate the challenge of unsuitable waste management to both developed and developing countries (Guerrero et al., 2013).

In Nairobi, the difficulty in rendering a level of service which is required is due to institutional, technical and financial constraints at national and local government levels and in the private sectors (UN-Habitat, 2010). Consequently, there are problems of continuous waste generation, insufficient collection, transportation and disposal, dumping of waste in open land, streets, drainage channel and floodplains of rivers (Foday et al., 2013). Municipal solid waste management is an activity which involves generation, source separation, storage, collection, transfer and transportation, processing and recovery, and disposal as the last resort (Gallardo et al., 2015).

Waste management challenges can be addressed only in a holistic way by getting together different fields which are of the natural sciences, social sciences, engineering and management, and concepts (sustainability, sustainable production and consumption) that are required to solve the problems associated with monitoring, prevention, reduction, mitigation of pollution that come from various human and natural activities (Sauvé et al., 2016).

South Africa has noted the impacts of municipal solid waste as huge concern of the twenty-first century in its Integrated Pollution and Waste Management Policy, recognised by the Department of Environmental Affairs and Tourism (DEAT, 2000). The policy outlined goals to be attained through the National Waste Management Strategy, and focuses on the various key elements of integrated waste management planning, waste information systems, general waste collection, waste minimisation, recycling, waste treatment and disposal, capacity building, education and awareness as strategic intervention measures required to encourage efficient use and management of waste in South Africa (DEAT, 2001).

The Department of Environmental Affairs and Tourism held the National Waste Conference in Polokwane city called “The Polokwane Declaration” in 2001. The meeting was held in order to address waste management challenges in the country. The declaration was based on the need for urgent action to reduce, re-use and recycle waste to protect the environment and to implement the waste management system which encourages effective waste reduction. The goal of the declaration was to reduce waste generation and disposal by 50% and 25% respectively in 2012 and develop a zero-waste plan in 2022 (Pikitup.co.za, 2019). The current study focuses on the investigation of the effectiveness of municipal solid waste management system, its potential implication in Vhembe District Municipality and to recommend strategies for effective management of municipal solid waste in the district.

## **1.2 Study area**

### **1.2.1 Location**

Vhembe District Municipality is situated in the northern part of Limpopo province. The geographical coordinates of the study area are 22° 56′ S latitude and 30° 28′ E longitudes (Figure 1.1). It is sharing borders with Capricorn and Mopani District Municipalities in the eastern and western directions. It also shares borders with Zimbabwe and Botswana in the north west, and Mozambique in the south east through the Kruger National Park. It covers approximately 21 407 square km of land with total population of 1.240 035 million people (Statistics of South Africa, 2007) of which 1.1% of the district is urban area (Limdlgh.gov.za, 2017). Vhembe District Municipality is composed of four local municipalities which include Musina, Thulamela, Makhado and Collins Chabane. The District Municipal offices are located in Thohoyandou town (Municipalities.co.za, 2017).

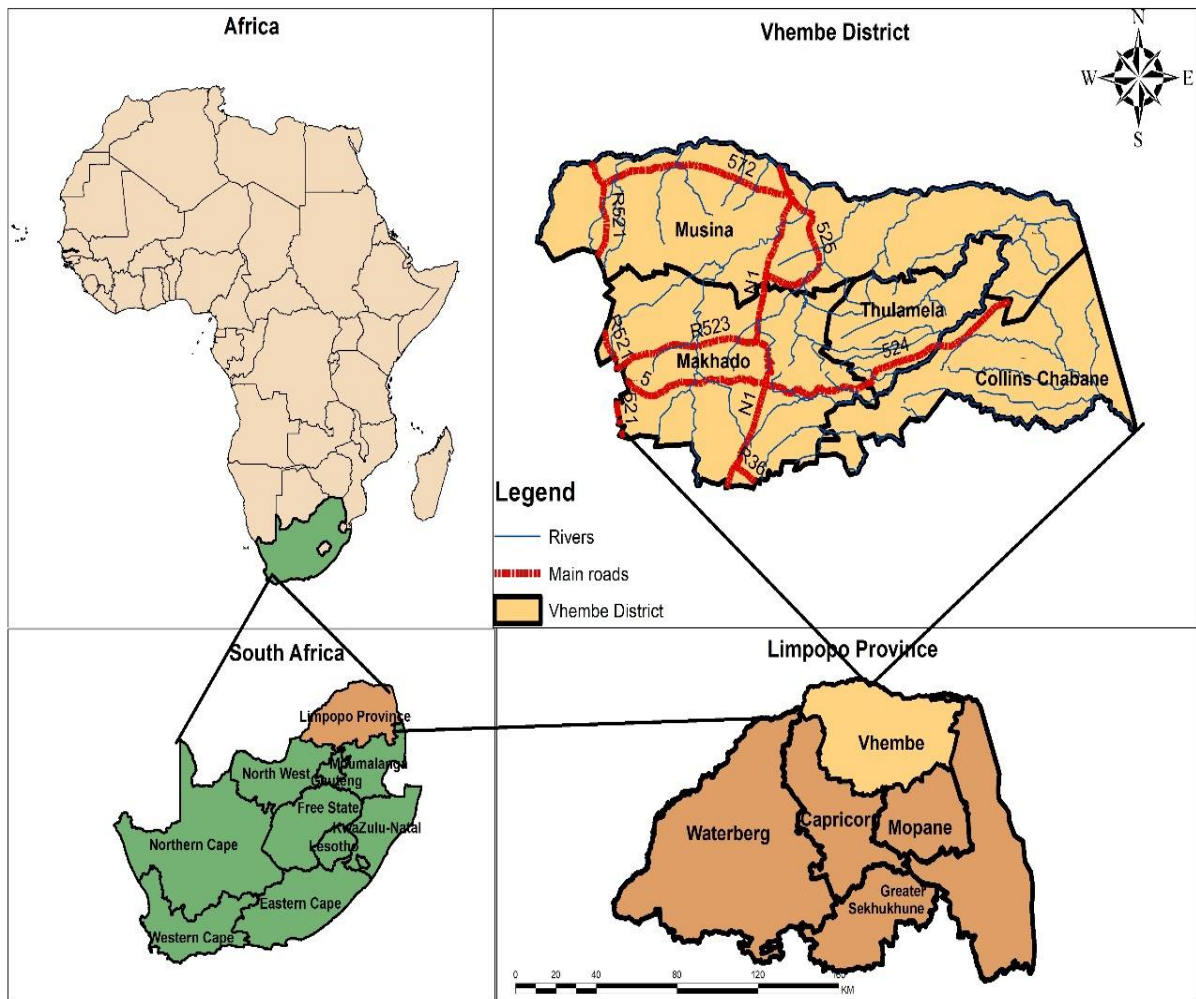


Figure 1. 1: Location map of the study area (Source: ARC GIS Software 10.2).

### 1.2.2 Population

The population of Vhembe District Municipality from the Census report of 2001 was 1 198 056 and 1 240 035 from 2007 Community Survey. It shows that the population of Vhembe district municipality has increased by 41 979 people from 2001 to 2007. The number of households in Thulamela is 137 852, Makhado is 114 060, Musina is 163078. Thulamela Local Municipality is having the highest number of households followed by Makhado and Musina Local Municipality. The number of households usually increases as the population increases (Limdlgh.gov.za, 2017).

### 1.2.3 Climate

Climate in Vhembe District typically is subtropical, with mild, moist winters and warm summers which is characterised by Low-veld. The area received annual rainfall of

approximately 500mm per annum with 87.1% of it fallings between October and March. The pattern of rainfall is greatly determined by the Orographic rain effect of the Drakensberg Mountains joining the Soutpansberg perpendicularly and it is decreasing from the east to the west of the district. The annual temperature varies from a minimum of 10°C in winter to a maximum of 40°C particularly in Musina Local Municipality. The area usually goes through drought especially in Musina Local Municipality which is semi-arid (Limdlgh.gov.za, 2017).

#### **1.2.4 Topography and drainage**

The area is made up of Sacred Forests. The district has relatively limited supply of both ground and surface water resources. The Limpopo river system is considered to be the life blood of the northern Vhembe semiarid area. There is a number of wetland areas scattered throughout the district. The water bodies that are currently in place are old and were intended to serve a small population. Vhembe area is also boasted by a widely known Lake Fundudzi with a lot of cultural history. There are also Mutale and Luvuvhu catchments with a number of tributaries emanating within the catchments area. Flood-pans are of significant importance in this area as they hold water right into the very dry seasons, thus acting as refuge zone for wildlife and water birds during both winter and summer seasons (Limdlgh.gov.za, 2017).

#### **1.2.5 Soil and Vegetation**

Vhembe District Municipality is having the greater Savanna Biome. This biome is commonly known as the Bush-veld with little pockets of grassland and forest biomes. The area is made up of the Mountain Fynbos, Sacred Forests and Baobab Trees. There are large conservation areas in Vhembe district which include the Kruger National Park (Pafuri and Punda Maria Gates in Musina and Thulamela Local Municipalities). Musina is also the home of Makuya Park which is part of the Kruger National Park. There is also Mapungubwe National Park in Musina Local Municipality which is also known as World Heritage Site. The land is fertile and well suited for agriculture, a large portion of which falls under the tribal authorities (Limdlgh.gov.za, 2017).

#### **1.2.6 Land-use**

Vhembe District Municipality consists mainly of commercial farms, tourism hot sports and small-scale mining activities. There are opportunities for developing viable, sustainable agricultural projects. Field crops and cotton are produced, and there is a potential to develop agro-processing. A small percentage of the land is utilized for settlement purposes. The district settlement pattern is largely rural. There are insufficient health facilities within the

district and people usually travel long distances to access health services (Limdlgh.gov.za, 2017).

### **1.3 Problem statement**

Vhembe District Municipality is a developing district which is also facing a high rate of population growth due to rapid urbanization. People are migrating from rural areas to urban centres where everyone hopes for a better job opportunity to improve their livelihoods. As urban population increases, the quantity of solid waste generated also increases which needs to be properly managed. Vhembe District Municipality is producing a considerable amount of solid waste from local municipalities which include Thulamela, Makhado, Collins Chabane and Musina. The increase on solid waste generation puts pressure on available waste management facilities which are already in short of supply. Increasing complexity of the waste stream directly affects the complexity of its management, which is intensified when hazardous waste mixes with general waste. In addition, waste management suffers from a pervasive under-pricing, which means that the costs of waste management are not fully satisfying the consumers and industries (DEA, 2012).

Municipal solid waste management is not given first priority, consequently, there are few studies pertaining to municipal solid waste management in the district which do not focus on the whole municipal solid waste management value chain. Local municipalities within Vhembe District Municipality do not adhere to the existing guidelines on waste minimisation, for example; they do not have zero waste strategy (3R) reduce, reuse and recycle, which is the highest priority of the National Waste Management Policy. Lack of the application of the existing waste management policy leads to large amount of solid waste which eventually ends up in landfill sites. According to the National Environmental Management Waste Act: Waste Act, 2008 (Act No. 59 of 2008), a waste holder must, within the holder's power, take all reasonable measures to avoid waste generation and where such generation cannot be avoided, the holder should minimise the toxicity and amounts of waste generated through reduce, re-use, recycling and waste recover and where waste must be disposed of, the holder must ensure that the waste is treated and disposed of in an environmentally sound manner.

There is also lack of regional refuse landfill site and transfer station with the availability of transfer stations and drop-off point facilities which are not licensed are not cost effective to operate. Few households within a district had access to basic refuse removal and these lead wastes to be dumped haphazardly in open spaces and within the catchments which ultimately

contaminate water bodies. Nationally, the percentage of households which have access to basic refuse removal by the municipality increased from 58,3% to 64% between 2002 and 2012 (Statistics South Africa, 2012). In Vhembe District Municipality, only 9 856 households had access to basic refuse removal out of 129 000 households (Mudau, 2015). In Thulamela Local Municipality, Khakhanwa village, municipality does not render waste collection to the households and community does not collect their wastes to the legal landfill sites (Mabadahanye, 2017). The purpose of the current study is to investigate effectiveness of municipal solid waste management system, its potential implication and to recommend strategies for effective management of municipal solid waste in the district.

#### 1.4 Justification

Municipal solid waste management is a worldwide challenge which is faced by many municipalities both in developed and developing countries including South Africa. Vhembe District Municipality like many municipalities in South Africa is generating a considerable amount of solid waste due to rapid urbanization and industrialization. For example, in Vhembe District Municipality, waste generation trends of Makhado and Thulamela Local Municipality shown an increase from 2008 until 2012 (Table 1.1). Thulamela Local Municipality generated large amount of waste as compared to Makhado Local Municipality. In 2008, Thulamela generated 62 265kg whereas Makhado generated 53 941kg and in 2012, Thulamela Local Municipality generated 81 033kg whereas Makhado Local Municipality generated 71 697kg (Mudau, 2015). In many developing countries, solid waste management is receiving insufficient attention and this leads to ineffective waste management system. The results of the study will be used as a guide to implement effective waste management system and to comply with South African waste management regulations and policies.

Table 1. 1: Waste generation trends in Vhembe District Municipality (Mudau, 2015).

Years	2008	2009	2010	2011	2012
<b>Makhado</b>	53 941 kg	56 780 kg	60 404 kg	65 657 kg	71 697 kg
<b>Thulamela</b>	62 265 kg	65 543 kg	69 475 kg	74 685 kg	81 033 kg

The study will be valuable in municipalities to develop operational and monitoring waste management plans which will create continuous improvement on managing waste by municipalities. The study will be useful in understanding the environmental and health implications of municipal solid waste and the implementation of mitigation and precautionary

measures in the district. It will also create a base for further studies of the whole waste management value chain in Vhembe District Municipality. The results of the study will also help Vhembe District Municipality to improve its solid waste management strategies through managing waste in accordance to the new approach of waste separation at source, reduction, reuse and recycling which is necessary for environmental conservation and sustainability. It will reduce the amount of wastes that eventually end up in landfills and not to be dumped haphazardly in open space and water bodies.

### **1.5 Research questions**

- What are the waste management strategies/ practices employed in Vhembe District Municipality?
- What are the problems encountered when managing municipal solid waste in Vhembe District Municipality?
- What are the sources and nature of municipal solid waste being produced in Vhembe District Municipality?
- How can solid waste management be improved in Vhembe District Municipality?

### **1.6 Objectives**

The main objective of the study is to establish the effectiveness of municipal solid waste management system, its potential implication in Vhembe District Municipality and to recommend strategies for effective management of municipal solid waste in the district.

#### **Specific objectives were to:**

- Investigate the solid waste management practices currently used in Vhembe District Municipality.
- Examine the factors affecting sustainable waste management practices in Vhembe District Municipality.
- Examine the potential impacts of municipal solid waste on the environment in Vhembe District Municipality.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Introduction**

This chapter reviews literature which is available on municipal solid waste management. This chapter firstly presents a discussion of the legal frameworks which are applicable to waste management. It also presents a discussion on the sources of municipal solid waste management and detailed discussion of the waste management practices which is currently being employed in deferent countries. This chapter also gives a detailed discussion of the factors affecting sustainable waste management practices around the world. The impacts of municipal solid waste on the human health and the environment are discussed.

### **2.2 Legal Frameworks applicable to municipal solid waste management in South Africa**

The legal framework of South Africa on waste management is one of the virtually progressive things in the continent. There is a specific division of roles, responsibilities, and mandatory obligations for the three sectors of government. This legislative alignment among the different sectors of government regulating the waste, presents the country's aspiration on the issue of a clean environment and healthy society (Anon, 2017).

Section 24 of the Constitution of the Republic of South Africa (Act 108 of 1996) states that everyone has the rights to be on the environment which is not harmful to the health and protected environment for the benefits of present and future generations. This is done through reasonable legislative and other measures which help to prevent pollution and ecological degradation, and encourages conservation, which also helps secure ecologically sustainable development and promotes the use natural resources while on the other hand encouraging justifiable economic and social development. This constitution underpins all environmental policies and legislations, and this environmental legislation framework has been introduced by the National Environmental Management Act.

The National Environmental Management Act (Act No. 107 of 1998) states that the state should respect, protect, encourage and meet the social, economic and environmental rights of everybody and strive to meet the basic needs of the communities which have been previously disadvantaged. National Environmental Management Act also outlines the principle which states that those who are harming the environment are the ones who should pay for remedying pollution, environmental degradation and consequent adverse health effects and

preventing, controlling or minimizing further pollution, environmental and harmful health effects. It is also stated that waste should be avoided and where it cannot be altogether avoided, should be minimised, re-used or recycled where possible and otherwise disposed of in a responsible manner.

National Environmental Management Waste Act: Waste Act, 2008 (Act No. 59 of 2008) adopts the internationally recognized waste management hierarchy, which considers disposal as a last resort and encourages reduction of waste entering the system. It provides the legal framework for the implementation of the waste management hierarchy derived from the National Waste Management Strategies of 1999, through the provision of additional measures for the remediation of contaminated land to protect human health and secure wellbeing of the environment.

The National Water Act (Act No. 36 of 1998) states that the owner of the land, a person who is controlling the land or who occupies the land in which the activity is or was being carried out or other situation exists, which has caused or is likely to cause water pollution should take all reasonable measures to prevent such kind of pollution from occurring or continuing. The reasonable measures referred to include, governing any process causing the pollution, comply with any prescribed waste standard or management strategies, to prevent the movement of pollutants, remove any source of the pollution, remedy the impacts of the pollution, and remedy the effects of any disturbance to the banks of a stream.

Integrated Pollution and Waste Management (2000) shows a paradigm shift from dealing with waste only after waste is produced towards: pollution prevention, waste minimisation, institutional integration, participation of all sectors of government and society in pollution and waste management. This Integrated Pollution and Waste Management Policy applies to all government institutions, society at large, and to all activities that impact on pollution and waste management. One of the important approaches of this policy is to prevent pollution, minimise waste, and to control and remediate the impacts. Waste management should be implemented in a holistic and integrated manner, including the generation, storage, collection, transportation, treatment, and final disposal of waste.

The National Policy for the Provision of Basic Refuse Removal Services to Indigent Households (Gazette No. 34385, Notice 413 of 2011) aims to address the basic service backlog amongst the impoverished households, especially those crucial services such as waste removal. The key policy objectives include the establishment the framework for the

development, identification and management of poor households in the municipalities to set principles for the implementation of guidelines for tariff policy implementation and rising awareness concerning suitable management of domestic waste within municipalities.

The National Domestic Waste Collection Standards (Gazette No. 33935, Notice 21 of 2013) are planned to deal with imbalances in the rendering of waste collection services. They are aiming to set a satisfactory, reasonable and sustainable assortment services for residents to improve the quality of life within communities and ensure clean and more acceptable places to live and work in. These standards recognize the practical differences between areas based on cost efficiency of delivery of services. They are based on the principles of equity, affordability and availability of resources, practicality and community participation.

Polokwane Declaration of Zero Waste (2001). The declaration was based on the need for urgent action to reduce, re-use and recycle waste to protect the environment and to implement the waste management system which encourages effective waste reduction. The goal of the declaration was to reduce waste generation and disposal by 50% and 25% respectively in 2012 and develop a zero-waste plan in 2022.

## **2.2 Sources of municipal solid waste**

### **2.2.1 Residential waste**

Residential wastes contain organic and inorganic wastes generated from residential areas. Organic waste contains materials which include food waste, papers, cardboard, plastics, textiles, rubber, and leather, wood, and yard wastes. The inorganic waste contains materials such as glass, crockery, tin cans, aluminium, ferrous metals, and dirt (Guangyu, 2009). Special wastes from residential sources include bulky items, consumer electronics, white goods, yard wastes, batteries, paints, waste oils and tires. These wastes are normally managed separately from other residential wastes (Bouanini, 2013).

### **2.2.2 Commercial waste**

Commercial waste refers to the waste from shops, offices, restaurants, hotels, and similar commercial establishments, typically consisting of packaging materials, office supplies and food wastes. Commercial waste is also similar to residential waste. Commercial waste also contains hazardous materials (Kubanza, 2012).

### **2.2.3 Institutional waste**

Institutional sources of solid wastes are universities and schools, prisons and hospitals. The solid wastes produced from these institutions are quite similar to mixed municipal solid waste. Hospital medical wastes are handled and processed separately from other solid wastes in most developed countries (Bouanini, 2013).

### **2.2.4 Municipal services**

Waste from municipal services refer to other community wastes generated due to functioning and maintenance of municipal facilities and the rendering of municipal services such as street sweepings, roadside litter, waste from municipal litter containers, landscape and tree trimmings, dead animals, and vehicles which are abandoned. These wastes are always managed because they come from non-stationary sources in contrast to residential sources of waste as they produce waste at constant rate and composition in a specific area and time (Otchere et al., 2015).

### **2.2.5 Industrial waste**

Composition of industrial waste usually depends on the kind of industries which are involved. Industrial waste includes materials which are similar to domestic and commercial waste as well as food wastes from the kitchens and canteens, packaging materials, plastic, paper and metal items. Some production processes sometimes use or generate hazardous materials (Kubanza, 2012).

### **2.2.6 Construction and demolition waste**

Construction and demolition refer to non-hazardous waste generated from the construction, remodelling, renovation and demolition of buildings or physical infrastructure. This source of waste includes waste such as concrete, bricks, masonry, ceramics, metals, plastic, paper, cardboard, gypsum drywall, timber, insulation, asphalt, glass, carpeting, roofing, site clearance and sweepings and excavation materials (Bouanini, 2013).

## **2.3 Municipal solid waste management practices**

### **2.3.1 Waste generation**

The total global waste generation is about 7-10 billion tonnes per year, out of which municipal solid waste is about 2 billion tonnes per year. Global waste generation will show a strong increase in Asia in the near future and in Africa in the coming decades. In Latin America, waste generation is expected to peak in the middle of the century. Per capita waste

generation tends to increase by about 20% until the year 2100 due to population increases, urbanization and economic and social developments (Global Waste Management Outlook, 2015). In 2014, a total of 78,583,405 tons of municipal solid waste was produced in Brazil and in composition with the amount of waste produced in 2013; this quantity of waste represents an increase of 2.9% of waste produced while the population growth in this country was lower to 1% for the same period (Coelho and Lange, 2018).

In Nigeria, the current estimate of 500,000 tons of municipal solid waste generated daily by Nigerians would increase by a drastic 75% per day in 2020, if the current lifestyle continues, an effort should be put in place to reduce the waste by recycling, reuse and reduction at the household level. The amount of waste produced by people on a daily basis is increasing geometrically as a result of change in socioeconomic characteristic of people, technology and lifestyle (Abd'Razack et al., 2017). In China, waste generation has increased rapidly in the past 20 years from 31.3 million tons in 1980 to 113.0 million tons in 1998. The annual growth rate is 10%. There are 660 cities in China which produce approximately 190 million tonnes of waste annually and, it accounts for about 29% of the world's municipal solid waste every year. In 2006, the total amount of municipal solid waste produced was about 212 million tons and the generation rate was 0.98tonnes per capita/year (Zhang et al., 2010).

In India, about 90 million tons of solid wastes are generated every year as by product of industrial, mining, municipal, agricultural and other processes. Per capita generation rate of municipal solid waste in India ranges from 0.3 to 1.5 kg/ day and quantity of municipal solid waste produced per capita is estimated to increase at a rate of 1–1.33% annually (Pandey et al., 2016). The Third National Waste Information Baseline Report estimated that South Africa produced about 108 million tons of waste in 2011 and about 98 million tons of waste was dumped at the landfill (DEA, 2012b).

In New York City, 8 million residents and millions of businesses and construction projects produce 14 million tons of waste and recyclables per year (Cohen et al., 2015). In South Africa, waste generation by society is seen as a manifestation of the wasteful use of resources and it is the core cause of pollution and related environmental degradation. Increased waste generation is an inevitable result of economic development. The proper global waste management is important to conserve resources and protect the environment (DEA, 2012a). The main influence of waste generation is essentially expanding economies, increased goods production and increasing populations (DEA, 2012a).

Dramatic increases in population in urban areas are typically happening in Africa and Asia; and the amount of municipal solid waste generated dramatically increases as consequence (United Nations, 2009). Some of the largest African cities which include Nairobi, Dares Salaam, Lagos, Cairo and Johannesburg are experiencing population growth which is mainly fuelled by high levels of migration (Simelane, 2011).

In Africa, urbanization is not a new phenomenon and the rate of unrestricted and unplanned urbanization has increased to large quantity of both liquid and solid wastes being generated and these wastes have exceeded the capacity of the city's authorities to collect and dispose them safely and efficiently. Rapid urbanization in African countries by the same logic lead to rapid accumulation of waste and it is what has been likened to “a monster that has terminated the efforts made by city authorities, urban planners, states and federal governments” to manage waste (Otchere et al., 2015). By 2020, more than 50% of the sub-Saharan Africans are going to be residing in the cities (Ahmed and Ali, 2004). It is likely to increase the daily waste generation rate by approximately 1,0 kg per capita. Mauritius produced around 1,1 kg/capita daily of mixed municipal solid waste, which has increased significantly from about 0,8 kg per capita (Surroop and Mohee, 2011).

### **2.3.2 Waste storage**

In Libya, Benghazi city, public bins and metallic containers are normally placed along major roads and near the houses for temporary storage of waste by the public company of general services. These bins or metallic containers are utilized by the public to drop their small quantity of wastes, such as food, paper, or wrappers to avoid littering and to improve the cleanliness and appearance of these areas (Gebriel et al., 2010). In India, most of the urban areas lack municipal solid waste storage at the source. The waste storage bins used in several cities are not designed properly or are not properly located and maintained. It leads to poor waste collection in those cities. In India, the bins used for waste storage are for both decomposable and non-decomposable waste and those storage bins are classified as movable bins and fixed bins. Fixed bins are more durable but their positions cannot be changed once they have been constructed, while the movable bins are flexible in transportation but lacking in durability (Gupta et al., 2015).

Addis Ababa city, Central Ethiopia, waste is not stored in standardized bins, and dust bins are located only on the main roads with the assumption that the roads are the popular ones and for residential waste storage, households use different types of storage facilities including

baskets, card boxes, bamboo made containers, cans, plastic bags and barrels (Regassa et al., 2011). In Tha Khon Yang, Maha Sarakham Province, northeast Thailand, the waste storage bins are provided by private business in residential areas. The private bins are simple receptacles such as plastic baskets or bins made from old tires. Most people use plastic bags for residential waste storage. Residents place their waste storage bins or plastic bags of mixed waste outside the gate of their house or at unfixed waste collection points along main roads for collection by municipality (Yukalang et al., 2017).

In Freetown, Sierra Leone, the residents use containers such as old buckets, plastic containers, baskets, dustbins and polythene bags for solid waste storage and with no litter bins. Those containers used are not having covers. Most of the waste material is stored in old buckets and plastic containers (Sankoh and Yan, 2013). In Ghana, separate storage waste containers are placed by shops in certain places, which were evacuated directly into the trucks. This is carried out to prevent illegal dumping of waste. Concrete waste litter bins, however, may be very difficult to be afforded in Ghana, especially, in the Kpone Township (Sepenoo, 2018). In residential areas, solid waste storage is done by residents and renters. Commonly used equipment for waste storage is plastic containers or galvanized metal containers and disposable plastic bags. Waste in residential areas is placed in plastic bags and left along the kerbside for collection. In commercial and institutional areas which include schools, hospitals, prisons, and government centres, wastes are usually disposed of in large non-standard bins that are provided by individual owners. Solid wastes from commercial buildings are collected in large containers that are transportable (Singh et al., 2014).

In Pretoria, some of the waste from residential areas are stored in black refuse bag and shopping plastic bag whereas other waste is stored in bins and placed outside the gates for collection by the municipality (Nkosi, 2014). According to the study conducted in Polokwane, countries throughout the world have Acts that provide waste for the removal by the local authorities, on specified days. The waste is normally stored in containers, bags and bins, for easier removal (Ogola et al., 2011). Lack of suitable storage system of waste at the generation point is considered the most serious failing of the current waste management in the city. Availability of suitable waste storage system is considered a means to facilitate the collection operation and to avoid littering and illegal dumping. Wastes are usually scattered by scavengers when they are searching for food and valuables. The cost of

removing littered waste from the streets is much higher compared to the cost of collecting waste which is stored in waste containers and domestic waste bins (Gebril et al., 2010).

### **2.3.3 Waste collection and transportation**

In India, municipal solid waste collection is the responsibility of the municipal corporations and litter bins are normally provided by municipalities for biodegradable and inert waste (Kumar, 2017). In Ethiopia, Bahir Dar City, collection of solid waste in urban areas is difficult and a complex job because the generation of waste from different sources in a diffuse process complicates the collection task (Kassie, 2016). Collection and transportation of municipal solid waste involve storage at the generation point and collection point, picked up by the waste management crew, trucks driving around the neighbourhood to a disposal site (Singh et al., 2014). In Nepal, vehicles and equipment which are available for waste collection and transport in each municipality vary widely. Vehicles which are usually used include rickshaws and carts for primary waste collection. In secondary collection or transport, they utilized tractors, and dump trucks for transport to the disposal sites (Bank, 2013).

In Indonesia, Makassar city, household solid waste is dumped along the road, and the municipality uses trucks to collect and transport waste to landfill site. Alternately, carts are used to collect waste from roadside waste bins and transport it to a selected transfer station. Then, trucks collect waste from the transfer stations and transport it to the landfill site (Permana et al., 2015). In Brazil, mixed waste collection and source separated collection are not carried out by the same vehicles. Mixed waste is collected using two axis trucks with a waste compaction ratio of 3:1 and the net capacity of 7 tons of waste and separated waste was collected using two axis trucks which are not having compaction but having a net capacity of 2.4 tons of waste (Coelho and Lange, 2018). In China, waste collection in major cities is carried out through primary and secondary collection methods. On primary waste collection method, waste is collected from households to the local collection points which are also called point of treatment and secondary collection which involve collection of waste from local collection points of treatment to the landfill sites by the municipalities (Zhang et al., 2010).

In Mozambique, waste collection service is extremely dependent on the living standards of different neighbourhood. Municipal waste collection from door-to-door is rare especially in Maputo. Waste collection service is carried out from primary neighbourhood collection, where in some districts is carried out by private initiatives, and secondary collection is carried

out by the municipal council. The municipal councils provide waste storage containers where residents dispose of their waste on those containers for primary collection. The municipality collects waste and transports it to the treatment facilities for further processing (secondary collection). Those who generate large quantities of waste e.g. over 50 litres, contract a waste management service provider for transportation of their waste to the closest disposal site. With the support of Non-Governmental Organizations (NGOs), waste collection crew collect Municipal Solid Waste (MSW) in carts from household and transport it to the public dumping site where the secondary waste collection takes effect. Vehicles used for secondary waste collection include open tippers, compacting vehicles and tractors in municipal areas and in the suburbs where fine fraction and rubble in municipal solid waste is very high, compacting trucks with the hydraulic systems are not seen as effective (Sallwey et al., 2017).

In communities, the virtually collection methods of solid waste are curb side, set-outback and backyard carry. Curb side collection method is when residents carry the waste plastic bags and containers to the collection point and then return the empty container at homes after collection. Set-outback collection method uses a crew that carries the waste containers to the pickup point. A collection crew empties the containers and then residents return the empty containers. Backyard collection method is when the waste collection crew transfers the solid waste into a wheeled barrel, and then unloads it into the collection truck. The containers remain in the backyard (Singh et al., 2014). Solid waste collection is a crucial factor of sustainable waste management. The availability of a good collection system is vital for the operation of waste management system and generators resort to official disposal sites and adopt suitable practices to protect human health and the environment (Dos Muchangos et al., 2015).

In South Africa, Johannesburg citizens do not have access to waste collection and where the collection of waste exists; the collection standard is not adequate. The improvement on waste collection requires urgent attention over the whole world (Kubanza, 2012). In Polokwane city, waste collection system is uniform in most countries and individual households store their waste into a nearby container daily, then the waste is collected and transported to the waste pick up point or disposal site (Ogola et al., 2011).

#### **2.3.4 Waste disposal**

In Pakistan, there is no landfill in the city of Lahore. A proposal was presented as part of the master plan for the development of three new landfill sites, but only one of these sites,

Mehmood Booti, is currently in operational mode. Two other landfill sites are also being unofficially used to dispose of waste, namely Saagian dumpsite and Bagrian dumping site (Masood et al., 2014). According to the study conducted in Malaysia, the safe and good functioning of landfills relies on the sound planning, administration, and management of the whole municipal solid waste management system (Aja et al., 2014). Open dump is a disposal method which is utilized through the world especially in developing countries because they do not have sufficient budgets for municipal solid waste management. Municipal solid waste management is a challenging issue for both residents and authorities in the cities of Sub-Saharan Africa. Important technology and regulatory improvements have already been done but still the treatment facilities in many countries are not yet adequate, considering adverse health effects coming from the wastes (Özbay, 2015).

In India, waste generated is usually disposed on low lying area in routine way violating the practices of sanitary landfilling. There is no adequate sanitary landfilling facility and waste is disposed of at the edge of town along the roads. The unscientific dumping of waste is prone to flooding and major source of surface water contamination during monsoon and ground water pollution as a results of percolation of leachate (Joshi and Ahmed, 2016). According to the study conducted in Malaysia, an open dump causes environmental pollution and threats to public health because the landfill gas from the disposal site has limited utilization as large amount of it is emitted to the atmosphere. A landfill is an engineered depression in the ground where wastes are buried to avoid any contact between the wastes and the surrounding environment, especially groundwater. In Malaysia, the landfill is the method of solid waste disposal which is widely utilized throughout the world and has the longest history, the widest range of capabilities and in most cases; it is the waste disposal method which is least expensive (Aja et al., 2014).

It is highly used in developing countries. The main reason for high landfilling in developing countries is the absence of other waste management facilities in addition to the fact that landfilling is relatively cheap compared to other waste management options. Landfills existing in many developing countries, most of them are poorly sited and unsuitably managed and are not sanitary (Mohee et al., 2015). In South Africa, municipal solid waste management services depend mostly on the landfills for the disposal of waste, which account for the majority of the licenced waste facilities. Approximately, 90% of all South Africa's waste is disposed of at landfill sites (DEA, 2011). In South Africa, most disposal sites are located

close to residential areas. For example, Muledane open dump in Thohoyandou is now in the heart of Muledane housing estate. The location of this disposal site presents serious threats to the quality of ground and surface water through contaminant leaching and runoffs from the disposal site (Adeniyi et al., 2008).

## **2.4 Integrated solid waste management practices**

### **2.4.1 Waste reduction**

In Indonesia, the amount of waste entering the Piyungan Landfill Site is reduced from its source. If the reductions on its source run well, then the amount of waste transported to the landfill is reduced (Sudibyo, 2017). In South Africa, waste reduction initiatives seek to reduce the amount of solid waste at generation points by redesigning of products or changing patterns of production and consumption; and products and materials must be designed in a manner that minimizes their waste components or in a manner that reduces the natural material quantities used and potential toxicity of waste generated during the production, and after use (DEA, 2012a). In developed and developing countries, strategies that improve municipal solid waste management system include recycling, repair and reuse which require cultural change (Abdoli et al., 2016).

Reduction of waste is achieved in many cases through reducing consumption of products, goods and services. The good way to reduce waste is not through creating it in the first place, and so waste reduction is put at the top of waste management hierarchies (USEPA, 2010). Waste reduction can also be attained through the reuse of by-products (HRM, 2010). The decrease of waste generation has a two-fold benefit in terms of greenhouse gas emission reductions. First, the emissions linked with material and product manufacture are avoided. The second benefit is eliminating the emissions linked with the avoided waste management activities. Products and materials should be designed in such a way that minimizes their waste components or in a way which decreases the amount of natural material utilized and possible toxicity of waste produced during the production, and after consumption (Hoornweg and Bhada-Tata, 2012).

### **2.4.2 Waste re-use and recycling**

In Europe, the concept of waste hierarchy was proposed, which consists of five steps: prevention, reuse and preparation for reuse, recycle, recovery, and disposal. The goal is to achieve waste minimization by source-reduction, waste diversion, and non-diverted wastes

disposal through incineration and landfilling. This new trend pushes municipal solid waste management beyond the scope of technology and requires the involvement of all stakeholders, including product manufacturers, government institutions, private businesses, and householders (Rada, 2017). In India, waste separation at source is not carried at household level. Since there is no waste separation at source, waste is dumped at community bins and recycling of materials is not possible. However, rag-pickers usually sorted out and took and sell recyclable material like plastics, glass, etc. In Pondicherry, almost all recyclable material is sorted out by rag-pickers and absorbed in material stream through recycling (Joshi and Ahmed, 2016).

According to the study conducted in Malaysia, recycling of materials is the beneficial-reuse of products that would otherwise be disposed in landfill site. It diverts waste from landfills besides providing raw materials that use less fuel during the manufacturing process (Aja et al., 2014). In the study conducted in China, recycling has a lot of positive aspects, it creates job opportunities and it provides products in lower prices (Bouanini, 2013). In Mongolia, recyclable waste materials are informally recovered from the municipal solid waste stream and flow into the recyclable stream during each process of discharge, collection, transportation and disposal. There is a need to address these uncertainties, which occur in solid waste management (Byamba and Ishikawa, 2017). The participation of the informal sector in recycling is a crucial characteristic of waste recovery and recycling in developing countries (Xue et al., 2011). In Pakistan, the recyclable materials are collected by the waste pickers/waste collectors operating on the dumping site. There is no formal waste recycling system in place in the city, although segregation of waste starts at the source in many cases, a trend common in many developing countries. A strong informal network including waste pickers on streets, communal waste container sites and dumpsites, itinerant waste buyers, formal waste collectors and even domestic servants primarily capture all the recyclables in municipal waste (Masood, et al., 2014).

In Jordan, informal waste recycling activities, including waste-pickers and scavengers become apparently active in the last twenty years. Recycling takes place informally by individual scavengers in the city or by hired waste-pickers at the dumpsites to recover and scavenge recyclable materials before waste is landfilled. Recycling activities in Jordan are considered pilot projects with small-scale interventions, which also have been initiated and supported by NGOs and international organizations (Saidan et al., 2017). In Malaysia,

consumers are reusing plastic grocery bags for lining small waste cans. Canvas plastic bag can also be used by a shopper to carry groceries and this reduces the need for a new plastic grocery bag entering the waste stream (Badgie et al., 2012). In La Paz (Bolivia), the waste recycling is carried out mainly by the informal sectors, which is not recognized by the formal recycling process. Waste pickers are not organized and they collect the recyclable materials from temporary garbage dump sites and storage containers. They are reducing the inflow waste materials into the landfill site (Ferronato et al., 2018).

In Malaysia, recycling is the reclamation of material and its reuse which could include repair, remanufacture and conversion of materials, parts and products (Aja et al., 2014). In Vietnam, the recycled waste materials quantity accounts for a small proportion, approximately 8-12% of the total collected recyclable materials quantity at present (Luong et al., 2013). Many materials from municipal solid waste are currently recycled which include paper and paper products. These products are recycled in manufacturing building materials such as roofing felt, insulation and wallboard, and are also utilised to manufacture cartons and containers. Plastics are recycled to generate insulating material, sheets, bags, and structural material (Singh et al., 2014). In West Rand District Municipality, Gauteng, South Africa, recycling is a resource and energy saving activity which offers great return for many recyclers. Recyclable materials being recovered from the landfill sites consist of plastics, bottles, waste paper, tins and light scrap (Ginindza, 2016). Polokwane Local Municipality does not have a formal waste recycling system, recycling is done in the disposal site by informal waste recyclers and they collect recyclable materials on a daily basis (Ogola et al., 2011).

In South Africa, management of waste through the hierarchal approach is a recognized international model for the prioritization of waste management options. It bargains a holistic approach to the management of waste materials, and provides a systematic method for waste management during the waste lifecycle addressing in turn waste avoidance, reduction, re-use, recycling, recovery, treatment, and safe disposal as a last resort. This aims to eventually reduce the reliance of South Africa's waste disposal on landfills, as currently the majority of waste ends up therein (Anon, 2017). In South Africa, materials can be utilized for similar or different purposes without changing a form. A product is reused when it reaches the end of its life span; it turns into input for new products and materials. This approach includes separation of materials from the waste stream and processing them as products and the first elements of the waste management hierarchy are the foundation of the cradle-to-cradle waste

management approach (DEA, 2012a). In South Africa, Limpopo province, existing recycling facilities are for private companies and those facilities are operating as buyback centres where people from different communities go and sell their recyclable materials to the company (Mudau, 2015).

### **2.4.3 Incineration**

In European countries, incineration is the general practice used in disposing residual waste to avoid the used of landfill for disposal in European countries (European Environment Agency, 2013). In Malaysia, some of the municipal managers are looking to the development of municipal incinerators around the periphery of their cities as a first solution in many countries (Badgie et al., 2012). In Bhopal, India, incineration is one of the virtually basic solid waste treatment methods that have been utilized in different parts of the world due to its ability to reduce waste mass by 70% and waste volume by 90% (Pandey et al., 2016). In Malaysia, some of the municipal managers are looking to the development of municipal incinerators around the periphery of their cities as a first solution in many countries (Badgie et al., 2012).

In the United Kingdom, there are 25 waste management incinerators. 80% of those incinerators are used to generate electricity and the rest recover heat and electricity. Most of the incinerators are moving-grate plants and are designed to handle large quantities of waste without any pre-treatment (Jeswani and Azapagic, 2016). In the Indian cities, incineration is limited to the hospital and other biological wastes. This may be as a result of high organic waste material, high moisture content and low calorific value content in solid waste. The number of research studies has been conducted on management of municipal solid waste incinerator (Gupta et al., 2015).

In Vietnam, municipal solid waste incineration activity is not often carried out. The main reasons for not having incineration facilities is the high investment cost required, high organic waste materials and high moisture content in solid waste which causes the difficulty in combustion of waste. There is one incinerator with a capacity of 300 tons/day installed in Son Tay town, Ha Noi city (Luong et al., 2013). In South Africa, Ekurhuleni Municipality, waste incineration is used as a waste treatment method. Waste incineration involves the formal treatment of waste using extremely high temperatures. For example, waste oils can be recycled through incineration. In areas where there are no suitable waste management practices in place, the residents usually burn their waste to reduce the unpleasant smell and

aesthetic view. It is usually not done in the recommended way which makes use of an incinerator. In such instances, there is usually the problem of air pollution which can, in the long run lead to respiratory tract infections of individuals exposed to such pollution types (Tembon, 2012).

#### **2.4.4 Composting**

Composting refers to the biological decomposition of organic waste by micro-organisms under aerobic conditions to a condition waste can be used in landscaping, agriculture and horticultural works. It does not produce odours and it does not attract flies or other animals when it is carried out under controlled conditions. Composting is an alternative technique for reducing the quantity of wastes that are disposed, hence extending their lifespan. It helps in recycling nutrients by returning them back to the soil. It also prevents pollution and extends the life of landfills (Singh et al., 2011).

In India, composting is carried out in two ways, for example, aerobically and anaerobically. During the aerobically process, the aerobic micro-organisms oxidize organic compounds to carbon dioxide, nitrite and nitrate whereas in anaerobically process, the anaerobic micro-organisms metabolizing the nutrients and break down the organic compounds through a process of reduction. An anaerobic process is a reduction process and the final product is exposed to certain minor oxidation when being used on the land (Gupta et al., 2015).

In Mozambique, composting is not carried on garden waste in most parts of Maputo as there are too small backyards. It is not culturally popular among Mozambican citizens hence the quality the compost produced in the backyards would be low, even if attempted. The small-scale composting activities have become successful in South Africa and Congo in areas with large gardens and with residents having cars that are able to transport the organic waste materials to the centralized yards (Sallwey et al., 2017). In Malaysia, composting is also not popular in some countries as it is having high investment cost, large space need and low value of the compost product (Sakawi, 2011).

In Pakistan, Lahore, a composting plant is operating as a public private partnership project. The plant is located in the vicinity of the dumping site and uses a windrow-type composting method to produce 47,230 tons year<sup>-1</sup> of compost of what is expected to be sold as 100% organic fertiliser (Masood et al., 2014). In Mozambique, biomass makes up a largest portion of municipal solid waste generated focusing on recovery of organic materials as a good solid

waste management strategy and besides reducing the volume of waste to be disposed in the landfill sites, it makes the nutrients available again in soil. Processing of organic waste materials is a process that does not require a lot of technology or investment (Sallwey et al., 2017).

In Vietnam, manual composting method is used in small urban areas. However, the efficiency of composting waste treatment plants is not high due to waste which is not separated at sources (Luong et al., 2013). In South Africa, Ekurhuleni Municipality, composting is also used to produce compost to be used in landscaping, agriculture and horticultural works. It does not produce odours and it does not attract flies or other animals when it is carried out under controlled conditions (Tembon, 2012).

#### **2.4.5 Land filling**

In Kaduna, North West Nigeria, one of the most solid waste management strategies normally implemented is landfill and this method has been overstressed. Currently, many cities are facing a critical condition in managing domestic solid waste. In 1970, Port-Harcourt in southern Nigeria was known as the garden city and it is currently known as refuse city due to implementation of poor waste management strategies. In 2010, it was indicated that there are approximately 509 landfill sites in Nigeria. Most of those landfill sites are operated as open dumps and it leads to environment pollution. There are few sanitary landfills in Nigeria operated by state called Lagos, Kano and Cross Rivers (Abd'Razack et al., 2017). In the United Kingdom, municipal solid waste is disposed in managed sanitary landfill sites with recovery of biogas and a leachate treatment facility. Such types of landfill sites are common both in the United Kingdom and Europe (Jeswani and Azapagic, 2016).

In India, landfilling is continuing to be the extensively accepted practice in India, though metropolitan centers such as Delhi, Mumbai, Kolkata and Chennai have little space for waste disposal and selected landfill sites are running beyond their life span. The development of new sanitary landfills/expansion of existing landfill is reported in the state called Andhra Pradesh (Joshi and Ahmed, 2016). Landfills are usually the final disposal sites for waste and should be engineered and controlled to protect the environment and public health. In developing countries, there is no suitable landfilling. Landfilling usually progresses from open-dumping, controlled dumping, controlled landfilling to sanitary landfilling (Hoornweg and Bhada-Tata, 2012).

Sanitary landfills are utilized in developed countries and have facilities for interception and treatment of the leachates. There is a generation of leachate and gases from the landfill. This landfill has system for the control of gases generated from waste decomposition. It is an engineered disposal option, which prevents negative effects of uncontrolled dumping by spreading, compacting and covering the waste land that has been carefully engineered before use. Through suitable site selection, preparation and management, the function of landfill can reduce the effects of leachates and the generation of gas both in the present and in the future. Waste which is arriving at the sanitary landfill is compacted and covered with a layer of compacted soil daily. Compacted soil layer avoids any access of waste by insects, rodents and other animals (Singh et al., 2011).

## **2.5 Factors affecting sustainable solid waste management system**

### **2.5.1 Legal Policies and Strategies**

Globally, policy implementation is a crucial issue and there is a clear gap between the policy-making and implementation. For example, in India, different regulatory bodies and directives from Honorable Supreme Court of India are not effectively implemented (Ma and Hipel, 2016). In developed and developing countries, due to the absence of regulation, it is particularly difficult to manage waste on a systemic level. This difficulty has been realized by entities and governments, and has triggered a move towards programs and regulations which are promoting the close loop, “moving from the concept of ‘end-of pipe’ waste management towards a more holistic resources management. Examples of such shift include ‘Sustainable use and production initiatives’ and regulation like the Eco-label and the Eco-management and national waste prevention programs (Marshall and Farahbakhsh, 2013). In Ulaanbaatar, Mongolia, waste management laws regulate the relations arising from storage, collection, transportation and landfill of household and industrial waste as well as promoting the re-use of waste as an alternative to virgin waste materials (Byamba and Ishikawa, 2017).

In Europe, Serbia, there is weak and insufficient law enforcement, inefficient law enforcement organizational structures, weak motivation of staff, lack of finances for investments are few of issues responsible for undeveloped waste management system in Serbia. From experiences of member states, Serbia will have difficulties in practical implementation and enforcement of Europe waste legislation at national level, and development of waste management system, as now waste management depends much on landfill sites (Mihajlovic, 2016). Ulaanbaatar, the capital city of Mongolia, is one of the cities

facing unprecedented consequences of rapid population growth coupled with economic growth and lack of proper regulations in place (Byamba and Ishikawa, 2017).

In Vietnam, municipal solid waste is disposed of in an uncontrolled and poorly managed manner. Waste covering, compaction and levelling and final covering by compacted soil are hardly observed practices at most of the waste disposal sites (Luong et al., 2013). In India, Kinondoni District Municipality, by-laws are not effectively forced and settings of laws are for the most part weak, this results to utilization of improper waste management practices (Kumar et al., 2016). In Kwazulu Natal, UThukela District Municipality, in some of the local municipalities, waste management by-laws are very old and municipalities have huge problem because law enforcement personnel/officers are unable to enforcement those by-laws (Khumalo, 2016). The policy and regulatory environment is not actively encouraging the solid waste management hierarchy in South Africa. This has limited the economic potential of the waste management sector (DEA, 2012a).

In South Africa, Limpopo province, there is an insufficient enforcement of waste management by-laws within local municipalities due to lack of law enforcement personnel, lack of penalties information and delay in the National Waste Management Policy adaptation and implementation at local level. The policy implementation monitoring by the provincial government within time frame is not considered a priority (Mudau, 2015). In South Africa, the processes of processing, treatment and disposal of waste should be done in accordance with the rules of the environmental justice and equitable access to environmental services as articulated in the National Environmental Management Act (DEA, 2012a). In Vhembe District Municipality, some of the local municipalities are still struggling to comply with the minimum requirements for waste management and lacked resources to achieve the elements of waste management (Limpopo Mirror, 2017).

### **2.5.2 Financial and economic aspects**

In Asian countries, the major problem in financial and economic aspect is that 20-50% of municipal revenues are spent in developing countries to manage the waste, but it is not yet adequate to cover all the population (Othman et al., 2013). In India, Kinondoni District Municipality, willingness and unwillingness of the residents to pay for waste management service could have the impacts on the availability of the effective waste management system. Most of the investigations present improved solid waste management by residents'

willingness to compensate for the waste management services. In some studies, it is found that elderly people are not willing to compensate for the services because most of the people believe that collection of municipal solid waste is not their responsibility. They consider it as the government's duty and that they are not at risk to pay for the waste accumulation. However, youth are more familiar with cost sharing and they are more eager to pay for the services (Kumar et al., 2016).

In Freetown, Sierra Leone, the problem of solid waste management in urban cities is attributed to poor financial status of the municipality. Municipal solid waste management requires a huge expenditure and it is given insufficient attention in most parts of the world. Cities in both developed and developing countries normally do not spend more than 0.5% of their per capita growth national product (GNP) on solid waste management activities and it covers only approximately one-third of total cost. In high income countries, the problems frequently centre on the difficulties and high cost of disposing the large quantities of waste produced from households and businesses whereas in lower income countries, the main challenges are associated with waste collection and disposal, with one-third to half of all solid waste produced in the third world countries remaining uncollected (Sankoh and Yan, 2013).

In Vietnam, management of waste requires proper infrastructure, maintenance and upgrade for all activities and it becomes gradually expensive and complex due to continuous and unplanned growth of urban areas. The struggle in the provision of desired level of public service in urban areas is always attributed to the lack of financial and human resources of the responsible organizations. Majority of collection facilities have not met the technical standard and not yet ensured the requirement for environmental sanitation. There is no investment for construction of transfer stations areas and the number of vehicles is not yet met the required demand for daily waste transportation. It results to the accumulation of waste in residential areas causing odor to the community (Luong et al., 2013). The study conducted in New York City, Hong Kong and Beijing indicated that the global cost of managing waste is rising too, from \$205 billion a year in 2010 to \$375 billion by 2025, with the sharpest cost increases in developing countries (Cohen et al., 2015).

The study conducted in Serbia indicated that lack of finances is a common problem faced by developing countries. Financial sustainability is the crucial driver in the design of the future waste management infrastructure. The cost of waste management infrastructure development

is crucial for development of the future waste management strategy (Mihajlovic, 2016). In developed and developing countries, there is a lack of financial resources to buy suitable equipment and machinery for the waste producers to store their wastes; these services are expensive for municipalities especially in developing countries (Mohee et al., 2015). In South Africa, waste management sections within municipalities are suffering from a pervasive under-pricing, which means that the costs of waste management are not fully appreciated by consumers and industry, and waste disposal is preferred over other options; there are few waste treatment options to manage waste and most of them are more expensive than landfill costs (Anon, 2017).

In South Africa, Ekurhuleni Municipality reported that there is an uneven allocation of tariffs for waste management to the municipal members and the residents in the informal squatter settlements do not compensate for waste management service and the residents from the high density suburb pay less compared to the urban area residents (Tembon, 2012). In South Africa, North-eastern Free State province, there is a constrained budget allocation on waste management section as compared to other sections within the municipalities in the province (Mahasa, 2013). The National Waste Management Strategy (NWMS) of South Africa of 2011 also confirmed that waste management section within municipalities in South Africa has several challenges as result of high rapid economic growth and historical waste services backlog. In 2007, only 61% of South African households were receiving household waste collection services, with the services skewed in favour of the urban residents. On the other hand, most of the low income rural areas remained deprived (Mabadahanye, 2017).

### **2.5.3 Socio-cultural aspects**

In both developed and developing countries, strategies that improve municipal solid waste management system include recycling; repair, reuse and these require cultural change. Without public participation, municipal solid waste management system may become less effective. For example, source separation efficiency and cleanliness of city strongly rely on public manner. Source separation is a good method to facilitate the functioning of waste management system (Abdoli et al., 2016). In Isfahan, Iran, community should be familiar with types of wastes that are recyclable, compostable and combustible, and which are not and should also be informed about the health risk of informal system (Abdoli et al., 2013).

In India, Konondia District Municipality, waste management includes municipal councillors, municipal official and other private agencies/person involved in transportation, collection,

storage and processing of waste. With the aid of government, the thrust of the awareness program and campaign was on facilitating a door to door collection of separated waste (Kumar et al., 2016). In Mexico, human environmental research on municipal solid waste management has expanded in the past decade but still, it has yet to basically solve the problem of littering. Littering is still a crucial matter for households in rural Mexican municipalities as it has the potential to pollute the landscapes. In rural areas, where municipal budgets to manage waste are already stretched thin, litter prevention and clean-up are always ignored. Littering is global problem, especially in economically marginal areas like rural Mexico, where the limited budgets of municipalities do not allow for extensive clean-up, adequate public waste receptacles or expansive anti-litter campaigns (Hilburn, 2016).

In Brazil, Rio de Janeiro, public campaigns and programs which are focusing on advising the communities about the important of source separated collection and recycling to the environment and society are already being implemented. Still the campaigns need to be expanded and strengthened as public engagement because they are important to the success of waste management systems (Coelho and Lange, 2018). In Mozambique, there is a low level of raising awareness and public participation and there is high level of littering as well as mismanagement of municipal solid waste. Waste management educational programs such as awareness campaign and programs about sanitation and waste handling have been conducted in a few municipalities such as Manhiça, Dondo and Ilha with the help of international partners. The sustainability of those programs after the withdrawal of the international partners has been insufficient (Sallwey et al., 2017).

In Freetown, Sierra Leone, proper solid waste management is a complex task which depends much on organization and cooperation among residents, private sector and government authorities as it also depends on the selection and application of appropriate technical solutions for waste collection, transfer, recycling and disposal (Sankoh and Yan, 2013). In South Africa, Johannesburg, municipal solid waste management systems that are inattentive to social and cultural aspects are defeated throughout the world. The main sources of littering include the anti-social behaviour of individuals in dropping litter on footpaths, dumping households wastes, the failure of street sweeping services to rid pavements and public areas of litter, in adequate disposal facilities, breakdown of litter collection facilities or the provision of in appropriate collection bins, open bins and collection vehicles may provide an opportunity for litter to be blown in to the public domain, the failure by the authorities to enforce effective penalties to act as a deterrent to offender, it is obvious is a problem

associated with human habitation. Significant cost is incurred by the local authorities on carrying clean-up operations (Kubanza, 2012).

Illegal dumping of waste in open spaces is another challenge which is faced by South Africa in solid waste management. It is not unusual to see beverage, cans, cigarette packets, fast food packaging and other waste on the streets and in public areas in South Africa. Illegal dumping is unsightly and it also creates a health hazard and deprives community space that could otherwise be utilized for recreational purpose. Illegal dumping results in high social costs because of contamination of water resources, the spread of diseases, litter and aesthetic deterioration are all problems resulting from illegal dumping (Kubanza, 2012).

In South Africa, Limpopo province, municipalities such as Ba-Phalaborwa, Polokwane and Lepelle-Nkumpi have illegal dumping hot spots where municipal skip bins are installed for the communities to dispose their waste (Mudau, 2015). In Thulamela Local Municipality, Khakhanwa village, there is an illegal dumping of waste such as bottles, decomposable vegetables, food remnants, napkins and plastics along the roads, in the vicinity of the residential areas and within catchment areas (Mabadahanye, 2017). In South Africa, Ekurhuleni Municipality, there is a littering of within a disposal site due to the incoming loaded trucks and children who are scavenging with a landfill site.

#### **2.5.4 Institutional aspects**

In Nigeria, waste collection service in slums is not inadequate, due to the unplanned nature of the settlements, lack of space for placing waste containers, lack of trucks and road network which is not in good condition (Onu, 2014). Addis Ababa city, central Ethiopia, as a result of topographic location of the houses or the inaccessibility of households which is caused by poor road networks, the high income residential areas have high access to the waste collection services whereas low income residential areas have little access to waste collection service (Regassa et al., 2011). In developed countries, the infrastructure is well developed where as in most developing countries the roads are in bad conditions. Due to poor road network, the waste collection vehicles are unable to reach waste collection areas, and wastes are left uncollected at their sources of generation for a longer time (Mohee et al., 2015). In Pakistan, there is a fleet of approximately 500 vehicles for waste transportation to the disposal sites. It also operates a workshop to maintain these vehicles. Most of the fleets are old and obsolete and require continuous repair (Masood et al., 2014).

In Freetown, Sierra Leone, the major institutional challenges are the difficulties on the development of the new landfill sites due to non-availability of land. The residents who are having a piece of land in the surrounding villages and towns of Freetown are not willing to give the municipality a piece of land for landfill site development. One-third to one-half of solid waste produced within cities in low and middle income countries is remaining uncollected. Uncollected waste usually ends up as illegal dump hot spot on streets, open spaces and waste lands. It seems like the disposal facilities have not been able to keep pace with the significant of solid waste being produced. It is common to find large heaps of waste in a disorganized manner everywhere. In low income countries, there are no formal waste collection activities (Sankoh and Yan, 2013).

In Nigerian, there are challenges of continuous waste generation; poor collection, transportation and disposal; illegal dumping of waste in open spaces, streets, drainage channels and flood plains of rivers (Wahab, 2013). In India, Konondia District Municipality, waste collection systems vary from the utilization of small and poor quality of metal or plastic containers and waste platforms to well monitored bins, which are disgustingly insufficient (Kumar et al., 2016). In Adelaide, Australia, as a result of those factors solid waste management is one of the virtually challenging service sectors in the 21<sup>st</sup> century for municipal authorities (Zaman, 2014).

In South Africa, Ekurhuleni Municipality, there are no recycling facilities with the municipality and communities are not provided with recyclable receptacles for sorting out recyclable materials (Tembon, 2012). In South Africa, municipalities are not able to construct recycling infrastructures at the communities which will enable separation of waste at source and diversion of waste streams to material recovery and buy-back facilities (Anon, 2017). In Limpopo province, Vhembe District Municipality declared a war against littering of waste in an occasion held at Tshisaulu Sports Grounds in July 2014 to ensure that good waste management system is practiced. The key elements of the declared war were to reduce, recycle and reuse of waste materials because there are some municipalities that are struggling to meet the waste management requirements due to budget constraints in the District (Limpopo Mirror, 2017).

### **2.5.5 Technical aspects**

Globally, lack of knowledge by the public is a key technical factor affecting implementation of municipal solid waste management system. Lack of public knowledge has been globally seen as one of the most important barriers to information, to the success of any municipal solid waste management system (Ma and Hipel, 2016). In Mongolia, Ulaanbaatar, there is data which is not reliable and up to date and is one of the biggest challenges faced by developing countries which is related to the insufficiency of data collection and reporting. It might constitute a barrier to action, or allow incorrect assumptions which lead to incorrect actions (Byamba and Ishikawa, 2017). In developed and developing countries, waste characteristics, quantities and local conditions have important impact on technical aspects of municipal waste management. Although waste incineration is known as a suitable option in developed countries, it faces with difficulties. For example, the low heat value is a prevalent barrier especially in developing countries due to the high percentage of degradable organic matter in waste stream. There is lack of skilled workforce to setup and operation of incineration facilities. Therefore, municipality must have to train technical personnel in this regard (Abdoli et al., 2016). In Zambia, Kitwe city, unskilled waste management personnel affect waste management processes (Mwanza et al., 2018). In Zimbabwe, Beitbridge Border town, unavailability of proper facilities and equipment, technologies and consistent solid waste generation databases and absence of waste management facilities for safe disposal of waste affect waste management system (Mundoga and Moyo, 2017).

In India, there is lack of technical expertise necessary to deal with the disposal of municipal solid waste and the two leading innovative instruments of municipal solid waste disposal being used in India include composting and waste-to-energy incineration (Gupta et al., 2015). In South Africa, there is little understanding of the main waste flows and national waste balance because the submission of waste data is not obligatory and where data is available, it is always unreliable and contradictory, there is a growing pressure on available out dated waste management facilities which decrease the levels of capital investment and maintenance (DEA, 2012a). In South Africa, Limpopo province, as a result of inadequate equipment, the waste management system cannot achieve requisite compliance targets (Mudau, 2015).

### **2.6 Potential impacts of municipal solid waste on the environment**

Unsuitable collection and disposal of waste result to public health risk and environmental contamination. Open dumping and burning of solid waste deteriorates air quality. Health

hazard increases from the air pollution and from poor sanitation and unrestrained leachate that pollutes surface and underground water. Again, waste which is not managed properly usually blocks the drainage systems and worsens flooding. Furthermore, waste in disposal sites and landfills also contributes to greenhouse gas emissions (World Bank, 2014).

Solid waste is disposed into the unsuitable site and due to unsuitable and ineffective management, the disposal sites become the sources of environmental and health impacts to nearby residents (United Nations Environment Programme Report, 2015). Open dumps emit methane from decomposition of biodegradable waste under anaerobic conditions. Methane causes natural fires and explosions and is a main contributor to global warming (Sridevi et al., 2012). Open dumps are also associated with odour and migration of leachates to the receiving waters (Srivastava et al., 2014).

The impacts of mismanagement of solid waste on human health are well documented, with increased incidences of nose and throat infections, allergies, breathing difficulties, reduced immunity, inflammation, bacterial infections, anaemia, asthma and other infections (Central Pollution Control Board, 2000). The disposed old tyres at the dumps sites collect rain water; it causes mosquitoes to breed which lead to increase in spread of diseases which include malaria, dengue and West Nile fever. Unrestrained combustion of solid waste at dump sites emits fine particles which are the main cause of respiratory disease and cause smog (Sridevi et al., 2012).

The dumping sites of solid waste are situated at the edge of the city; they become children's sources of pollution because of brooding and proliferation of flies, mosquitoes and rodents which become disease transmitters that affect the health of the population and these organisms have their own organic defences in a formative and creative state. The condition creates gastrointestinal, dermatological, respiratory and several other forms of infectious diseases. The disposal site has smelly and unsightly conditions. The conditions of smelly and unsightly are worse especially in summer because of extreme temperatures, as they increase the rate of bacterial action on biodegradable organic waste (Alam and Ahmade, 2013).

The group of people who are at the risk from the unscientific disposal of solid waste includes the population in areas where there is no suitable waste disposal method, particularly the pre-school children; waste workers; and workers in facilities producing toxic, and infectious material. Other groups which are at high risk include the population which is residing adjacent to a waste dump and those whose water supply has become polluted, either as results

of leakage of leachate from the landfill sites. Unattended solid waste also increases the risk of injury and infection to population (Foday et al., 2013).

The disposal sites can also be harmful to wildlife which resides around them. Animals can also eat chemicals which are found in the disposal sites, or may become trapped amongst the mangled mess of tires, plastic containers, wires and metal scrap (EMA, 2013). Solid waste which is not collected can also obstruct storm water runoff and lead to stagnant water bodies that become the breeding ground of disease. Wastes dumped adjacent to the water body also cause pollution of the water body. Disposal of waste which is not treated in areas which include rivers, seas, and lakes lead to the accumulation of toxic substances in the food chain through the plants and animals as they feed on it (Medina, 2002).

## **2.7 Summary of key findings**

This chapter has provided a review of the state of knowledge in the context of the research problem of the study. It has shown that there are legislations and policies in the waste management sector with which municipalities in South Africa must comply. Studies reporting characterisation of waste streams or sources and types of wastes, technical and institutional aspects affecting sustainable waste management practices are practically lacking. There is little study conducted on best practices of waste management such as separation at source, waste reduction, reuse and recycling and potential implications of waste on the environment and human health. The reporting on the application of legal frameworks around the world is practically lacking. The gaps reported in section 2.7 are addressed. Ultimately, this study should add value to the state of understanding of the whole municipal waste management value chain around the world and help the municipalities on the application of legal frameworks.

## **CHAPTER THREE: METHODOLOGY**

### **3.1 Introduction**

The chapter provides data collection methods used and the type of data which were required to achieve the research objectives. The chapter also discusses how sampling of the respondents was carried out. The limitation of the study is also discussed and how data collected was analysed.

### **3.2 Desktop study**

Desktop study focused on gathering information about the study from published and unpublished literature that was beneficial in conducting the study. The researcher utilised resources such as journals, published articles, online resources and books to obtain background information about the work which was carried out in the study area. Desktop study also prepared the researcher psychologically and contributed towards the selection of methods that were necessary for undertaking the study.

### **3.3 Research design**

The study adopted a mixed method approach involving triangulation of qualitative and quantitative designs. The researcher used mixed method approach because it is flexible and adaptable to many study designs such as observational studies and randomized trials to clarify more information than can be obtained only in quantitative research method. A mixed method approach is an approach where the researcher tends to base knowledge claims on practical grounds (e.g., consequence-oriented and problem centered). It involves the strategies of collecting data either simultaneously or sequentially to best understand research problems (Wisdom and Creswell, 2013).

The study used mixed method as the researcher was going to collect both qualitative and quantitative data. The data collection in mixed method approach involves gathering both numeric information and text information so that the final database represents both quantitative and qualitative data (Creswell and Creswell, 2017). Mixed method refers to an emergent methodology of research that advances the systematic integration of quantitative and qualitative information within a single investigation program of inquiry. Integration of those methods permits a more complete and interactive use of data than do separate

quantitative and qualitative data collection and analysis (Wisdom and Creswell, 2013). Mixed method approach was also used on the study conducted in Zimbabwe, Harare, on the investigation of the effectiveness into the household solid waste management strategies (Mandevere, 2015).

Qualitative approach refers to the systematic collection, organization and interpretation of textual material derived from conversation. On qualitative, stories can actually be expressed in almost any medium conversations such as interviews and focus group discussions (Grossoehme, 2014). Quantitative methods place primary emphasis on generalizability to ensure that the knowledge gained is the representative of the population from which the sample was drawn (Palinkas, 2015). A quantitative approach is one in which the investigator primarily uses postpositivist claims for developing, employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data. A qualitative method refers to an approach where the inquirer often makes knowledge claims based primarily on constructivist perspectives with intent of developing a theory. It uses strategies of inquiry which include the narratives and case studies (Creswell and Creswell, 2017).

Table 3.1 depicts summary of quantitative and qualitative data that the study collected. In this study, the qualitative design incorporated the following methods of data collection: open-ended questionnaires, interviews, focus group discussions and field observations. The quantitative design incorporated the following methods of data collection: closed ended questionnaire survey. The data collected on the effectiveness of municipal solid waste management system in Vhembe District Municipality, its potential implications and problems encountered when managing waste by municipalities was analysed using descriptive statistics. Descriptive statistics is an analysis method which deals with the presentation of numerical facts, or data, in either tables or graphs form, and with the methodology of analysing the data. The researcher used tables and graphs to present the data.

Table 3. 1: Summary of qualitative and quantitative data.

Qualitative data	Quantitative data
Waste management strategies: waste reduction, reuse and recycling, storage, collection, transportation and disposal.	Total number of respondents participated in the study and personnel employed with the municipalities.
Problems encountered: illegal dumping, vandalism, lack of prioritization, law enforcement and equipment and etc.	Amount of waste generated, recycled and disposed and number of waste management facilities and equipment.
Potential impacts of solid waste on human health and the environment: how solid waste pollutes the environment and how people are affected by disease caused by waste	Tariffs charged for waste collection and budget allocated for management and waste collection timetable

### 3.4 Site selection

Vhembe District Municipality has four local municipalities which include Makhado, Thulamela, Musina and Collins Chabane. The study therefore focused on selected urban centres of these local municipalities which include Thohoyandou, Malamulele, Messina and Louis Trichardt town. The researcher purposeful selected the urban centres of these local municipalities as the places for data collection due to the number of criteria which include the proximity of local municipality offices to urban centres. This helped the researcher to collect data easily from the waste management department. Urban centres also have commercial, industrial, municipal services and institutional activities which are sources of municipal solid waste and these sources generate a lot of waste than in rural areas or communities. High rate of urbanization occurs in towns as people migrate from rural areas to urban areas and it leads to large amount of waste being generated in urban centres. This helped the researcher to collect the data easily and it also reduced time to be consumed by the researcher to travel for data collection.

### 3.5 Study population and Sample

The respondents were purposively selected including directors, superintendents, managers, landfill supervisors, interns and waste collectors to be the respondents of the study. Purposive sampling refers to the sampling technique which involves identifying and choosing individuals that are particularly knowledgeable about or experienced with a phenomenon of interest by the researcher. In addition, it involves identifying individuals who are willing to

participate, ability to communicate experiences and opinions in an articulate, expressive and reflective manner (Palinkas et al., 2015). All the respondents purposively selected in the four local municipalities were interviewed and form part of the focus group discussion and filled the questionnaires distributed to them (Table 3. 2).

Table 3. 2: Number of respondents participated on the study.

<b>Respondents</b>	<b>Number of respondents</b>	<b>Percentage of respondents</b>
<b>Director</b>	1	4,76%
<b>Waste managers</b>	4	19.05%
<b>Superintendents</b>	4	19.05%
<b>Landfill supervisor</b>	3	14.29%
<b>Interns</b>	4	19.05%
<b>Waste collectors</b>	4	19.05%
<b>Environmental Engineer</b>	1	4.76 %
<b>Total number</b>	<b>21</b>	<b>100%</b>

There was one (1) waste manager per local municipality, which brought the total number of managers that were used in the study to four (4) waste managers. Some municipalities have superintendents while other municipalities do not have superintendents. In other local municipalities, the director of a community service also formed part of the respondents. There were a combined total number of twenty-one (21) respondents from the four local municipalities. All key participants contributed to all methods which were used by the researcher to collect the data.

### **3.6 Questionnaire survey**

The researcher used questionnaire survey in a form of close and open-ended questions to collect primary data from waste management officials about the potential impacts of solid waste on the environment and human health. The questionnaires were administered to the directors of community services, waste managers and environmental engineer, refuse removal and cleansing service superintendents, landfill supervisors and interns of the waste management directorate in each of the local municipality. Appendix 1 depicts the questionnaire survey guide utilised for the study by the researcher to collect the data. The questionnaire survey guide has three sections: Section A of the questionnaire survey

contained questions on socio-economic characteristics and Section B contained questions about the potential implications of waste on the environment and human health.

### **3.7 Interviews**

Structured interviews were used to collect primary data on the municipal solid waste management strategies and their effectiveness from the municipal solid waste management officials in Vhembe District Municipality. The researcher also interviewed the directors of community services, waste managers and environmental engineer, refuse removal and cleansing service superintendents, landfill supervisors and interns of the waste management directorate in each of the local municipality. It was also used to collect data from waste management officials on the application of existing policies and guidelines pertaining to waste management and their effectiveness.

The researcher used the questionnaire guide as a tool to collect the data and it has two sections: Section A contains questions on socio-economic characteristics; and Section B contains questions on waste management practices, policies and guidelines. Appendix 2 depicts the interview guide used by the researcher to collect the data. The researcher also collected secondary data through structured interview about the statistics of the waste management personnel, tariff charged for waste collection, waste disposal and recycling quantities, waste collection timetable, number of equipment utilized and waste management by-laws (policies and guidelines). The interviews helped the researcher to obtain information that could not be collected by other methods. The interviews were recorded for the purpose of accuracy of information.

### **3.8 Focus group discussion**

Focus group discussion refers to the informal discussion among selected individuals on a particular topic. Focus groups discussion for this study was used to gather both primary and secondary data on the factors affecting sustainable waste management practices from waste management officials in Vhembe District Municipality. The participants of the discussion included directors, waste managers and superintendents, environmental engineers and interns. The researcher did not manage to include landfill supervisors, drivers, foreman and collection crew because it was going to affect waste management processes such as collection and transportation, landfill operation and the administration structure work. It was also used to gather data on policies and guidelines pertaining to waste management from waste management officials.

The researcher prepared the questions or topics for discussion based on institutional, technical, socio-cultural, financial aspect and policy and strategies. Focus group discussion guide does not have sections like questionnaire survey and interview guide but it contained questions on problems encountered by local municipalities when managing solid waste. Appendix 3 depicts the focus group discussion guide utilised by the researcher to collect data. The researcher facilitated the discussions that were recorded at their work place for the purpose of accuracy of information.

### **3.9 Field observation**

Field observation for this study was utilized in the form of participant observation by the researcher and waste management officials to gather information on the waste management practices and how the municipal solid waste affects the environment and human health. Participant observation validated information obtained from interviews, questionnaire surveys and focus group discussion as the researcher followed waste collection crew from point of collection until the last resort which is disposal at the landfill site, thus gave a true picture of municipal solid waste management system used, potential implications of waste and problems encountered when managing waste within a district. The researcher conducted field observation in residential areas, public spaces, urban centre, landfill sites, illegal dump sites, catchment areas, transfer stations and recycling facilities. That was an effective and efficient way of acquiring information which led the researcher to the reliable conclusion about the concern of this study.

Field observation was also used to collect information on the application of policies and guidelines pertaining to waste management in Vhembe District Municipality. An observation checklist used to collect the data on policies and guidelines in the district. Appendix 4 depicts the checklist utilised to collect the data during field observation. During field observation photographs were taken as evidence of the waste management system used.

### **3.10 Limitation of the study**

The time allocated limited the researcher's ability to effectively investigate since it was not possible for the researcher to be in the study area for extended period of time. Another key limitation of the study was the fact that the data collection could not be carried out by the researcher alone as other waste management processes need the waste management officials to explain to the researcher. The researcher did not manage to involve all waste management officials on focus group discussion and interview as it was going to affect waste management

processes such as collection and transportation and landfill operation as well as the administration work.

### **3.11 Ethical clearance certificate**

The researcher took a number of ethical steps to ensure that this research was ethically acceptable. The researcher wrote letters to the local municipalities of Vhembe District Municipality to seek permission to conduct the study and the permission was granted. The researcher informed the respondents about the purpose of the study and their rights were stated clearly. The consent to participate in the study was sought and participants were informed that participation to study was voluntary. However, the respondents were encouraged to take part or to participate in the study so that the researcher will get useful and reliable information for the study. The researcher also informed the respondents that they had the rights to withdraw their participation in the study and they are allowed to do so at any given time of the study.

The researcher also advised the respondents of the days on which field observation and photographs were to be taken and when the collection crew was followed to see how they manage waste. It ensured no conflict between the researcher and the waste management crew. Field work plan was made with the respondents from each local municipality to ensure that there was no conflict with regards to time. Appendix 5 depicts the ethical clearance certificate of the researcher. The data obtained regarding individuals and institutions was kept strictly confidential and securely stored in the researcher's electronically personalised and protected files. Unless prior data and explicit consent was given, research data was not presented in a way that could possibly identify any person(s).

## CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

### 4.1. Introduction

In this chapter, the research findings were presented and analysed. This chapter firstly presents a demographic profile and educational qualification of the participants, responsibilities of waste management sections, waste management organisational structure, integrated development plan and integrated waste management plan of the municipalities. It also presents data on the waste generation and waste management strategies currently being employed by the municipalities within a district. This chapter also gives a detailed presentation of the factors affecting sustainable waste management practices within local municipalities. Data on the impacts of municipal solid waste on the human health and the environment within a district are presented and analysed.

### 4.2 Demographic profile and educational qualification of the respondents

#### 4.1.1 Gender and ages of the respondents

The respondents who participated in the study were both male and female officials from Vhembe District Municipality. The respondents interviewed were from Musina, Makhado, Thulamela and Collins Chabane Local Municipalities. The respondents were grouped according to their age and gender (Table 4.1). The age group of 21-30, 31-40 and 41-50 were identified based on gender and the total number of each group expressed in percentage. A total number of 17 respondents participated in this study, 47% being male and 53% were female (Figure 4.1). Females had the highest number in the age group 31-40 with 56%. It shows that municipalities are capacitated by young people as aging of the personnel affects waste management value chain because elderly people are unable to work like young people.

Table 4. 1: Gender and ages of the respondents.

Ages of the respondents	Male	Percentage	Female	Percentage
21-30	2	25%	4	44%
31-40	3	38%	5	56%
41-50	3	38%	0	0%

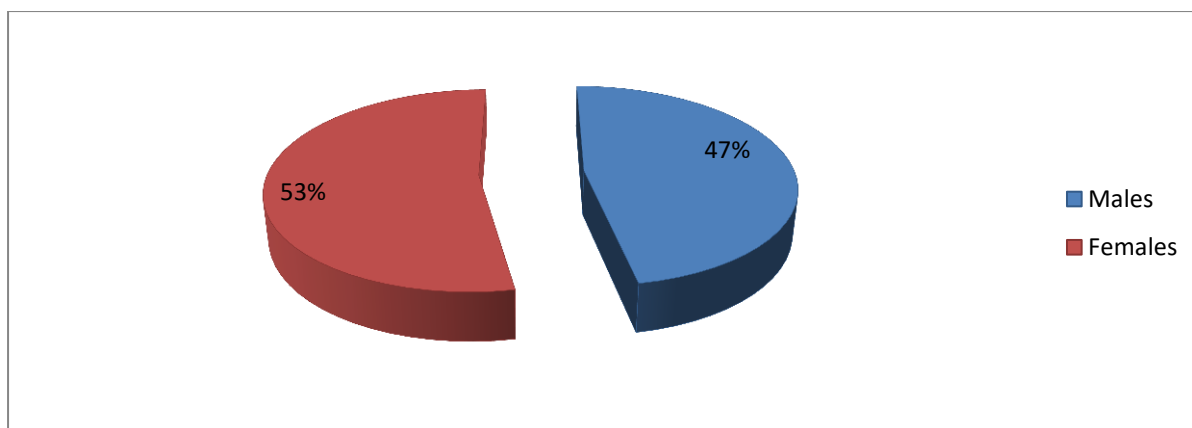


Figure 4. 1: Gender of the respondents on the study.

#### 4.1.2. Educational qualification of the respondents

Figure 4.2 below shows educational qualifications of the respondents interviewed. 8% of the respondents interviewed have secondary qualification, 25% have Environmental Sciences Bachelor’s Degree, 34% have Environmental Sciences Honours Degree, 17% have B-Tech in Environmental Sciences, 8% have PhD in Environmental Sciences and 8% have Honours Degree in LLB. It shows that waste management directorate within municipalities are capacitated by appropriate trained personnel who had the requisite tertiary qualifications for waste management and this will help municipalities to implement sustainable waste management strategies/practices.

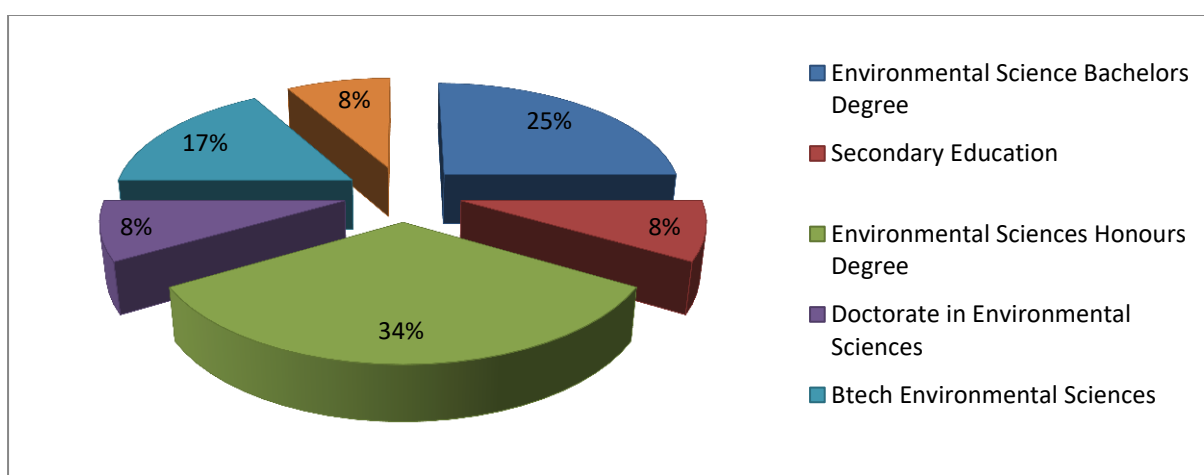


Figure 4. 2: Educational qualifications of the respondents.

#### 4.1.3. Job titles of the respondents

The respondents participated in the study were directors, waste managers, supervisors, superintendents, drivers and interns (Figure 4.3). 22% of the respondents interviewed were

waste managers, 29% were superintendents, 7% were directors, 21% were landfill supervisors and 14% were interns and 7% were drivers. This indicates that waste management sections within municipalities have sufficient capacity and waste management value chain would not be affected by shortage of staff as officials on the managerial levels have their assistants.

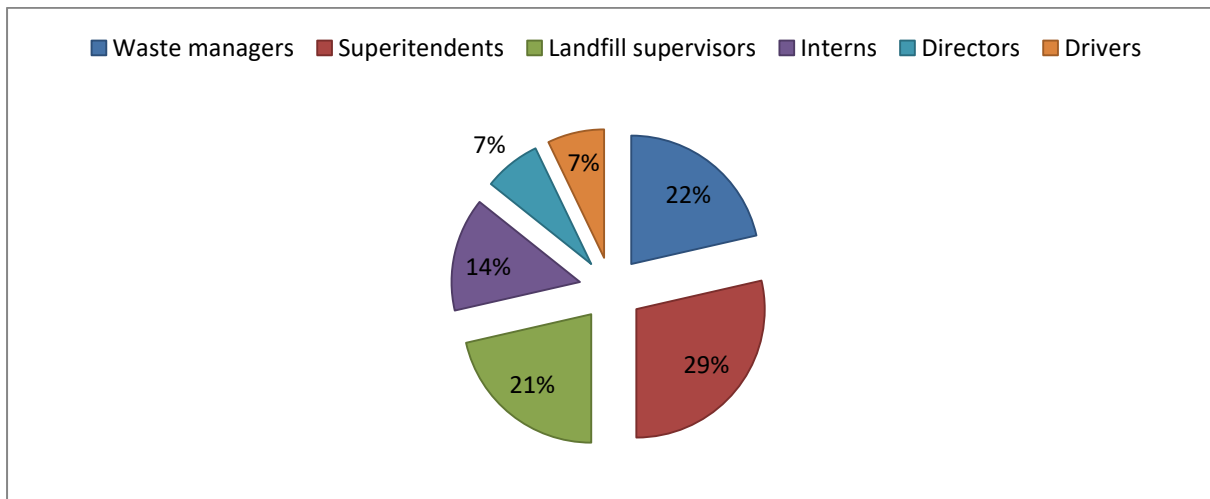


Figure 4. 3: Job titles of the respondents.

#### 4.2 Responsibility of Vhembe District Municipality Waste Management Directorate

Vhembe District Municipality has a Waste Management Directorate that makes sure that waste management activities are conducted according to the legal framework pertaining to waste management. It further ensures that communities receive environmental education on how to manage waste in a sustainable manner in order to reduce amount of waste eventually end up in landfill sites.

The directorate also makes sure that trucks are collecting waste as scheduled and are going to the collection points in time to collect waste, all waste management vehicles are in good condition, landfill sites, buy back centers, transfer stations and drop-off points facilities are well managed. It also works into labour issues. It is responsible for the safety of personnel at work place and to monitor if services are rendered in a way that communities and the environment would not be affected by waste. The directorate also plans, develops, maintains parks, recreation facilities, and cemetery management and manage municipal servitudes. In conclusion, waste management directorate within a district is the one that ensures that the towns and community settlement areas within the district are clean.

### 4.3 Solid Waste Management organizational structure in Vhembe District Municipality

Waste management organizational structure in Vhembe District Municipality is presented in (Figure 4.4). The organizational structure comprises of directors and their assistants at the management level. The organogram comprises of Directors of community services as well as general workers, waste management managers, refuse removal superintendents, cleansing superintendents and foreman both in refuse removal and cleaning service and landfill supervisors. The foreman personnel are responsible for making sure that trucks are going out for collection in time and to the right locations.

The street cleaners are responsible for cleaning the streets in the city and urban residential roads. In residential areas, waste management is left to the members of the community; drivers and waste collection crew who move around residential areas collecting the waste stored in refuse plastic bags and street liter bins. Landfill supervisors are ensuring that landfill sites are being operated as per the license conditions/requirements.

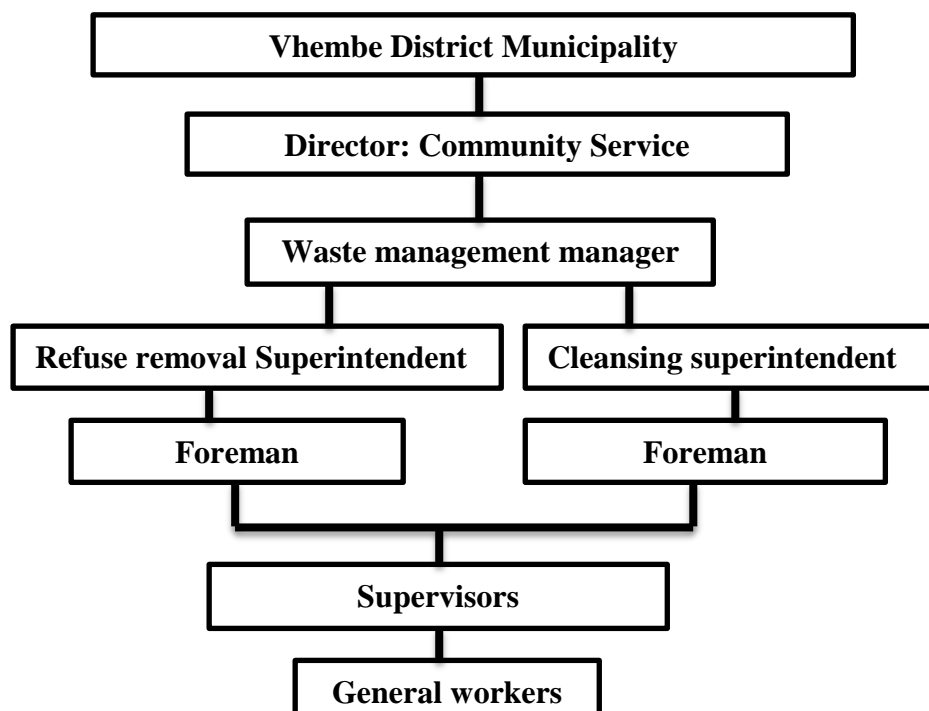


Figure 4. 4: Solid Waste Management organizational structure in Vhembe District Municipality.

The Vhembe District Municipality that has four local municipalities has a total of 214 permanent and 1000 temporally workforce (Table 4.2). Makhado Local Municipality has the highest number of permanent workers (127); whereas Thulamela Local Municipality has the highest number of temporally workers (796) Collins Chabane Local Municipality has the

lowest number of permanent workers (11). The total number of waste management personnel in Vhembe District Municipality is 1242 of which 18% are permanent workers and 82% are temporally workers (Figure 4.5).

Table 4. 2: Waste management personnel of Vhembe Local Municipalities.

Municipalities	Permanent workers	Temporally workers	Total no of personnel
<b>Makhado</b>	127	22	149
<b>Thulamela</b>	56	796	852
<b>Collins Chabane</b>	11	68	79
<b>Musina</b>	20	114	134
<b>Total</b>	214	1000	1214

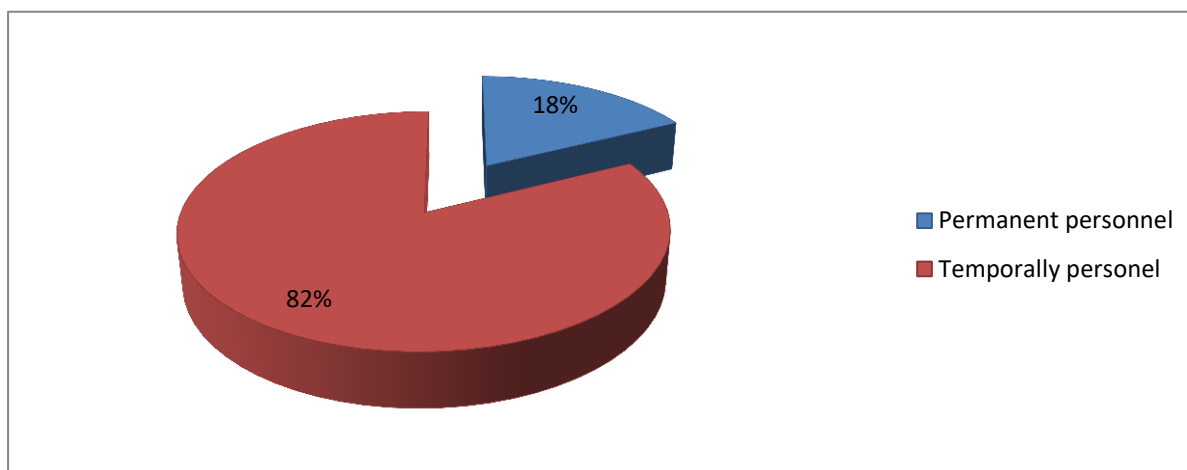


Figure 4. 5: Waste Management Personnel of Vhembe District Municipalities (%).

#### 4.4 Integrated Waste Management Plan and Integrated Development Plan

The respondents interviewed in the local municipalities said that Thulamela and Makhado Local Municipalities had up-to-date Integrated Waste Management Plan (IWMP) and these municipalities had already received financial and technical waste management support from independent trust fund of the National Department of Environmental Affairs (NDEA). Musina and Collins Chabane Local Municipalities reported that their Integrated Waste Management Plans are under review and these municipalities are relying on the already existing District Integrated Waste Management Plan as a guide. The Municipal Integrated Waste Management Plans are aligned with Integrated Development Plan. Integrated Waste Management Plan is reviewed after five-year cycle, whereas Integrated Development Plan (IDP) is reviewed every year.

The respondents further stated that, the delay on the development and implementation of Integrated Waste Management Plans by municipalities at local level affects implementation of sound waste management system. Unavailability of Integrated Waste Management Plan leads to unsuitable implementation of the waste management hierarchy and the targets of zero waste management strategy will be difficult to achieve. The respondents said that in the absence of the Integrated Waste Management Plan within municipalities, waste by-laws cannot be aligned properly with the National Waste Management Policy. Integrated Waste Management Plan comprises information about the gaps identified in the implementation of the waste management hierarchy and alternatives to bond the identified gaps. Waste management plan also includes goals, objectives, short, medium and long-term targets together with strategies to be implemented by municipalities.

#### **4.5. Municipal waste management practices/strategies in Vhembe District Municipality**

##### **4.5.1 Waste prevention and minimization**

Municipalities within the district do not have waste prevention and minimization strategies in place, which are the highest priorities of the waste management policy. The respondents interviewed stated that some people within communities do separation at source while others do not separate waste at all. The respondents further stated that there are no equipment and program in place by municipalities to encourage waste separation at source. Municipalities do not have household's recyclable receptacles to encourage separation at source. Unavailability of household receptacles leads communities to mix recyclable materials with non-recyclable materials. In Musina Local Municipality, waste separation at the source is only done by the recyclers. The recyclers separated and stored card boxes in Musina town (Figure 4.6). The study conducted in Malaysia reported the same results that waste separation is rare and it is only done by waste collection crew and rag pickers.



Figure 4. 6: Separated card boxes by Musina recyclers.

Municipalities are encouraging the communities to reuse waste materials to avoid large amount of waste that eventually ends up in landfill sites, for example, to utilize tins and containers to store their seeds and to use plastic bags that they have to carry their groceries instead of purchasing new plastic bags. The respondents stated that communities are being educated on monthly and quarterly basis through environmental awareness campaigns, school out-reach and imbizos on how to prevent waste generation through reusing some of the waste materials. The communities are not able to manage waste in a sustainable manner through separation at source, waste minimization and recycling even if they are being educated.

#### **4.5.2. Waste generation**

The respondents interviewed stated that due to dramatic increases in population especially in urban areas, the amount of waste generated dramatically increases as a consequence. Waste generation is directly proportional to the population growth. The other respondents said that large amount of waste generation is also caused by congestion of people in towns during month-end when people are doing shopping. People are also greatly relocating from rural areas to urban centers for better standard of living which leads to high population in urban areas. In Musina Local Municipality, there is high population as compared to Thulamela, Makhado and Collins Chabane because Musina Local Municipality is situated at the boarder of the two countries, South Africa and Zimbabwe.

Vhembe District Municipality generates different types of municipal solid waste which include industrial, commercial and residential waste. The produced waste is categorized as general waste, garden waste and building rubbles. Makhado Local Municipality produces the highest amount of waste on a monthly basis whereas Musina Local Municipality produces the least amount of waste (Table 4.3). The total amount of waste produced in Vhembe District Municipality is summarized and the category of waste is presented and the bulk of waste generated is general waste comprising 9942 tons, garden waste is 3651 tons and building rubbles is 1930 tons and general waste is representing 64% of waste produced. Garden waste is 24%, while building rubbles is 12% (Figures 4.7). Municipalities also generated different quantities of waste per square meter within local municipalities, for example, In Makhado Local Municipality waste generated within square meters is 8 tons, Thulamela Local Municipality generated 6 tons per square meters, Collis Chabane Local Municipality generate 2 tons per square meters and Musina Local Municipality generate 4 tons.

Table 4. 3: Monthly waste generated within Vhembe District Municipality (tons).

<b>Municipalities</b>	<b>General waste</b>	<b>Garden waste</b>	<b>Building rubbles</b>	<b>Total waste generated (ton)/month</b>
<b>Makhado</b>	5044 tons	1826 tons	1130 tons	8000 tons
<b>Thulamela &amp; Collins Chabane</b>	3500 tons	1500 tons	500 tons	5500 tons
<b>Musina</b>	1398 tons	325 tons	300 tons	2023 tons
<b>Total</b>	9942 tons	3651 tons	1930 tons	15523 tons

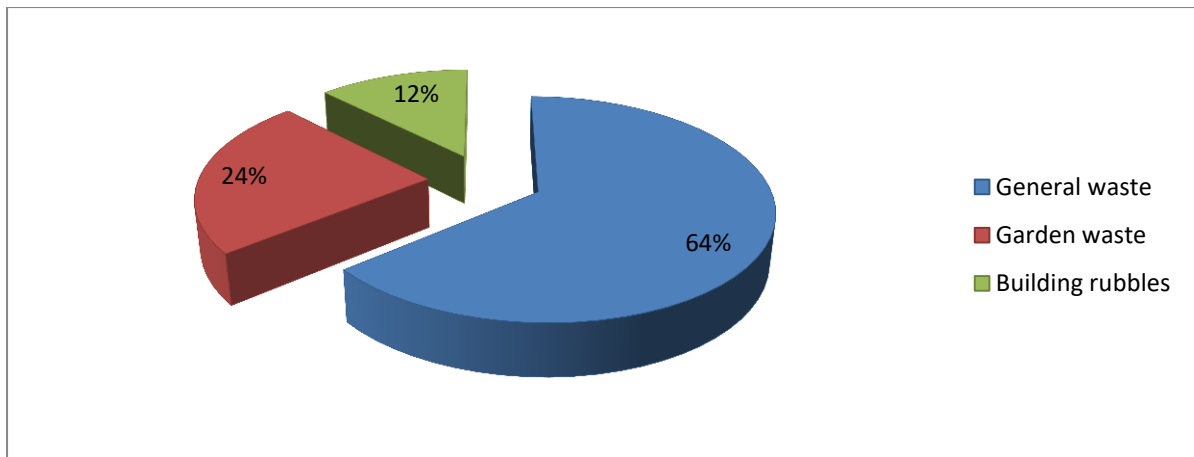


Figure 4. 7: Monthly waste generated in Vhembe District Municipality.

#### 4.5.3. Waste storage

Respondents interviewed said that there are different waste storage facilities used in different areas within the district municipality. Waste from residential areas are stored in refuse plastic bags and placed outside the gate of the houses waiting for collection (Figure 4.8). Municipalities do not provide communities with refuse plastic bags as they are easily tired by creatures such as dogs and rats when looking for food materials. Some of the wastes from residential areas are stored in plastic and metallic bins.



Figure 4. 8: Refuse plastic bags with domestic waste waiting for collection.

In commercial and institutional area, waste is stored in skip bins, plastic and metallic bins. Skip bins are used in areas where large amount of waste is being produced (Figure 4.9). Skip bins, plastic and metallic bins are provided by the municipalities. The bins used are different in terms of sizes; some of them are 240 liters, 80 liters and 60 liters bins (Figure 4.10). Makhado and Musina Local Municipalities also use CCTV bins for waste storage by the public (Figure 4.11).



Figure 4. 9: Skip bins for commercial and institutional waste storage.



Figure 4. 10: Street litter bins for waste storage within towns and urban centres.



Figure 4. 11: CCTV storage facility used by some other municipalities in the district.

The respondents reported that municipalities also use transfer stations and drop-off point facilities for temporarily storage (Figure 4.12). Municipalities constructed transfer stations and drop-off point facilities in areas far from the landfill sites. Transfer station and drop-off point

facilities are constructed to avoid too much transport cost of waste to the landfill sites. Waste is collected once per week, per collection schedule to the landfill sites.



Figure 4. 12:Dzanani transfer station in Makhado Local Municipality.

Recyclers also separate recyclable materials such as cans, bottle, glass, papers, aluminum and boxes at the transfer stations before waste can be transported to the landfill site. Information on the transfer station is generally posted on bill boards (Figure 4.13). The notice board states that the following waste materials are prohibited to enter the transfer stations: construction and demolition waste and garden, medical, sewage waste, asbestos and pesticides waste.



Figure 4. 13: Notice board of Dzanani Transfer station in Makhado Local Municipality.

Within the district, there are number of drop-off center and transfer station facilities (Table 4.4). Collins Chabane Local Municipality has 1 transfer station which is not functional at Vuwani, but there is no drop-off point facility. Thulamela Local Municipality has 6 transfer stations at Makonde, Tshikombani, Mulenzhe and Tshaulu. Thulamela Local Municipality also has 5 drop off point facilities at Malavuwe, Tshaulu and Tshandama, however, those transfer stations and drop off center are not yet functional due to unavailability of licenses. Makhado Local Municipality has 1 transfer station at Dzanani region and six drop-off point facilities at Sinthumule-Kutama village and those facilities are functional. Vhembe District Municipality has a total number of 8 transfer stations and 11 drop-off center facilities, 1 transfer station 6 and drop-off point facilities are functional.

Table 4. 4: Number of transfer stations and drop-off centre facilities within the district.

Local Municipalities	Makhado	Thulamela	Collins Chabane	Musina
Transfer station	1	6	1	0
Drop-off point	6	5	0	0

#### 4.5.4. Collection and transportation

There are different waste collection methods used within a district. The respondents interviewed said that in urban areas waste is collected from door to door because there is a

good route network. In rural areas, waste is collected from roadside as there is no good route network and it is difficult to reach collection points. In Vhembe District Municipality, waste is collected and transported using refuse compactor trucks, half trucks, LDV bakkies, and tractors and skip loader truck to the landfill sites. Skip loader truck is used to collect skin bins each and every time when it is full and transport it to the landfill site. The respondents said that institutions such as University of Venda collect and transport waste on its own to the landfill site. University of Venda uses a tractor trailer combination to collect waste stored in skip bins and half trucks to collect waste stored in bins to the disposal site (Figure 4.14).



Figure 4. 14: Waste storage facilities used by University of Venda.

Vhembe District Municipality refuse compactor truck works with one driver and three waste collectors to pick up the refuse bags and load them into the truck (Figure 4.15). Skip loader works with a driver only to collect only the skip bins.



Figure 4. 15: Waste collection and transportation in Vhembe District Municipality.

Municipalities have waste collection timetable. Waste is collected differently in terms of days, time, location and frequency of collection. The respondents interviewed said that Makhado Local Municipality has the following collection location: industrial areas, central business district (CBD) and residential areas (Table 4.5). In CBD, waste is collected twice daily from 14H00-5H00. In industrial areas, waste is collected on Monday, Wednesday and Friday from 8H00-12H00 and it is collected once per day. In residential areas, waste collection varies in terms of the day of collection. At Makhado town, households waste is collected every Tuesday and Thursday, Tshikota households waste is collected on Friday and Makhado Extension 8 waste is collected on Tuesday. In residential areas, waste is collected once per day from 8H00- 12H00.

Table 4. 5: Waste collection time table in Makhado Local Municipality.

<b>Wards/Location</b>	<b>Days of collection</b>	<b>Time</b>	<b>Number of collection</b>
<b>CBD</b>	Daily	02H00-05H00	Twice per day
<b>Industrial area</b>	Monday, Wednesday & Friday	08H00-12H00	1 per day
<b>Residential areas</b>			
<b>Makhado Town Households</b>	Tuesday and Thursday	08H00-12H00	1 per day
<b>Tshikota households</b>	Friday	08H00-12H00	1 per day
<b>Makhado town Extension 8</b>	Wednesday	08H00-12H00	1 per day
<b>Route</b>			
<b>Kutama</b>	Sunday	08H00-12H00	1 per day
<b>Vleifontein R293</b>	Tuesday & Friday	08H00-12H00	1 per day
<b>Watervaal</b>	Monday & Thursday	08H00-12H00	1 per day
<b>Braamboss &amp; Tshakhuma</b>	Wednesday	08H00-12H00	1 per day
<b>Williespoort to siloam</b>	Tuesday & Thursday	08H00-12H00	1 per day

The respondent interviewed at Collins Chabane Local Municipality said that waste is collected in terms of days of collection at each ward (Table 4.6). On Monday, waste is collected at CBD and villages which include Malamulele Block A, Xhikundu, Saselemani

and Mhinga village. On Tuesday, waste is collected at CBD and Malamulele Block B1. On Wednesday, waste is collected at CBD, Malamulele Block B2, Xhikundu, Saselemani and Mhinga village. On Thursday, waste is collected at CBD, Malamulele Block C and D. On Friday, waste is collected at CBD, Xhikundu, Saselemani and Mhinga village. Waste is collected once per day on Monday until Friday from 08H00-13H00. Waste is collected every day at the CBD.

Table 4. 6: Waste collection time table in Collins Chabane Local Municipality.

Days of collection	Ward/Location	Time	Number of collection
<b>Monday</b>	Malamulele Block A, CBD, Xhikundu, Saselemani, Mhinga village	08H00-13H00	1 per day
<b>Tuesday</b>	Malamulele Block B1, CBD	08H00-13H00	1 per day
<b>Wednesday</b>	CBD, Malamulele Block B2 and Xhikundu, Saselemani, Mhinga village	08H00-13H00	1 per day
<b>Thursday</b>	CBD & Malamulele Block C & D	08H00-13H00	1 per day
<b>Friday</b>	CBD, Institutional areas, Xhikundu, Saselemani, Mhinga village	08H00-13H00	1 per day

The respondents interviewed at Musina Local Municipality stated that waste is collected differently in terms of days of collection at each ward/collection point (Table 4.7). On Monday, waste is collected at CBD, Nancefield Ext 1, hostel and proper, schools and industrial areas, Ngwele mutsi and long homes and schools. On Tuesday, waste is collected at Musina Ext 1 and 5, Rwanda, skoonplaas, Mushongo, phase 13 and Nancefield Ext 2. On Wednesday, waste is collected at Musina proper, Nancefield Ext 8: phase 1,2,3,4,5,6 Tana Na shishevo partial, phase 10,11,12, CBD and schools. On Thursday, waste is collected at Musina Ext 4 and 14, Nancefield Ext 8: phase 7, 8,9,10 partial, Tana na shishevo partial, Ext 9 and 10 partial. On Friday, waste is collected at Musina Ext 2, 6, 7 and 8 Nancefield Ext 9 and 10 partial (sihlala nge nkani, Happer and Campbell, CBD and schools. On Surtaday, waste is collected at Mushongo ville: Phase 13 and 4. Waste is collected 3 times per day in areas where collection is done on Monday and Friday. Areas where waste collection is on

Tuesday, Wednesday, Thursday and Saturday, the collection frequency is twice per day. Waste is collected from 07H00-16H00.

Table 4. 7: Waste collection time table in Musina Local Municipality.

Days of collection	Ward/Location	Time of collection	Number of collection
Monday	Nancefield Ext 1, Schools and industrial areas, Nancefield hostel and proper, Ngwele mutsi and long homes including business areas and schools	07H00-16H00	3
Tuesday	Musina Ext 1 and 5, Rwanda, skoonplaas, Mushongo, phase 13 & Nancefield Ext 2	07H00-16H00	2
Wednesday	Musina proper, Nance field Ext 8: phase 1,2,3,4,5,6 Tana Na shishevo partial, phase 10,11,12 and business areas and schools	07H00-16H00	2
Thursday	Musina Ext 4 & 14, Nancefiled Ext 8: phase 7,8,9,10 partial, Tana na shishevo partial, Ext 9 & 10 partial	07H00-16H00	2
Friday	Musina Ext 2, 6, 7 and 8 Nancefield Ext 9 and 10 partial (sihlala nge nkani, Happer & Campbell, business areas and schools	07H00-16H00	3
Saturday	Mushongo: Phase 13 and 4	07H00-16H00	2

In Thulamela Local Municipality, waste is collected differently in terms of days of collection and time of collection (Table 4.8). The collection of waste also includes the collection along the road. In Central Business District (CBD), waste is collected daily and twice a day. Waste from industrial, institutional areas and along the main road is collected daily. In all locations waste is collected from 08H00-16H00. Waste from industrial and institutional areas is collected once per day. In Thulamela Local Municipality waste is collected from Monday to Sunday.

Table 4. 8: Waste collection time table in Thulamela Local Municipality.

Days of Collection	Ward/Location	Time of collection	Number of Collection
<b>Monday</b>	Thohoyandou & Sibasa CBD, Thohoyandou Block P, F, G, Dzondo, Mvudi, Mudaswali & Nqwenani rivers, Matangari to Tshiombo village	08H00-16H00	1 per day

<b>Tuesday</b>	Thohoyandou Block P, C, D, A, Q, G, J, K, Mbilwi, Mathule and Makwarela village, Tshidumbi, Manzere river & Duthuni Dam, Sibasa traffic, Department of education and magistrate offices	08H00-16H00	1 per day
<b>Wednesday</b>	Thohoyandou & Sibasa CBD, Muledane Block N, S & H, Shayandima, marude & Khwevha Commercial secondary schools, School of tomorrow, Tshidumbi, Mashila Primary , Lurenzheni, Manzere and Dambalwashi primary school, The Fig tree & For a change hotels, Shayandima clinic & town, Matidze lodge, Ditike, Tswana Zwavhvhili, Dzwerani, Duthuni and Mapate village.	08H00-16H00	1 per day
<b>Thursday</b>	Thoyandou unit C, E, J, Thohoyandou & Sibasa CBD, Muledane, Maungani, Shayandima villages & industrial area, Tshisaulu & Maungani riverside, Mvudi park, Maniini Block M-East	08H00-16H00	1 per day
<b>Friday</b>	Makwarela town, villages and institutional areas, Maniini villages, Tswana Villages	08H00-16H00	1 per day
<b>Saturday</b>	CBDs, Tshikombani, Tshifudi and Makonde Stadiums, Phangami Mall, Mukula Complex, T/ndou government building	13H00-19H00	1 per day
<b>Sunday</b>	Tshifulanani and Thohoyandou CBD, Tshisaulu, Lwamondo, Phiphidi, Tshalovha and Tshililo village	11H00-15H00	1 per day

Waste collection crew, street cleaners, landfill operators, scavengers, and drivers are provided with personal protective clothing or equipment to ensure that they are safe. Personnel are provided with a 1 pair of mask, work suit, t-shirt, protective boots, cricket hat and hand gloves.

#### 4.5.5. Recycling

The respondents interviewed reported that Vhembe Local Municipality does not have formal recycling activities. Recycling activity is left to the mercy of private companies and individuals. Municipalities are encouraging communities to alleviate poverty through doing recycling activities in order to generate income. Municipalities also provide recyclers with technical waste management support. Makhado and Musina Local Municipalities have recycling forums to discuss about recycling related matters which are held in quarterly basis. In Thulamela and Collins Chabane Local Municipalities, recycling forums are held monthly to discuss recycling related matters.

Municipalities also invite people who are successful in recycling to motivate individuals who are doing recycling. There are personnels from different recycling companies which are working in the landfill sites to sort recyclable materials. Materials which are collected are cardboardes, cans, glasses, plastic and cans. After collection, they are compacted using bailing machines (Figure 4.16), and transported once a weak to big recycling companies in Gauteng for further processing. Makhado Local Municipality has recycling facility for storing recyclacle materials whithin a landfill site (Figure 4.17). Materials are seperated on a daily basis within the landfill sites and stored on sacks within the landfills (Figure 4.18).



Figure 4. 16: Bailing machine used by Matongoni recycling company at Makhado Landfill Site.



Figure 4. 17: Recycling facility at Makhado Landfill Site.



Figure 4. 18: Sacks of recycling materials separated by recyclers within the district.

The respondents interviewed said that Collins Chabane Local Municipality has 1 recycling company called Kensha Mills Recycling which is in town for collection of recyclable materials (Table 4.9). The materials recycled include 18 tons of glass bottles and 17 tons of aluminium cans and cans are representing 51%, whereas aluminium cans are 49% (Figure 4.19). These materials are sold to large recycling companies called PECTCO distel and Consol for further processing. The company has 3 permanent male employees and 3 temporarily male employees. The company also has 1 bailing machine and 1 weighing scale.

Table 4. 9: Kensha Mills Recycled materials, equipment, workers and company sold to.

Recycling company	Equipements	No. of Workers	Quantity recycled in tons/month	Recycling company sold to
<b>Kensha mills recycling</b>	1 bailing machine and 1 weighing scale	3 permanent male workers and 3 male temporary workers	17 tons aluminium can and 18 tons glass bottles	PECTO distel and Consol

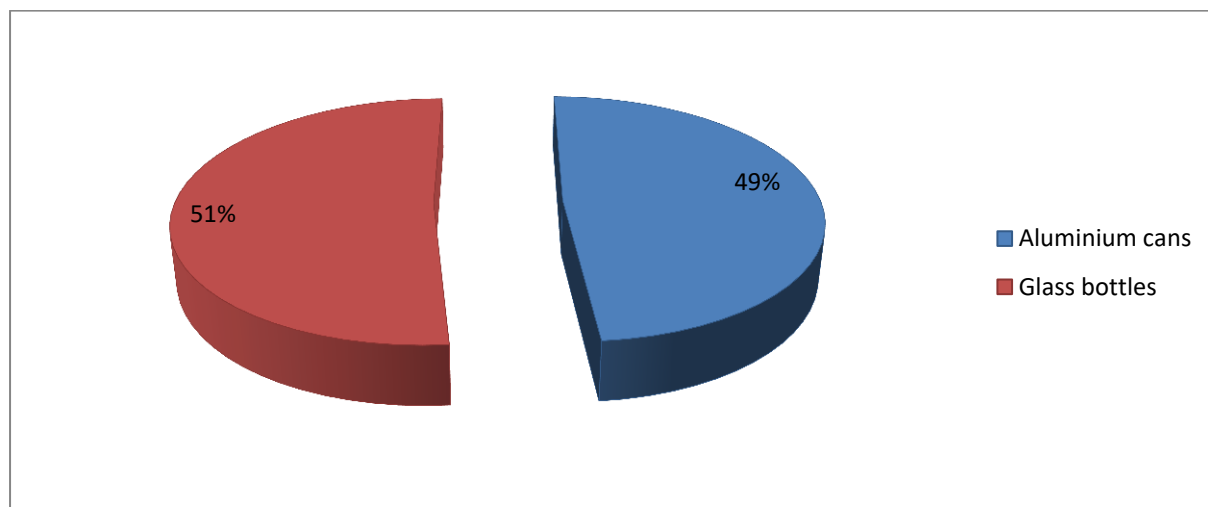


Figure 4. 19: Kensha Mills recycled materials in percentage.

Thulamela Local Municipality has 3 recycling companies, for example, Keep It Clean Environmental Solution based at the landfill site for collection of recyclable materials. The materials recycled include 18 tons of plastics, 15 tons of papers, 30 tons of cardboardes, 30 tons of bottles, cans are 30 tons (Table 4.10). Plastics are representing 15%, papers are 12%, cardboardes are 25%, bottles are 24% and cans are 24% (Figure 4.20). Materials are sold to large recycling companies called Lothlorien and Extrupet Recycling for further processing.

The company has 5 female and 5 male permanent employees. The company also has 3 bailing machine, 3 weighing scale and 3 Pallet Jack.

Table 4. 10: Keep it Clean Environmental Solution Recycled materials, equipment, workers and company sold to.

Recycling company	Equipments	No of Labour	Quantity of materials in tons/month	Recycling company sold to
<b>Keep it clean environmenta l Solution</b>	3 weighing scales,bailing machines and pallet jack	5 female and 5 male permanant workers	Plastics 18 tons , papers 15 tons, cardboxes 30 tons, bottles 30 tons and cans 30 tons	Lothlorien Extrupet recycling

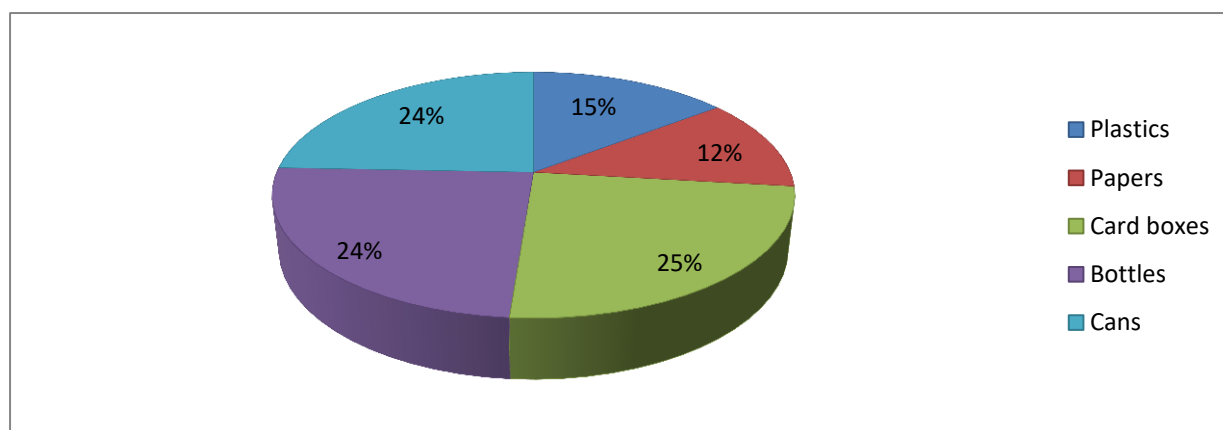


Figure 4. 20: Keep It Clean Environmental Solution recycled materials in percentage.

LTT Algemene Handelaars Recycling in Thulamela Local Municipality is based at the landfill site for collection of recyclable materials. The materials recycled include 15 tons of plasics, 24 tons of papers, 240 tons of cardboxes, 30 tons of bottles, and 30 tons of cans (Table 4.11). Plastics are representing 3%, papers are 7%, cardboxes are, 72%, bottles are 9% and cans are 9% (Figure 4.21). Materials are sold to large recycling companies called Extrupet, Consol, Sappi and Neopak Recycling for further processing. The company has 20 females and 4 males permanent employees. The company also has 3 bailing machine, 3 weighing scale and 3 forklifts.

Table 4. 11: LTT algemene Handelaars recycled materials, equipment, workers and company sold.

Recycling company	Equipments	No of Labour	Quantity of materials in tons/month	Recycling company sold to
<b>LTT Algemene Handelaars</b>	3 weighing scales,bailing machines and forklift	24 permanent workers(20 females and 4 males)	Plastic bottles 15 tons , papers 24 tons, cardboxes 240 tons, bottles 30 tons and cans 30 tons	Extrupet Consol Mpack/noepak & Sappi Neopak

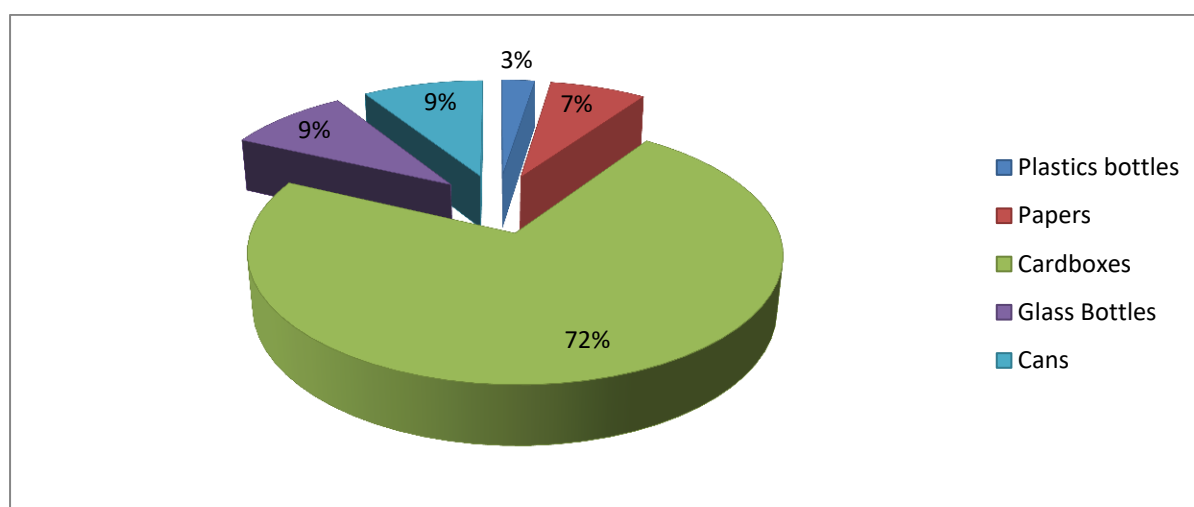


Figure 4. 21: LTT Algemene Handelaars recycled materials in percentage.

Shumani glass recycling company in Thulamela Local Municipality is based at the landfill site for collection of recyclable materials. The materials recycled include 15 tons of clear plastics, 70 tons of papers, 70 tons of cardboxes, 3.5 tons of plastic bottles, 30 tons of HD, 30 tons of Polyprop (Table 4.12). Clear plastics are representing 7%, papers are 32%, cardboxes are, 32%, Plastic bottles are 1%, HD is 14%, Polyprop is 14% and cans are 9% (Figure 4.22). Materials are sold to large recycling companies called Mpack and Remade Germiston Recycling for further processing. The company has 1 female and 4 male permanent employees. The company also has 2 bailing machine and 2 weighing scale.

Table 4. 12: Shumani Glass Recycling recycled materials, equipment, workers and company sold.

Recycling company	Equipments	No of Labours	Quantity of materials in tons/month	Recycling companies sold to
<b>Shumani Glass Recycling</b>	2 weighing scales and bailing machines	1 Female and 4 Males permanent workers	Plastics bottles 3.5 tons, Paper 70 tons, Cardboxes 70 tons, Clear plastics 15 tons, HD 30 tons, Polyprop 30 tons	Impact JHB Remade G

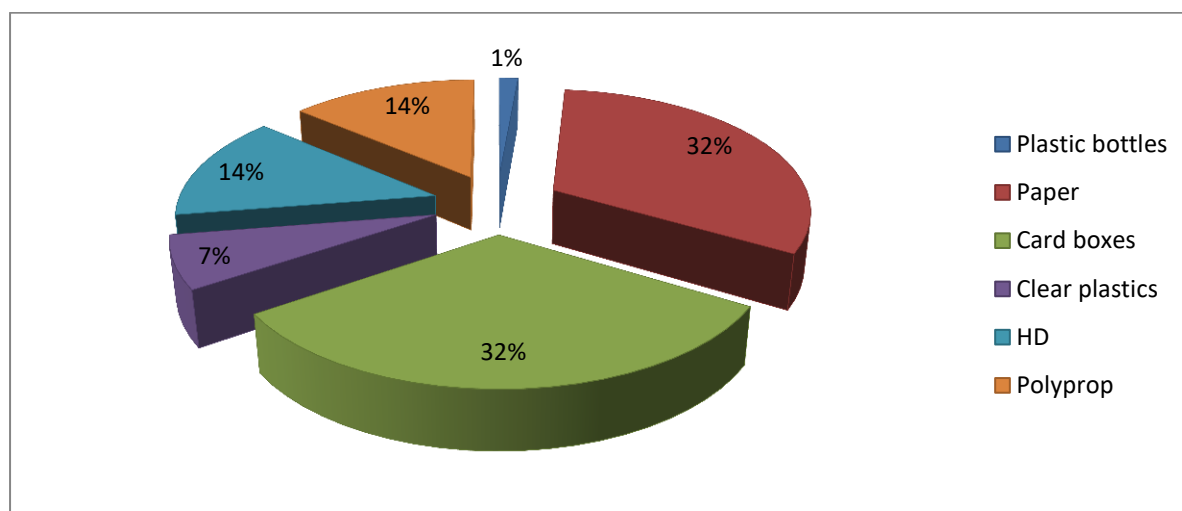


Figure 4. 22: Shumani Glass recycled materials in percentage.

Matongoni General Trading in Makhado Local Municipality is based at the landfill site for collection of recyclable materials. The materials recycled include 18 tons of plastics, 15 tons of papers, 30 tons of cardboxes, 30 tons of bottles (Table 4.13). Plastics are representing 15%, papers are 12%, cardboxes are 25%, bottles are 24%, and cans are 2% (Figure 4.23). Materials are sold to large recycling companies called Consol and PECTO distel for further processing. The company has 54 permanent employees. The company also has 2 bailing machine, 1 weighing scale and 1 Forklift.

Table 4. 13: Matongoni General Trading recycled materials, equipment, workers and company sold.

Recycling Company	Equipments	No. of Labours	Quantity of materials in tons/month	Recycling Company sold to
<b>Matongoni general trading</b>	2 bailing machines and 1 Focklift 1 weighing scale	54 permanent worker	0.8 tons cans, 33 tons plastics, 0.75 tons Aluminium, 6 tons paper	Consol and PECTO distel

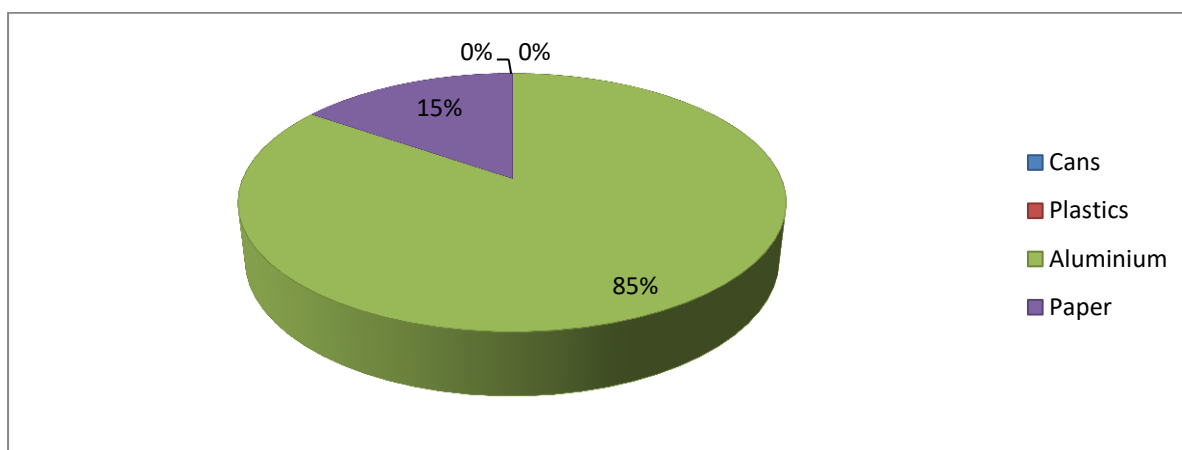


Figure 4. 23: Matongoni General Trading recycled materials in percentage.

Makhado Reclamation Group in Makhado Local Municipality is based in town for collection of recyclable materials. The materials recycled include 250 tons of ferrous metals, 10 tons of Non-ferrous Scrap metals (Table 4.14). Ferrous metals are representing 96% and Non-ferrous Scrap metals are representing 4% (Figure 4.24). Materials are sold to large recycling companies called Foundries: Scaw metal and Columbus for further processing. The company has 1 female and 4 male permanent employees. The company also has 2 bailing machines, 1 weighing scale and 1 excavator.

Table 4. 14: Makhado Reclaim Group recycled materials, equipment, workers and company sold.

Recycling company	Equipment	No. of Labours	Quantity of materials in tons/month	Recycling company sold to
<b>Makhado reclamation group (PTY) Ltd</b>	1 Excavator	1 Female and 4 Males permanent	Non-ferrous Scrap metals:10 tons and Ferrous metals: 250 tons	Foundries: Scaw metal and Columbus

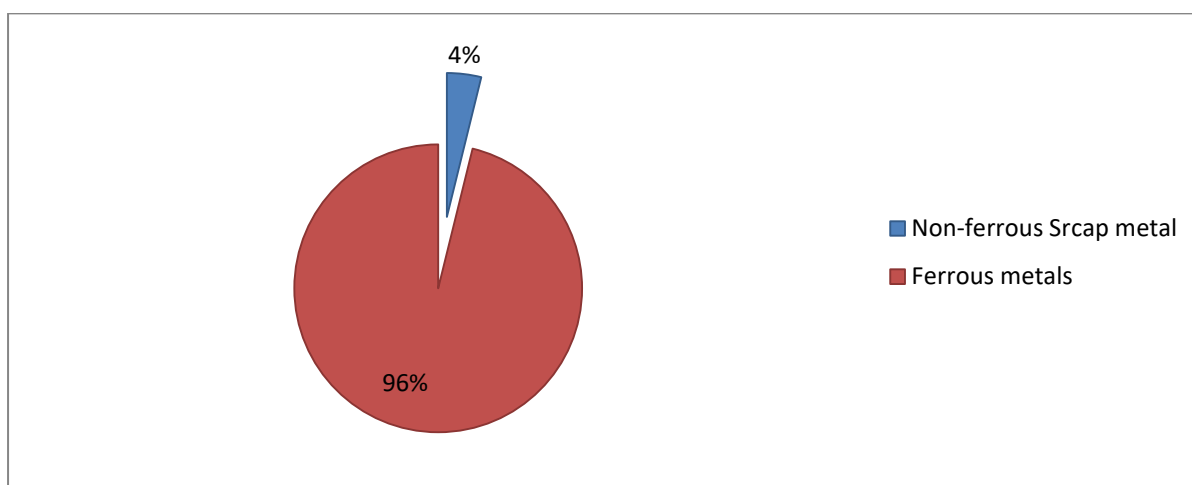


Figure 4. 24: Makhado Reclamation Group recycled materials in percentage.

Messina Recycling in Thulamela Local Municipality is based at the landfill site for collection of recyclable materials. The materials recycled include 64 tons of plastics, 8 tons of papers and 64 tons of cardboard boxes (Table 4.15). Plastics are representing 49%, papers are 14%, cardboard boxes are, 45%, bottles are 9% and cans are 9% (Figure 4.25). Materials are sold to large recycling companies called Sappi Recycling for further processing. The company has 4 female and 5 male permanent employees. The company also has 2 bailing machine, 1 weighing scale and 1 forklift.

Table 4. 15: Messina recycling recycled materials, equipment, workers and company sold to.

Recycling company	Equipements	No. of Labours	Quantity of materials in tons/month	Recycling company sold to
<b>Messina Recycling</b>	2 bailing machine and 1 weighing scale 1 forklift	5 male and 4 female permanent workers	8 tons papers, 64 tons Plastics 64 tons cardboard	Sappi

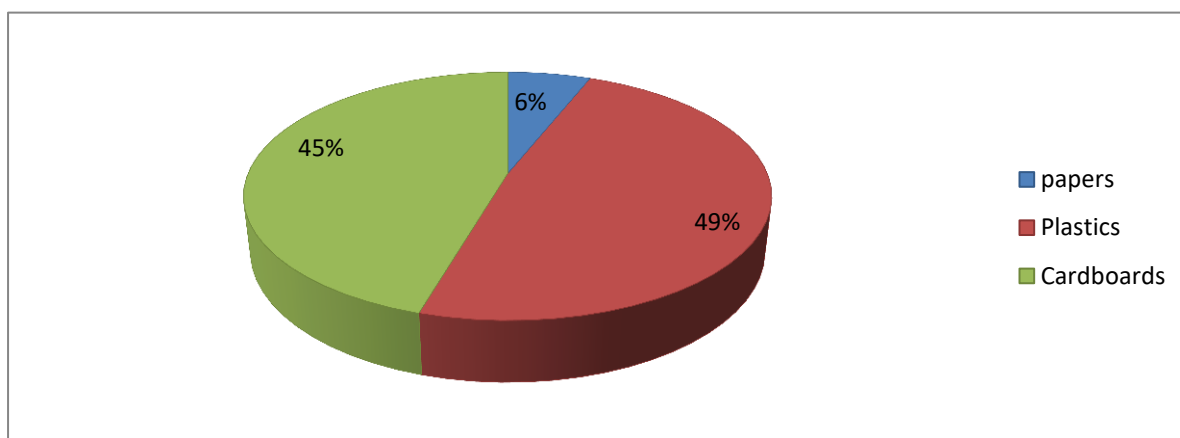


Figure 4. 25: Messina Recycling recycled materials in percentage.

Rehoboth Recycling in Makhado Local Municipality is based at the landfill site for collection of recyclable materials. The materials recycled include 6 tons of plastics, 27 tons of papers and 2 tons of cardboardes (Table 4.16). Plastics are representing 55%, papers are 14% and cardboardes are 18% (Figure 4.26). Materials are sold to large recycling companies called Extrupet, Consol, Sappi and Neopak Recycling for further processing. The company has 5 male permanent employees. The company also has 1 bailing machine and 1 weighing scale.

Table 4. 16: Rehoboth Recycling recycled materials, equipment, workers and company sold to.

Recycling company	Equipements	No. of Labours	Quantity of materials in tons/month	Recycling company sold to
<b>Rehoboth Recycling</b>	1 bailing machine and 1 weighing scale	5 male permanent workers	3 tons papers, 6 tons plastics, 2 tons cardboard	PECTO distel consol

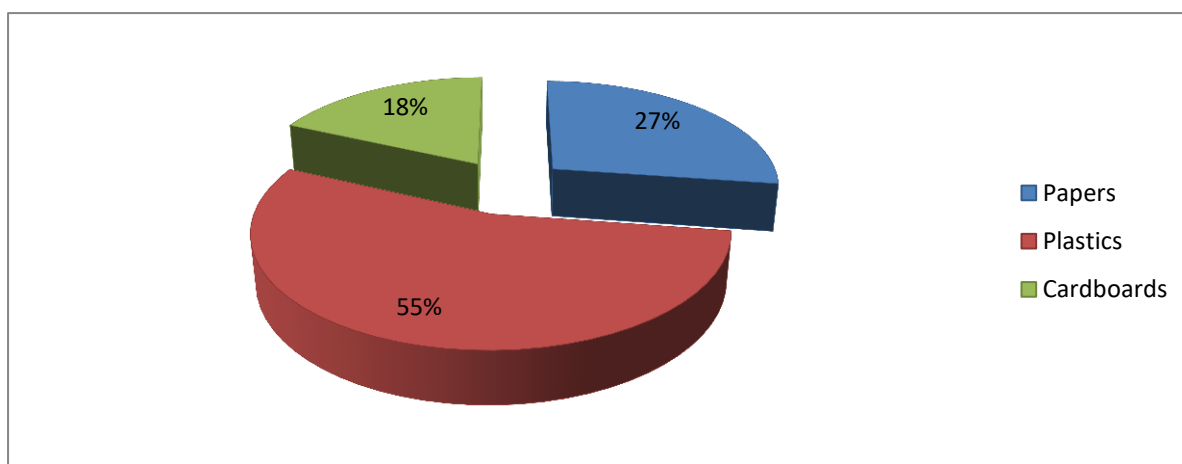


Figure 4. 26: Rehoboth recycling recycled materials in percentage.

Neo scrap metal in Musina Local Municipality is based at the landfill site for collection of recyclable materials. The materials recycled 300 tons of steel per month (Table 4.17). Materials are sold to large recycling companies called Enviroserve and Scraw Metal for further processing. The company has 8 male permanent employees. The company also has 1 forklift and 2 weighing scale.

Table 4. 17: Neo Scrap Metal recycled materials, equipment, workers and company sold to.

Recycling company	Equipement s	No. of Labours	Quantity of materials in tons/month	Recycling company sold to
Neo scrap metal	2 weighing scale and 1 forklif	8 permanent male workers	300 tons Steel	Enviroserve and scraw metal

Vhembe District Municipality has 7 recycling companies. These companies recycled different types of waste material. The researcher was not allowed to interview the waste recyclers. The municipalities provided the researcher with a data on the amount of recyclable materials, equipment, personnel employed, company sold to and the recycling companies. The municipalities are having recycling data on their municipal data bases as the recycling company are reporting to the municipalities on the materials that the companies are collecting per day from the landfill sites. The bulk of materials recycled within the district are metals comprising of 560 tons of card boxes, 349 tons of plastics, 215 tons of papers, 126 tons of cans, and 78 tons of glasses (Figure 4.27), thus metals constitute 40%. Boxes 25%, plastics 15%, and papers 9%, cans 6% and glasses 5% per month (Figures 4.28).

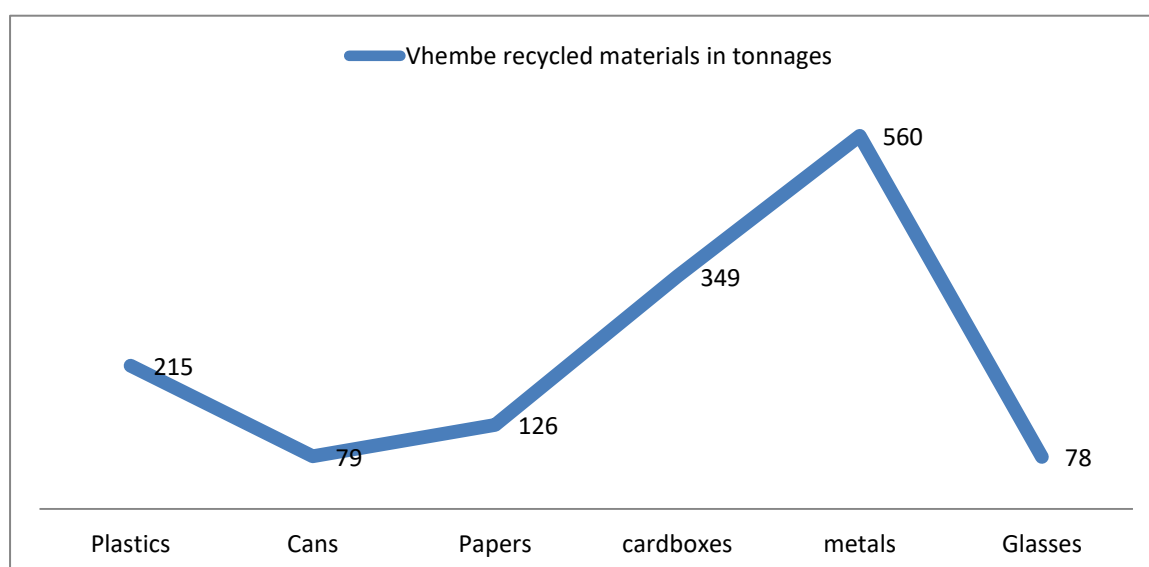


Figure 4. 27: Materials recycled in Vhembe District Municipality per month (tons).

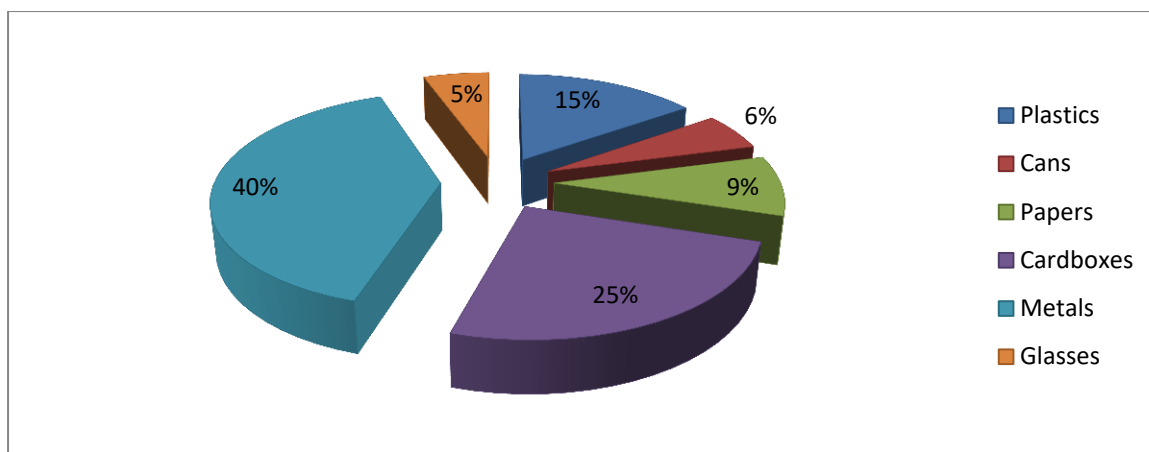


Figure 4. 28: Materials recycled in Vhembe District Municipality per month (%).

#### 4.5.6. Composting

In Vhembe District Municipality, some of the municipalities are creating compost from garden waste received at the landfill sites whereas other municipalities do not create compost, for example, garden waste from Thulamela and Collins Chabane Local Municipalities as they are using the same landfill site is disposed of in the cell demarcated for garden waste (Figure 4.29), whereas garden waste Musina and Makhado Local Municipalities is disposed of with other waste materials such as tyres, papers, plastics and building rubbles. Thulamela and Collins Chabane Local Municipalities are using garden waste to make compost and sell it to the communities, whereas Makhado and Musina Local Municipalities are not using garden waste to make compost, garden waste is compacted with other waste materials in the landfill sites.



Figure 4. 29: Demarcated area for garden waste disposal in Thulamela and Makhado Landfill Sites.

#### 4.5.7. Waste disposal

Municipalities are using sanitary landfill sites for waste disposal. There is a person called a Spotter at the entrance of each landfill site to check the type of waste to estimate the quantities of waste and to ensure that people are not entering with prohibited waste within the landfill sites. In Vhembe District Municipality, landfill sites have Weighbridge while other landfill sites are not having weighbridge to quantify waste entering the landfill. Makhado landfill site has a Weighbridge but it is not yet functional due to unavailability of electricity within the landfill (Figure 4.30), whereas Musina, Thulamela and Collins Chabane landfill sites are not having weighbridges. All municipalities within a district are still relying on spotter for waste quantification.



Figure 4. 30: Makhado Landfill site weighbridge.

Vhembe Local Municipalities landfill site receive different types of municipal solid waste which include industrial, commercial and residential waste. The received waste is categorized as general waste, garden waste and building rubbles. Makhado Local Municipality landfill site receives the highest amount of waste on a monthly basis whereas Musina Local Municipality receives the least amount of waste. The total amount of waste received in Vhembe District Municipality landfill sites is summarized in (Table 4.7) and the category of waste presented in (Figure 4.31). The bulk of waste generated is general waste comprising 9942 tons, garden waste is 3651 tons and building rubbles is 1930 tons and general waste is representing 64% of waste produced. Garden waste is 24%, while building rubbles is 12%.

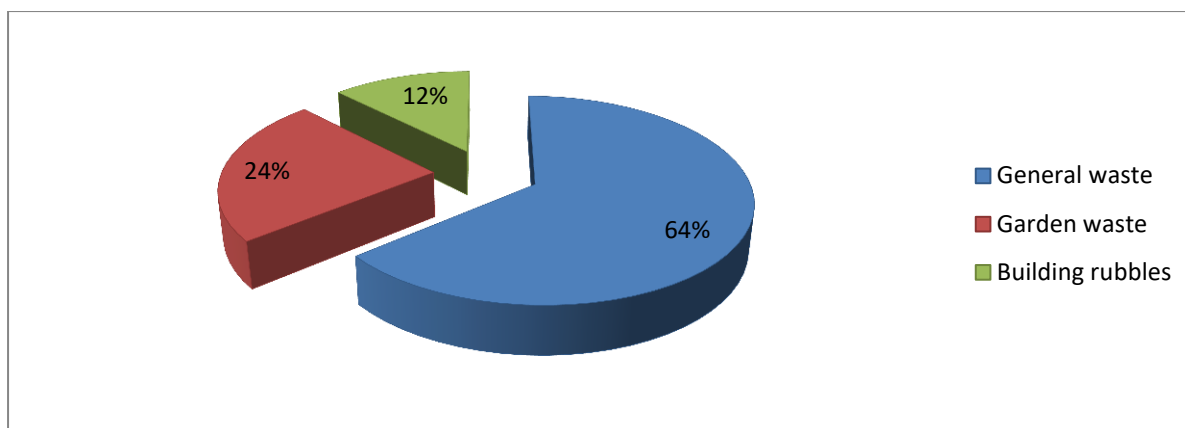


Figure 4. 31: Monthly waste received within Vhembe District Municipality landfills (%).

In Vhembe District Municipality, landfill sites are operated by municipalities whereas other landfills are operated by appointed contractors, for example, Thulamela Landfill site is operated by Ingwe Waste Management Contractor and Plant Hire, Musina Landfill site is operated by Ukukhomba Holdings whereas Makhado Landfill site is operated by the municipality and Landfill site for Collins Chabane Local Municipality will be operated by the municipality. Only Musina and Thulamela landfill sites are operated by appointed contractors because municipalities are not having enough equipment required to operate the landfill.

Vhembe District Municipality landfill sites have notice boards at the entrance of the landfill displaying information about the facilities (Figure 4.32). Thulamela and Makhado Landfill sites have notices boards whereas Collins Chabane and Musina landfill sites are not having notices boards. The Notice Boards are written in three languages such as Tsonga, English and Tshivenda for the site user to be able to read terms and conditions of the site. Waste required within the facilities is general waste and prohibited wastes are medical, sewage, asbestos, hazardous, abattoir, sludge, and pharmaceuticals waste. Operational hours from Monday to Saturday is 07H00-16h00 and Sunday/holidays is 07H00-13H00. License holders for facilities are local municipalities. Facilities are classified as GSB- which means that the facilities are for general waste.

Municipalities site rules are the same and are as follows: no burning of fire or waste within the landfill site, empty container showing hazardous or warning deals will not be allowed on site and speed limits must not be exceeded, traffic rules must be adhered to and traffic signs must be obeyed. All waste containers will be inspected at the weighbridge prior to disposal at the work face and no sealed container will be allowed to enter the site, only dry hazardous

waste materials may be disposed of and the contractor is legally bound to operate the site strictly according to the operational contract and instruction from the operation contractor’s personnel must adhered to.



Figure 4. 32: Makhado and Thulamela Landfill site rule notice boards.

Thulamela Landfill site notice board does not have information on prohibited whereas Makhado Landfill notice board has information on waste allowed and prohibited waste. It leads people to enter with prohibited waste within the Site (Figure 4.33).



Figure 4. 33: Hazardous waste within Thulamela Landfill Site.

Other municipalities within the District have bill boards at the entrance of the facilities, for example, Makhado landfill site has bill board at the entrance of the site, whereas Musina, Collins Chabane and Thulamela landfill sites are not having bill boards at the entrance of the facilities but municipalities have tariff charged for waste disposal on the databases. In Makhado landfill site, disposal of general solid waste up to 1000 kg is R27, 50, general solid waste in excess of 1000 kg is R85, 80 per ton, clean compostable garden waste up to 1000 kg is free, clean compostable garden waste per ton is R85, 80 in excess of 1000 kg, Clean building rubbles and soil usable as cover materials is free (Figure 4.34). In Musina Local Municipality, the dumping of any waste at the disposal site per 1 ton is R53, 18. In Thulamela and Collins Chabane landfill site, waste from residential areas per disposal time was R60 in 2016, R64 in 2017 and it is now R67 in 2018. Waste from business and government areas per disposal time was R75 in 2016, R80 in 2017 and it is now R84 in 2018. Collins Chabane Local Municipality is using the same tariffs charged with Thulamela Local Municipality for waste disposal as the municipalities are using the same landfill site (Table 4.18).



Figure 4. 34: Makhado Landfill Site bill board.

Table 4. 18: Tariff charged for waste disposal in Vhembe District Municipality Landfill sites.

Thulamela and Collins Chabane Local Municipalities					
Nature of service	Remarks	Years	2016	2017	2018
Residential waste	Disposal per time		R60	R64	R67
Business and government	Disposal per time		R75	R80	R84
Makhado Local Municipality					
Type of waste	Remarks	Volume in tons	Price in Rand	Year	
General waste	Disposal per time	Up to 1000 kg	R27.50	2017	
General waste	Disposal per time	In excess 1000 kg	R85, 80 per ton	2017	
Garden waste	Disposal per time	Up to 1000 kg	Free	2017	
Garden waste	Disposal per time	In excess 1000 kg	R85, 80 per ton	2017	
Soil	Disposal per time	Not mentioned	Free	2017	
Building rubbles	Disposal per time	Not mentioned	Free	2017	
Musina Local Municipality					
Dumping site	Per load	1 tons	53,18	2018	

In Vhembe District Municipality, landfill sites also have road signs within the landfill site, for example, Thulamela and Makhado landfill sites have roads signs to show direction and control speeding of cars within the site, whereas Musina Landfill Site has no road signs (Figure 4.35). In Vhembe District Municipality, there are scavengers from different recycling companies' collection recyclable materials such as cans, plastics and glass bottles and card boxes on a daily basis (Figure 4.36).



Figure 4. 35: Road signs within the Thulamela and Makhado Landfill Sites.



Figure 4. 36: Separation and collection of recyclable materials within the landfill sites.

Waste is disposed of within the landfill sites, leveled and covered with compacted soil. After covering the waste, the whole area is compacted in a manner that rain water will not stay on the landfill sites during rainy seasons using compactor machines (Figure 4.37). The compaction of waste in the landfill sites help to extend the life span of the landfill. Landfill sites within the district have expected life spans, for example, the expected life span of Thulamela Landfill site is 7 years and the whole landfill is 15 hectors, Makhado Landfill Site is 30 years life span and the whole landfill is 20 hectors, Musina Landfill Site is 20 years life span and the whole landfill is 30 hectors. Makhado Landfill site has the highest expected life span whereas; Thulamela landfill site has the least expected life span.



Figure 4. 37: Landfill compactor machines.

In the district, there are disposal sites used by municipalities for waste disposal (Figure 4.38). Thulamela, Musina and Makhado Local Municipalities have landfill sites for waste disposal whereas Collins Chabane Local Municipality is not having landfill site and it is still relying on Thulamela Local Municipality landfill site for waste disposal. Vhembe District Municipality landfill sites are lined using different layers such high density polyethane to avoid infiltration of leachate from the landfill which contaminates underground water whereas others disposal sites are not lined.



Figure 4. 38: Vhembe District Municipality Landfill Sites.

Makhado and Thulamela landfill sites are lined whereas Musina landfill site is not lined. Musina Local Municipality was using a quarry as the disposal site. A quarry was developed due to gravel which was used to build Musina road then the Municipality decided to use quarry as a landfill site. Due to unavailability of liners in Musina landfill site, it leads to contamination of the ground and surface water. Only Musina Local Municipality is using quarry as the landfill site whereas Thulamela and Makhado Local Municipalities are using sanitary landfill sites.

The quarry that was used by Musina Local Municipality has already reached its full capacity (Figure 4.39). The municipality does not have another place to develop a new landfill site. Musina Local Municipality decided to extend the old landfill site in order to have a space for waste disposal. The part that Musina Local Municipality has extended is still under construction by SANRAL (Figure 4.40) and the municipality is currently rehabilitating the old part of the landfill site (Figure 4.41). Collins Chabane Local Municipality has not yet started with the construction of Xigalo Landfill Site. The municipality is currently in the process of appointing a service provider who will develop the landfill. The service provider to be appointed will only construct the fence, access road and gate until the municipality gets a license from the Department of Economic Development, Environment and Tourism for the disposal facility then the service provider will start with the construction processes of the disposal cells with the landfill.



Figure 4. 39: Musina old landfill site.



Figure 4. 40: Musina constructed disposal cell.



Figure 4. 41: Rehabilitation of Musina old landfill site.

Vhembe District Municipality landfill sites have leachate ponds whereas others landfill sites are not having leachate ponds, for example, Thulamela and Makhado Landfill Sites have leachate ponds (Figure 4.42), whereas Musina Landfill Site is not having leachate pond but the municipality is in a process of constructing a leachate pond. In the district, leachate is treated in different ways at the landfill sites, for example, Makhado Local Municipality treats leachate through allowing it to evaporate from the leachate pond using sunlight, sometimes leachate is pumped and sent to the nearest water treatment plant for water purification when pond is full especially during heavy rainy season, whereas Thulamela Local Municipality treats leachate through pouring it on top of the soil within a landfill to suppress the dust.



Figure 4. 42: Makhado and Thulamela Landfill site leachate ponds.

In Vhembe District Municipality, there are landfill sites water monitoring boreholes; one is drilled down-stream and the other one is up the stream. Municipalities normally sent water sample from monitoring boreholes to laboratories on quarterly basis for analysis on whether the ground water is contaminated or not by leachate from the landfill Site (Figures 4.43) Thulamela and Makhado Landfill Sites have water monitoring boreholes whereas Musina landfill sites is not having water boreholes but Musina and Collins Chabane Local Municipalities are planning to install boreholes at the landfill sites.



Figure 4. 43: Makhado and Thulamela Landfill site water monitoring boreholes.

## **4.6 Factors affecting sustainable solid waste management strategies within a District**

### **4.6.1. Legal Policies and Strategies**

In Vhembe District Municipality, municipalities have law enforcement personnel whereas other municipalities are not having law enforcement personnel to create and enforce by-laws, for example, Makhado and Collins Chabane Local Municipalities have law enforcement officers, whereas Thulamela and Musina Local Municipalities are not having law

enforcement officers but Thulamela Local Municipality is in a process of appointing and training law enforcement personnel. Collins Chabane and Musina Local Municipalities drafted by-laws and Integrated Development Plan, the municipalities are waiting for the magistrate to approve the by-laws then the municipalities will start enforcing those by-laws within the municipalities, whereas Makhado and Thulamela Local Municipalities are having a serious challenge on drafting and enforcing by-laws. In Musina Local Municipality, by-laws were drafted by waste manager and superintendents as the municipality is not having law enforcement officers.

In the district, other municipalities are using traditional authorities as the municipalities polices officer, for example, Thulamela Local Municipality is using traditional authorities as the municipality's police officers who also introduce fines to the residents who are doing illegal dumping within their communities, whereas Musina, Thulamela and Collins Chabane Local Municipalities are not using traditional authorities as the municipality's police officers. Municipalities are using Constitution of the Republic of South Africa (Act 108 of 1996), The National Environmental Management Act (Act No. 107 of 1998), National Environmental Management Waste Act (Act No. 59 of 2008) and National Water Act (Act No. 36 of 1998) as policies. The policies are aligned with the National Waste Management Strategy (1998) and Polokwane Declaration of Zero Waste (2000).

In Vhembe District Municipality, other municipalities have penalties to offenders; for example, Makhado Local Municipality has penalties to people who are doing illegal dumping, whereas Collins Chabane, Thulamela and Musina Local Municipalities are not having penalties to people who are doing illegal dumping. Vhembe Local Municipalities do not have guidelines on waste minimization at source for example; they do not have zero waste strategy (3R) reduce, reuse and recycling, which is the highest priority of the national waste management policy and these lead to large amount of solid waste eventually end up in landfills. Municipalities are also not having the equipment and program in place to encourage waste separation at source, for example, municipalities do not have household's recyclable receptacles to encourage separation at source and unavailability of household receptacles lead communities to mix recyclable materials with non-recyclable materials and it affects recycling activities.

#### 4.6.2. Technical aspects

Vhembe District Municipality lacks qualified technicians to repair the equipment; it leads to long time of waiting for repairing the equipment. Most of the equipment used are sensitive and local technicians are unable to fix them. Makhado Local Municipality has 1 technician and 2 assistants, Thulamela Local Municipality has 4 technicians and 4 assistants, Musina and Collins Chabane Local Municipalities are not having technicians (Table 4.19). Thulamela Local Municipality has the highest number of technicians and assistants whereas Collins Chabane and Musina Local Municipalities do not have technicians. Vhembe District Municipality has a total of 5 technicians and 6 assistants. When equipment stuck, it affects waste collection, transportation and landfill operation when waiting for the qualified technicians to fix the equipment.

Table 4. 19: Number of technicians and assistants within the district.

Municipalities	Gender	No of technicians	No of assistants
Thulamela	Male	4	4
Collins Chabane	None	0	0
Makhado	Male	1	2
Musina	None	0	0

Thulamela Local Municipality has workshop for maintenance and repairing of break down equipment at Muledane and Matavhela village and if the technicians are not able to fix the equipment the municipality use to send the equipment to the external services provider in Polokwane. Makhado Local Municipality has workshop for maintenance and repairing of equipment at Makhado but if the technicians are not able to fix the problem, the municipality use to send equipment in Gauteng for repairing and maintenance. Musina Local Municipality has workshop in Musina for repairing the equipment and the municipality relies on the superintendent of maintenance for repairing the break down equipment (Figure 4.44). Collins Chabane Local Municipality has external service provider to repair the equipment who is based in Polokwane. The respondents also stated that it is expensive to transport equipment to Gauteng for repairing.



Figure 4. 44: Musina workshop facility for maintenance and repairing of equipment.

#### **4.6.3. Institutional aspects**

In Vhembe District Municipality, there are number of different waste management equipment used by local municipalities (Table 4. 20). The respondents stated that if equipment are not adequate it affects waste management value chain. Makhado Local Municipality has 4 refuse compactor trucks, 7 half trucks, 3 LDV bakkies, 1 skip loader, 1 TLB, 2 landfill compactor machine and 4 tractors, Thulamela Local Municipality has 14 refuse compactor trucks, 2 half trucks, 1 skip loader and 4 LDV bakkies, 1 rubber dozer, 1 front end loader, 1 landfill compactor machine and 1 tractor. Collins Chabane Local Municipality has 4 refuse compactor trucks, 1 tractor, 1 half truck, 2 TLB, 1 skip loader and Musina Local Municipality have 3 refuse compactor track, 1 TLB, 1 bull dozer, 1 water truck, 1 excavator, 1 tipper truck 1. Thulamela Local Municipality has the highest number of waste management equipment whereas Collins Chabane and Musina Local Municipalities have least number of equipment.

Some of the equipment used within municipalities are old, for example, in Makhado Local Municipality, trucks and tractors that they use are 20 years old and they often stuck on the road and this situation affects waste collection and transportation, whereas equipment used in Thulamela, Collins Chabane and Musina Local Municipalities are not old. Thulamela Local Municipality used to sell old equipment through auction to avoid the issue of break down. The respondents further stated that within the district there are poor road network especially in rural areas, municipalities cannot use trucks to collect waste from door to door because it is difficult to reach the collection point.

Table 4. 20: Number of equipment within municipalities in the district.

Municipalities	Compactor trucks	Half trucks	Skip loader	Rubber dozer	Front loader	Tractors & trailers	TLB	LDV Bakies	Compactor
<b>Thulamela</b>	14	2	1	1	1	1	1	4	1
<b>Collins Chabane</b>	4	1	1	0	0	1	2	0	0
<b>Makhado</b>	4	7	1	0	0	4	1	3	2
<b>Musina</b>	3	2	1	0	0	2	1	0	0

In the district, aging of the personnel also affects waste management value chain throughout the world. In Vhembe District Municipality, municipalities are having waste management personnel that are old and they are unable to carry heavy equipment. It forces the managers to change them to other soft jobs which are easy for them such as cleaning of the offices and toilets.

In Vhembe District Municipality, other local municipalities have a challenge of land claim, for example, in Makhado Local Municipality, there is a challenge of a land claim at Musekwa village, whereas Thulamela, Collins Chabane and Musina Local Municipalities do not have challenge of land claim. The challenge of land claim affects management value chain because the municipality was planning facilities such as drop-off point facilities and transfer station at Musekwa. It affects waste management value chain because municipality already planned to construct waste management facilities on that area such as transfer station and drop off points. When the municipality started preparing the land, the citizens start claiming the land on that area and it delays the process of constructing the facilities.

#### 4.6.4. Financial and economic aspects

The respondents reported that in Vhembe District Municipality, there is a lack of prioritization in some municipalities within the district while other municipalities use to prioritize, for example, Makhado Local Municipality, when budget comes to the municipality a lot of money is allocated to other proposed projects by councilors as they consider waste management to be too expensive and it leads to low level of compliance to municipalities as equipment are very expensive. In Thulamela, Collins Chabane and Musina Local Municipalities, when budget come, municipalities do not use money allocated to waste

management on other proposed projects. Municipalities within a district have different budgets for refuse removal and the budgets are supplemented by monthly refuse removal services fee paid by residents, for example, Makhado Local Municipality makes provision of about R900,000.00 for refuse removal for the whole municipality, Thulamela makes R1000 000.00, 600 000.00 and Collins Chabane Local Municipality makes R500 000. Thulamela Local Municipality has the highest budget for refuse removal whereas Collins Chabane has the least budget for refuse removal.

In the district, residents do not want to pay for waste collection service fee especially in rural areas. People from rural areas believe that it is a responsibility of the municipalities only to collect waste generated in their areas. The respondents further stated that people are not aware of the importance of their contribution on waste management. Municipalities have insufficient fund and they do not manage to collect waste from door to door both in rural and urban communities. Municipalities cannot afford to buy enough waste management equipment, for example, Musina, Thulamela, Makhado and Collins Chabane Local Municipalities have insufficient waste storage facilities. Municipalities within the district have indigent offices for poor households to register their names so that municipalities will provide free basic refuse removal while other municipalities do not have indigent offices, for example, Thulamela, Makhado and Collins Chabane Local Municipalities have indigent offices and poor households use to register their names whereas Musina Local Municipality is not having have indigent officers for poor households.

Vhembe District Municipality has tariff charged for waste collection per month, for example, in Thulamela Local Municipality (Table 4.21), collection of waste in residential areas per month in 2016 was R60, in 2017 was R63, and in 2018 is R67, extra ordinary refuse removal in residential areas for garden refuse per load in 2016 was R500, in 2017 was R531 and in 2018 is R562 and for building rubbles per load in 2016 was R674, in 2017 was R715 and in 2018 is R757. In businesses and government areas, collection tariff for standard refuse container removal once a week per month in 2016 was R150, in 2017 was R159 and in 2018 is R169, bulk container once a weak per month in 2016 was R 2 809, in 2017 was R2 980 and in 2018 is R3 156 and extra ordinary refuse for garden refuse per load was R600 in 2016, in 2017 was R637 and in 2018 is R674, for extra ordinary refuse removal for building rubbles per load in 2016 was R900, in 2017 was R955 and in 2018 is R1011. Waste removal in industrial areas for standard refuse container once a weak in 2016 was R150, in 2017 was

R159 and in 2018 is R169 and bulk container per weak, per month in 2016 was R2700, in 2017 is R2 865 and in 2018 is R3034. In Musina Local Municipality, collection of garden refuse is R469.53 and building rubbles is R923.30.

Table 4. 21: Tariff charged for waste collection in Thulamela Local Municipality.

Nature of service	Remarks	Years		
		2016	2017	2018
<b>Residential areas</b>	Refuse removal per month	R60	R63	R67
	<b>Extra ordinary refuse removal</b>			
	Garden refuse per load	R500	R531	R562
	Building rubbles per load	R674	R715	R757
<b>Businesses and government areas</b>	Standard refuse container one a week per month	R150	R159	R169
	Bulk container one a weak, per month	R2 809	R2 980	R3156
	<b>Extra ordinary refuse</b>			
	Garden refuse per load	R600	R637	R674
	Building rubbles per loud	R900	R955	R1011
<b>Industrial areas</b>	Standard refuse container once a week	R150	R159	R169
	Bulk container per weak, per month	R2700	R2865	R3034

#### 4.6.5. Social and cultural aspects

Respondents stated that it is difficult to change the mind-set of the communities. Few people within communities do separation at source and sometimes recyclables materials are mixed with prohibited waste at landfill, for example, in Thulamela Local Municipality, a refuse compactor truck was burning in 2017 during transportation of waste to the landfill due to ashes which were mixed with materials such plastics and papers by the residents. In Vhembe District Municipality, the nappies are disposed of in the open land and within the catchments which ultimately contaminate water bodies, for example, in Musina Local Municipality; there is an illegal dumping of waste in the catchment areas and on the roadside (Figure 4.45).



Figure 4. 45: Illegal dumping at Thulamela and Musina Local Municipalities.

Municipalities provide notice boards which are placed strategically to discourage illegal dumping. The residents continue doing illegal dumping and littering on areas where there is a notice boards (Figure 4.46). In Vhembe District Municipality, Musina and Thulamela Local Municipalities have the highest challenge of illegal dumping whereas Collins Chabane and Makhado Local Municipalities have the least challenge of illegal dumping.



Figure 4. 46: Illegal dumping at Musina Local Municipality.

There is a vandalism of storage facilities which sometimes occur accidentally within the district. Communities also cut steel bins and use them for recreational purposes while others use them to build braai stands, for example, University of Venda students use to break concrete bins and use them to block the roads during the strike and also burn the plastic litter bins (Figure 4.47). Thulamela Local Municipality faced the highest challenge of vandalism of storage facilities due to University of Venda students during strike whereas other local municipalities such as Musina, Makhado and Collins Chabane have least challenge of vandalism of storage facilities.



Figure 4. 47: Vandalised street litter bins at Thulamela and Makhado Local Municipality.

In Vhembe District Municipality, waste management officials use to propose ward councilors to sensitive communities about the issue of vandalizing storage facilities. Waste management officials also provide environmental education on monthly and quarterly basis to communities on how to manage waste in a sustainable manner using cleanup campaigns, community awareness programme, School out-reach and imbizos. The respondents further stated that pedestrians do not use waste litter bins and they use to dump waste next to the storage facility (Figure 4.48). Some of the street litter bins are painted in orange color to make them visible to the pedestrians in order to avoid littering, people continue litter waste everywhere.



Figure 4. 48: Waste which was not stored in litter bins in Musina and Thulamela Local Municipality.

#### **4.7. Potential implications of municipal solid waste on the environment and human health**

This section represents various impacts of solid on human health and the environment. The respondents said that mismanagement of municipal solid waste leads to implications on the environment and human health. Respondents further stated that waste also causes vegetation damage, water, air, land pollution and degradation of the natural resources, for example, in Musina Local Municipality, due to illegal dumping of waste; soil was contaminated in a manner that it was unfertile for growing vegetation. The issue of unfertile soil is already faced by Musina Local Municipality, whereas Makhado, Thulamela and Collins Chabane Local Municipalities do not have this challenge. The respondents further stated that illegal dumping also leads to destruction of habitat for other surface inhabitants.

In Vhembe District Municipality, when people burn waste from illegal dumping hot spot, it leads to respiratory infection to the surrounding communities. Waste from illegal dump hot spot sometimes block the water channels which lead to flooding during heavy rains. Other waste material is dumped in the catchment areas, thus ultimately contaminates the water bodies and impacts negatively on aquatic life due to presence of toxicants in the waste (Figure 4.49). These issues are faced by all local municipalities within a district due to illegal dumping of waste.



Figure 4. 49: Illegal dumping of waste in catchment areas in Musina Local Municipality.

In Vhembe District Municipality, solid waste also leads to ill health of children as they ingest some of the food waste material when they are playing in the vicinity of the illegal dumps. Vhembe Local Municipalities faced number of health and environmental issues due to municipal solid waste, rotten food waste attracts mosquitos, flies and rats which lead to the spread of pathogenic diseases to the surrounding communities, for example, in Musina Local Municipality, people generally request the municipality to visit the illegal dump hot spots and spray against mosquitos and other dangerous insects and rodents. The issue of spraying mosquitos is only faced by Musina Local Municipality whereas Thulamela, Makhado and Collins Chabane Local Municipalities residents do not have this challenge are. When waste entering the water bodies blocks the water bodies, mosquitos are attracted and it becomes a good breeding ground for mosquitos.

In the district, the respondents stated that waste which is not properly managed leads people to be affected by disease such as malaria, diarrhoea, respiratory problem and people can even get injured from waste materials such as bottles, glasses and metals. This challenge is faced by all local municipalities within Vhembe District Municipality. They spread several diseases such as malaria, cholera, typhoid fever and yellow fever to the surrounding communities. In Vhembe District Municipality, some of the landfill sites are close to the residential areas while others have already reached its full capacity, for example, Musina Landfill Site has already reached its full capacity, whereas Thulamela and Makhado Landfill Sites are not yet reached their full capacity but Thulamela Landfill Site is closer to the residential areas of Muledane.

In Musina Landfill Site, the municipality is still dumping waste on the landfill which is already full; it leads waste to be uncovered due to unavailability of soil cover materials, people who are residing around Musina and Thulamela landfill site which is closer to the residential area are affected by odour from the landfills. The respondents further stated that people who are having asthma and those residing around the landfill sites are also vulnerable to odour from the landfill sites. In Vhembe District Municipality, there are poor road conditions which lead to poor waste collection and some of waste remain uncollected which leads to attraction of pathogens and rodents. The rodents and pathogens tend to spread diseases to the surrounding communities.

Some of the local municipalities within Vhembe District Municipality are using sanitary landfill sites whereas other municipalities are using open dumps; for example, Musina Local Municipality is using a quarry as the landfill site, whereas Thulamela, Collins Chabane and Makhado Local Municipalities are using sanitary landfill sites. The quarry used by Musina Local Municipality was developed due to collection of sand to build the Musina road. The landfill does not have a sheeting type clay liner to prevent infiltration of leachate from the landfill. This leads to contamination of underground water by leachate when leaking from the landfill site.

## CHAPTER FIVE: DISCUSSION OF RESULTS

### Introduction

This chapter presents a discussion of the results on the waste management practices which are currently being employed within a district and in different countries. This chapter also gives a detailed discussion of results on the factors affecting sustainable waste management practices within a study area and around the world. The results on the impacts of municipal solid waste on the human health and the environment are discussed.

### Waste prevention and minimization

The study indicated that municipalities in the district do not have waste prevention and minimization strategies in place, which are the highest priorities of the waste management policy. There are no equipment and program in place by municipalities to encourage waste separation at source. For example, municipalities do not have household's recyclable receptacles to encourage separation at source. Unavailability of household receptacles leads communities to mix recyclable materials with non-recyclable materials. The results of this study is supported by the results of the study conducted in South Africa, where municipalities are still unable to implement the requirements of the National Waste Management Policy due to absence of a recycling infrastructure that enables separation of waste at source and alteration of waste streams to material recovery and buy-back facilities; and, there is also few waste treatment alternatives and they are more expensive than landfill site (Anon, 2017).

The results of this study is the same as compared to the results of the study conducted in India, where effectiveness of recycling and composting of waste material is greatly reduced due to the absence of source separation (Mani and Singh, 2016). The results of the study are also supported by the results of the study conducted in Vietnam, where practice of waste separation at sources is not yet being implemented (Luong et al., 2013). In Ghana, waste separation at source is not a common practice and most of the wastes collected are dumped at the land fill sites (Sepenoo, 2018). In India, there is no organized and scientifically planned waste separation at source. Waste separation is mostly carried out by unorganized sector and seldom practiced by waste producers (Joshi and Ahmed, 2016). This situation leaves large amount of solid waste to eventually end up in landfill sites and it affects the recycling activities. Municipalities should implement the program of providing recyclable receptacles to households to encourage separation at source.

Unavailability of waste minimization strategies is a challenge faced by municipalities around the world. The study indicated that separation at source is only conducted by the recyclers. The study conducted in Malaysia reported the same results that waste separation is rare and it is only done by waste collection crew and rag pickers, the efficiency of waste separation at source is very poor because waste collectors and rag pickers are only separating materials which have high economic value for recycling (Permana, 2015). This show that waste separation at source both in Malaysia and in Vhembe District Municipality is conducted by recyclers and communities are not contributing on separating waste at their homes. The study indicated that communities are being educated on monthly and quarterly basis through environmental awareness campaigns, school out-reach and imbizos on how to prevent waste generation through separation at source and waste minimization. People are ignorant and it is difficult to change their mind set. The results of this study is supported by the results of the study conducted in Malaysia, where the most serious challenges on waste separation at source and recycling activities is the communities' attitude towards making source separation and recycling activities a habit (Moh, 2017).

### **Waste generation**

It was indicated that the bulk of waste generated in the district is general waste comprising of 9942 tons, garden waste is 3651 tons and building rubbles is 1930 tons and general waste is representing 64% of waste produced. Garden waste is 24%, while building rubbles is 12%. The total amount of waste generated within a district per month is 15523 tons. Globally, the annual increasing rate of municipal solid waste generation is approximately 2 billion tons. Besides the explosive growth in the weight and volume, the composition of the waste is becoming more complex (Ma and Hipel, 2016). The amount of waste generated within the district very low compared to the results of the study conducted in India, where approximately 12 million tons of inert waste is generated from street sweeping and in the landfill sites, it occupies about one-third of total municipal solid waste (Joshi and Ahmed, 2016). In Mongolia, Ulaanbaatar, amount of waste generated is 1.12 kg per capita per day and 408.82 kg per capita per year. It is usually considered as the minimum amount because recyclable materials are collected (Byamba and Ishikawa, 2017).

In Jordan, per capita waste generation is estimated at 0.6 and 0.9 kg per day, in rural and urban areas. Municipalities are collecting the daily waste streams and transport them without sorting to waste disposal sites (Saidan et al., 2017).

### **Waste storage**

Waste from residential areas is stored in refuse plastic bags and placed outside the gate of the houses waiting for collection. The results of this study are the same as compared to the results of the study conducted in Zimbabwe, Harare, where plastic receptacles are used for household waste storage and the receptacles are usually placed outside the gate once a week for collection as scheduled (Mandevere, 2015). It was indicated that in commercial and institutional area, waste is stored in skip bins, plastic and metallic bins. Those bins used in the district are different in terms of sizes; some of them are 240 liters, 80 liters and 60 liters bins. The results of this study is different from the results of the study conducted in Zimbabwe, Harare, where residents in low density areas own bins that are big and durable, are sold by company called Bins for Africa. Those bins are 50 liters, 130 liters, 240 liters, 660 liters and 1000 liters (Mandevere, 2015). The results of the study conducted in the City of Tshwane Metropolitan Municipality, Gauteng province South Africa reported that there are different waste storage facilities used for residential waste such as 85 litre black bins, clear plastic bags, 85 litre galvanized steel bins, 120/240 litre mobile bins and 11m<sup>3</sup> skip bins (Nkosi, 2014). Some of the bins used in Zimbabwe, Harare and City of Tshwane Metropolitan Municipality, are bigger than those used in Vhembe District Municipality and in Zimbabwe, Harare, some of the residents own them whereas in Vhembe District Municipality, residents do not own bins and they only use refuse plastic bags for residential waste storage.

The study indicated that skip bins are used in areas where large amount of waste is produced. The results of this study is the same as compared to the results of the study conducted in Zimbabwe, where large skip bins are placed at the main market and bus station at Kudzanai and at the main entrance of the Shamrock Park industrial site and Monomotapa, where large amount of waste is produced so that people can use them to dispose their waste (Jerie and Tevera, 2014). In Vhembe District Municipality, skip bins, plastic and metallic bins are provided by the municipalities. The results of this study are the same as compared to the study conducted in India, Dhanbad City, where local municipalities and other local bodies provide waste storage facilities and stationary containers at different locations within the area for public to dispose their waste (Yadav and Samadder, 2018).

The study indicated that transfer stations and drop-off point facilities are used for temporary storage. Municipalities constructed transfer stations and drop-off point facilities in areas far from the landfill sites to avoid too much transport cost of waste to the landfill sites. Waste is collected once per week, per collection schedule to the landfill sites. The results of this study are the same as compared to the results of the study conducted in India, where transfer stations facilities are being used where disposal facilities are more than 10 km away from the city to avoid too much transport cost and to save time to be consumed for collection and cities have good performance record of the vehicle maintenance and enough facilities to maintain large size vehicles and containers (Mani and Singh, 2016). The results of this study are also supported by the results of the study conducted in South Africa, Limpopo Province, where it was found that transfer station can possibly reduce the cost of transporting waste (Chimuka and Ogola, 2015).

The study conducted in Mallorca, revealed the same results that municipal solid waste management system utilises transfer stations to increase effectiveness of the system. Transfer stations are considered as good options compared to transportation of waste daily to disposal facilities as it helps to economise transportation cost. When waste containers are full in transfer stations, then waste is transported to the disposal facility (Arbulú, 2016). The results of the study conducted in Tha Khon Yang, Maha Sarakham Province, in northeast Thailand reported that landfill site is approximately 25 km from the Tha Khon Yang, Maha Sarakham province and there is no waste transfer station to take waste for separation. This travelling distance in combination with the quantities of waste produced daily means that waste collection trucks make a few trips per day to the landfill site (Yukalang, et al., 2017). Other municipalities within a district are not having transfer stations and drop-off facilities whereas in Tha Khon Yang, Maha Sarakham Province, in northeast Thailand, there are no transfer stations.

The study indicated that in urban areas waste is collected from door to door due to good route network. In rural areas, waste is collected from roadside as there is no good route network and it is difficult to reach collection points. The results of this study are the same as compared to the results of the study conducted in South Africa, Limpopo province, where there is poor road network in some local municipalities within Vhembe and Mopani District Municipalities which include Ba-Phalaborwa, Makhado (Madombizha village) and Thulamela Local

Municipalities (Thohoyandou Unit C and E). Poor road condition affects waste collection processes because vehicles cannot be able to reach the collection point (Mudau, 2015). The results of this study are also the same as compared to the results of the study conducted in Nepal, where waste is collected from door to door, and roadside collection from open piles, are the types of collection systems which are generally employed by the municipalities (Bank, 2013). Municipalities around the world are using road side and door to door collection methods because there are no good road networks.

The study conducted in Addis Ababa city, Central Ethiopia, reported that majority of the households are using door to door waste collections service which could demonstrate the community's adaptation to better refuse removal service. High income residential areas use door to door refuse removal system than in middle and low income households and in Ethiopia, it is implied that the residential areas are determined by their income situation to use a better waste refuse removal service (Regassa et al., 2011). The study conducted in the City of Tshwane Metropolitan Municipality, Gauteng province, South Africa, reported that waste is collected from door to door collection method using Econo-trucks waste loader (Nkosi, 2014). Throughout the world, where there is good road network, waste collection is carried out from door to door collection method.

In the district, waste is collected and transported using refuse compactor trucks, half trucks, LDV bakkies, tractors and skip loader truck to the landfill sites. The results of this study is different as compared to the results of the study conducted in Indonesia, Makassar city, where the municipality uses carts to collect all waste from roadside and street bins and refer them to the selected transfer station. Trucks are used to collect waste from transfer stations facilities and refer them to the disposal site (Permana, 2015). The study conducted in Addis Ababa city, central Ethiopia, found that there are three types of waste collection equipment used such as human powered, animal powered, and engine powered. On the human powered aspect, waste is collected and transported to the containers using hands and hand pushed carts. The human powered collection system in some areas in the city is highly used due to poor road network and vehicles cannot be able to reach collection points and in other locations motorized collection system is used and strategic locations are assigned where collectors make ready for the motorized collection system (Regassa et al., 2011). The study conducted in India, Dhanbad city reported that waste generated daily is collected from community litter bins and transported to the adjacent landfill site using tractors and truck (Yadav and Samadder, 2018).

The study conducted in Zambia, Kitwe city revealed that the collected waste is transferred to the collection location using handcarts. Vehicles such as trucks, tractors and compactors trucks are being utilized to transport waste to the disposal site (Mwanza et al., 2018). It is different from the results of this study as Vhembe District Municipality uses different types of transport which include compactor trucks, half trucks, LDV bakkies, and tractors and skip loader trucks to collect waste from point of generation whereas in Ethiopia, waste collection equipment used include human powered, animal powered, and engine powered. Municipalities in the district have waste collection time table, because municipalities have waste collection timetable. Waste is collected differently in terms of days, time, location and frequency of collection. Waste is collected daily from 07H00-16H00 at Musina whereas in Makhado Local Municipality waste is collected from 08H00-12H00. The results of the study conducted in Tha Khon Yang, Maha Sarakham Province, in northeast Thailand indicated that there are three waste collection trucks used and they follow a route covering seven waste collection locations twice daily from Monday to Saturday 4:00 a.m. to 8:00 a.m. and 1:30 p.m. to 4:30 p.m (Yukalang et al., 2017). The results of this study is the same as the results of the study conducted in Zimbabwe, where municipalities have waste collection timetable and the collection frequency within a municipality varies in terms of days and location (Jerie and Tevera, 2014).

In the district, waste collection crew, street cleaners, landfill operators, scavengers, and drivers are provided with personal protective clothing to ensure that they are safe in a work place. Personnel are provided with a 1 pair of mask, work suit, t-shirt, protective boots, cricket hat and hand gloves. The results of this study is different as compared to the results of the study conducted in Polokwane city, where waste management personnel include collection crew, street cleaners, landfill operators, scavengers, and drivers, each labourer are provided a set of personal protective clothing comprising 4 overalls, 2 pairs of boots, 1 pair of rain coat per year and 1 pair of gloves monthly (Ogola and Chimuke, 2015). In Polokwane city, waste management personnel are provided with 4 pairs of overalls and two pairs of boots whereas in Vhembe District Municipality personnel get 1 pair of every protective clothing. The study conducted in India also reported the same results that personal protective clothing such as rain coats, gum boots and gloves are given to all sanitary waste management personnel (Bharti, 2013). The study conducted in the City of Tshwane Metropolitan Municipality, in Mamelodi East Township, Gauteng province South Africa indicated that

waste collection employees were wearing their own personal clothes rather than wearing personal protective equipment/clothing (Nkosi, 2014). In Vhembe district and Polokwane city, waste management crew are provided with personal protective clothing whereas in the city of Tshwane Metropolitan Municipality, in Mamelodi East township, Gauteng province, South Africa, waste management personnel use their own personal protective clothing.

### **Recycling**

It was indicated that municipalities are not having formal recycling activities. Recycling activity is left to the mercy of private companies and individuals. The results of this study is similar to the results of the study conducted in Polokwane city, where there is no formal recycling programmes and there are informal recyclers at the landfill sites collecting recyclables materials on a daily basis (Ogola and Chimuke, 2011). The results of this study indicated that the bulk of materials recycled within a district are metals comprising of 560 tons of card boxes, 349 tons of plastics, 215 tons of papers, 126 tons of cans, 79 tons and glasses are 78 tons, thus metals constitute 40%. Boxes 25%, plastics 15%, and papers 9%, cans 6% and glasses 5% per month. The highest material recycled are metals comprising 40% and the least material recycled are glasses comprising 5%. The percentages of materials recycled within a district are higher than the materials recycled in Zimbabwe, where papers are 5.69%, cardboards are 4.19%, plastics are 12.15%, glasses are 2.07%, metals are 1.54%, and textiles are 2.17% (Yadav and Samadder, 2018), but there is no different from the materials recycled in Polokwane city, where glasses are 11%, plastics are 18%, papers are 20% and cans are 11% (Chimuke and Ogola, 2011).

The study conducted in South Africa, Limpopo Province reported that materials recycled within a province are glass bottles which are 26%, plastic bottles and card boxes are 20%, papers are 9% tins are 14%, plastic bags are 11% (Mudau, 2015). In the district, most materials recycled are metals comprising of 40% and least material recycled are glass materials which is 5%, whereas in Zimbabwe, most of materials recycled are plastics which is 12,15% and least materials recycled are metals which is 1,54%. In Polokwane city, most of the materials recycled are papers which is 20% whereas least materials recycled are glasses and cans which are 11% whereas in Limpopo province, most of the materials recycled are glass bottles which is 26% and least materials recycled are papers which is 9%. Most of the materials recycled throughout the world are metals constituting 40% as compared to other recyclable materials and are recycled within Vhembe District Municipality. The private sectors responded through recognizing the potential of waste as a renewable resource and

associated business opportunities, not only with treatment and disposal, but also in reuse and recycling (Anon, 2017).

### **Composting**

The study indicated that Thulamela and Collins Chabane Local Municipalities are using garden waste to make compost and sell it to the communities, whereas Makhado and Musina Local Municipalities are not using garden waste to make compost, garden waste is compacted with other waste materials in the landfill sites. The results of this study is not the same as compared to the results of the study conducted in Johannesburg, where garden waste is used to do compost and the compost is used as cover materials when burying the crushed waste within a landfill site (Tembon, 2012). The study conducted in Bandung, Indonesia reported that the takakura home method has been used as a method of composting organic waste in many households. The use of takakura and community participation methods has successfully reduced organic waste sent to landfill site by 30%. In addition, household organic waste is composted and used as fertilizer, thus providing additional economic value for households (Proboretno, 2018). Other municipalities in the study area do not create compost from garden waste; garden waste is compacted with other waste materials in the landfill site whereas other countries are creating compost from garden waste.

### **Waste disposal**

Municipalities are using sanitary landfill sites for waste disposal. There is a person called a spotter at the entrance of each landfill site to check the type of waste, to estimate the quantities of waste and to ensure that people are not entering with prohibited waste within the landfill sites. It was indicated that landfill sites in the district have weighbridge while other landfill sites are not having weighbridge to quantify waste entering the site. For example, Makhado landfill site has a Weighbridge but it is not yet functional due to unavailability of electricity within the landfill, whereas Musina, Thulamela and Collins Chabane landfill sites are not having weighbridges. All municipalities within a district are still relying on spotter for waste quantification. In Pakistan, a weighbridge is installed on Mehmood Booti landfill site and is used to measure the quantities of waste brought to the landfill site every day (Masood et al., 2014).

The study found that waste received in the landfill sites is categorized as general waste, garden waste and building rubbles. Makhado Local Municipality landfill site receives the highest amount of waste on a monthly basis which is 8000 tons whereas Musina Local

Municipality receives the least amount of waste which is 2023 tons. The bulk of waste generated in the district is general waste comprising of 9942 tons, garden waste is 3651 tons and building rubbles is 1930 tons and general waste is representing 64% of waste received in the landfills. Garden waste is 24%, while building rubbles is 12%. The total amount of waste disposed within the landfill sites in the district per month is 15523 tons. The amount of waste disposed in the district is low compared to amount of waste disposed in China, where the waste disposal capacity has reached 533,455 tons /day, with a decontamination rate of 91.8% (Zhang et al., 2010). In Jordan, waste disposal site receives 200–250 tons of municipal solid waste per day which are generated from the Greater Mafraq Municipality districts and Zaatari camp (Saidan et al., 2017).

It was indicated that other landfill sites in the district have site information notice board at the entrance of the site. For example, Thulamela landfill site notice board does not have information on prohibited waste whereas Makhado landfill notice board has information on waste allowed and prohibited waste and Musina landfill site does not have site information notice board. It leads people to enter with prohibited waste within the site. For example, in Thulamela landfill site there is hazardous waste stored on the skip bins. The results of this study is the same as the results of the study conducted in South Africa, Limpopo Province, where Musina landfill site does not have site information notice board and lack of information boards at the landfill sites entrance lead people to enter with prohibited waste (Mudau, 2015).

It was indicated that some of the landfill sites used in the district are using different layers such high density polyethane to avoid infiltration of leachate from the landfill which contaminates underground water whereas other landfill sites are not lined. For example, Makhado and Thulamela landfill sites are lined whereas Musina landfill site is not lined. Musina Local Municipality is using a quarry as the landfill site. A quarry was developed due to the collection of gravel which was used to build Musina road. Due to unavailability of liners in Musina landfill site, it leads to contamination of the underground water. The results of this study is the same as the results of the study conducted in Nigeria, where landfill sites that are utilised are not subjected to regulations, they are normally located for convenience, and they were pre-existing holes which were created due to sand mining activities (Adogu et al., 2015). The results of this study is also supported by the results of the study conducted in Zambia, Kitwe city, where the dumping sites do not have liners to prevent ground water contamination by the leachate generated from the landfill (Mwanza et al., 2018). The results

of this study is also supported by the results of the study conducted in Vietnam, where disposal sites lack leachate treatment facilities, protection at the bottom by a geo-membrane or clay-lined layer, and landfill gas monitoring and collection equipment giving rise to serious environmental degradation (Luong et al., 2013). The landfill sites which are not lined are not only available in Vhembe District Municipality; but it is a problem which is also occurring in other countries.

It was indicated that landfill sites have leachate ponds whereas other landfill sites are not having leachate ponds, for example, Thulamela and Makhado landfill sites have leachate ponds, whereas Musina landfill site is not having leachate pond but the municipality is in a process of constructing a leachate pond. In the district, leachate is treated in different ways at the landfill sites, for example, Makhado Local Municipality treats leachate through allowing it to evaporate from the leachate pond using sunlight, sometimes leachate is pumped and sent to the nearest water treatment plant for water purification when pond is full especially during heavy rainy season, whereas Thulamela Local Municipality treats leachate through pouring it on top of the soil within a landfill to suppress the dust. The results of this study are similar to the results of the study conducted in Nigeria, where municipalities are using sanitary landfill sites which are having liners, leachate collection and treatment system, and gas collection system to protect human health and the environment (Adogu et al., 2015). The difference between the landfill sites in Vhembe District Municipality and those of Nigeria is that, in Nigeria, the landfill sites have gas collection system whereas in Vhembe District are only having liners and leachate treatment facilities.

### **Legal Policies and Strategies**

The study indicated that municipalities have law enforcement personnel whereas other municipalities are not having law enforcement personnel to create and enforce by-laws, for example, Makhado and Collins Chabane Local Municipalities have law enforcement officers, whereas Thulamela and Musina Local Municipalities are not having law enforcement officers but Thulamela Local Municipality is in a process of appointing and training law enforcement personnel. Collins Chabane and Musina Local Municipalities drafted by-laws and Integrated Development Plan, the municipalities are waiting for the magistrate to approve the by-laws then the municipalities will start enforcing those by-laws within the municipalities, whereas Makhado and Thulamela Local Municipalities are having a serious challenge on drafting and enforcing by-laws.

The study conducted in India revealed that legal constraints affect waste management processes due to poor enabling laws, regulations, standards, policies and poor enforcement of available laws, political intervention and penalty which are weak (Srivastava et al, 2015). The study conducted in Beitbridge border town reported the same results that inadequate waste management policies, weak regulations, legislative frameworks which are pertaining to waste management affect the implementation of effective sustainable waste management system (Mundoga and Moyo, 2017).

The study found that other municipalities within a district have penalties to offenders; for example, Makhado Local Municipality has penalties to people who are doing illegal dumping, whereas Collins Chabane, Thulamela and Musina Local Municipalities are not having penalties to people who are doing illegal dumping. The results of this study are different as compared to the results of the study conducted in South Africa, Limpopo province, where the practice of imposing penalties to the offenders is almost non-existent within Vhembe District Municipality (Mudau, 2015). This shows that there are changes within a district, as the results of the study conducted in South Africa, Limpopo province indicated that penalties to offenders was almost non-existent within Vhembe District whereas the results of this study indicated that only Makhado Local Municipality within a district has penalties to offenders.

### **Technical Aspects**

In the district, there is lack of qualified technicians to repair the equipment; it leads to long time of waiting for repairing the equipment. Makhado Local Municipality has 1 technician and 2 assistants, Thulamela Local Municipality has 4 technicians and 4 assistants, Musina and Collins Chabane Local Municipalities are not having technicians. There are only 5 technicians and 6 assistants within a district. Most of the equipment used are sensitive and local technicians are unable to fix them. When equipment breakdown, it affects waste collection, transportation and landfill operation while waiting for the qualified technicians to fix the equipment. The results of this study are the same as compared to the results of the study conducted in Kwazulu-Natal, where landfills sites are poorly managed within a district. Landfill permits are available, but licence requirements are not obeyed due to the shortage of personnel, covering material and machinery, which takes long to be repaired due to lack of qualified technical personnel and it leads to backlog on covering and compaction of waste within the landfill sites (Khumalo, 2016). The results of the study conducted in Mozambique reported that waste collection trucks given to the government cannot be maintained locally

due to lack of technical knowledge or qualified engineers and replacement parts (Sallwey et al., 2017). The study conducted in Polokwane city, revealed the same results that due to lack of qualified waste management personnel within municipalities and lack of skills on waste management technologies to be implemented; it limits the distribution of information and training on material recovery and recycling (Maluleke, 2014).

### **Institutional aspects**

It was indicated that if equipment is not adequate, it affects waste management value chain. Makhado Local Municipality has 4 refuse compactor trucks, 7 half trucks, 3 LDV bakkies, 1 skip loader, 1 TLB, 2 landfill compactor machine and 4 tractors, Thulamela Local Municipality has 14 refuse compactor trucks, 2 half trucks, 1 skip loader and 4 LDV bakkies, 1 rubber dozer, 1 front end loader, 1 landfill compactor machine and 1 tractor. Collins Chabane Local Municipality has 4 refuse compactor trucks, 1 tractor, 1 half truck, 2 TLB, 1 skip loader and Musina Local Municipality has 3 refuse compactor track, 1 TLB, 1 bull dozer, 1 water truck, 1 excavator, 1 tipper truck 1. Thulamela Local Municipality has the highest number of waste management equipment whereas Collins Chabane and Musina Local Municipalities have least number of equipment. The results of this study is the same as compared to the results of the conducted in Mozambique where lack of proper waste collection equipment and means for subsequent maintenance of equipment is among the major known problems affecting the progress in waste collection (Sallwey et al., 2017).

The study found that some of the equipment used within municipalities are old, for example, in Makhado Local Municipality, trucks and tractors that they use are 20 years old and they often breakdown on the road and this situation affects waste collection and transportation, whereas equipment used in Thulamela, Collins Chabane and Musina Local Municipalities are not old. The results of this study are similar to the results of the study conducted in Zimbabwe, Harare, where waste management vehicles frequently break down and it affects household waste collection service as the municipality does not have enough waste management vehicles (Mandeverere, 2015). The results of the study conducted in West Rand District Municipality, Gauteng, South Africa reported the same results that 70% of the waste management equipment are older than ten years and they need replacement due to frequent breakdowns on the route, overloads, lack of routine maintenance and poor road network. The study conducted in Addis Ababa city, central Ethiopia reported that the main challenge on waste transportation as trucks are very old, maintenance is difficult, negligence of drivers, and frequent of accidents (Regassa et al., 2011).

The study conducted in West Rand District Municipality, Gauteng, South Africa, found that the biggest problem is the spare parts used for repairing the equipment as they are always not readily available and existing waste collection and transportation systems cannot handle the amount of waste produced (Ginindza et al., 2016). The results of this study are also supported by the results of the study conducted at Beitbridge boarder town, where municipality waste management system is affected by implementing outdated strategic waste management plan, low priority to solid waste management issues by the municipalities, occupancy of un-serviced stands make waste collection service difficult, inadequate waste collection and treatment facilities (Mundoga and Moyo, 2017). It shows that the breakdown of equipment or vehicles is a problem which is faced by municipalities through the world. Thulamela Local municipality used to sell old equipment through auction to avoid the issue of break down. In the district, there are poor road network especially in rural areas, municipalities cannot use trucks to collect waste from door to door as it is difficult to reach the collection point. The results of this study is the same as compared to the results of the study conducted in South Africa, where roads condition are bad or inaccessible and waste collection vehicle cannot be able to reach collection point and wastes remain at their sources of generation for a longer time (Mmereki et al., 2016).

### **Financial and economic aspects**

It was indicated that there is a lack of prioritization in some municipalities within the district. For example, in Makhado Local Municipality, when budget comes to the municipality, a lot of money is allocated to other proposed projects by councilors as they consider waste management to be too expensive. The results of this study support the results of the study conducted in South Africa, Limpopo province, where little budget is allocated to waste management and it leads to organisational and technical weaknesses, inadequate service delivery and these lead to low level of compliance (Mudau, 2015). In Thulamela, Collins Chabane and Musina Local Municipalities, when budget come, municipalities do not use money allocated to waste management on other proposed projects.

In the district, residents are not willing to pay for waste collection service fee especially in rural areas. People from rural areas believe that it is a responsibility of the municipalities only to collect waste generated in their areas. Residents are not aware of the importance of their contribution on waste management. The results of this study is the same as the results of the study conducted in Baitbridge boarder town, where lack of financial resources, limited participation by the private sector on managing waste, un-willingness of the residents to pay

for waste management service and lack of economic instruments affect waste management system (Mundoga and Moyo, 2017). The study conducted in Tha Khon Yang, Maha Sarakham Province, northeast Thailand reported that financial constraints are one of the major obstacles to implementation of effective solid waste management. There are three main financial barriers which include waste management tariffs; the assumption that waste has no value; and that overall, insufficient external funding within municipalities (Yukalang et al., 2017).

It is also indicated that municipalities within a district have insufficient fund and they do not manage to collect waste from door to door both in rural and urban communities. Municipalities cannot afford to buy enough waste management equipment, for example, Musina, Thulamela, Makhado and Collins Chabane Local Municipalities have insufficient waste storage facilities. The results of this study are similar to the results of the study conducted in South Africa, where lack of financial resources leads municipalities not to be able to buy proper equipment and machinery for the waste generators to store their wastes; this service is expensive especially in developing countries (Mmereki et al., 2016). The results of the study conducted in Mozambique reported that in 2004, 46% of the waste collection vehicles of the municipality were out of order and the failure of equipment were not only originating from the variety of vehicles used for collection but also from the low level of investment funds set for the maintenance of the vehicles and this issue is not only limited to Mozambique, but it is a common problem in Africa (Sallwey et al., 2017).

The study indicated that municipalities within a district have different budgets for refuse removal and the budgets are supplemented by monthly refuse removal services fee paid by residents, for example, Makhado Local Municipality makes provision of about R900,000.00 for refuse removal for the whole municipality, Thulamela makes R1000 000.00, 600 000.00 and Collins Chabane Local Municipality makes R500 000. Thulamela Local Municipality has the highest budget for refuse removal whereas Collins Chabane has the least budget for refuse removal. The total amount of money used is R3000 000.00. The results of this study is not the same as compared to the results of the study conducted in Europe, Serbia, where the total estimated money used on waste management is (€) 19,114,368 19,958,718 (Mihajlovic, 2016). The money used in Europe, Serbia is too much high as compared to the money used in Vhembe District Municipality. In New York City, expenditure on residential and commercial waste is approximately \$2.3 billion of the city's \$75 billion annual budget (Cohen et al., 2015). In Pakistan, the total budget for waste management was R2.9 billion (US\$30 million

year-1) for the year 2009–2010. The budget was raised to R6.0 billion (US\$65 million year-1) for the year 2011– 2012 to accommodate the high costs of waste management by the private companies. The waste management cost has increased from approximately US\$13 tonne-1 to US\$20 tonne-1, with waste collection and transportation remaining the only focus (Masood et al., 2014). Money allocated to waste management in other countries is higher as compared to money allocated in Vhembe District Municipality.

### **Social and cultural aspects**

It was indicated that it is difficult to change the mind-set of the communities. Few people within communities do separation at source and sometimes recyclables materials are mixed with prohibited waste at landfill, for example, in Thulamela Local Municipality, a refuse compactor truck was burning in 2017 during transportation of waste to the landfill due to ashes which were mixed with materials such plastics and papers by the residents. The results of this study are similar to the results of the study conducted in Beitbridge boarder Town, where waste management system is also affected by social issues which include lack of cooperation between service providers and the service users, unwillingness of society to contribute on waste management, lack of knowledge about the importance of waste separation at source as well as the issue of illegal dumping by communities (Mundoga and Moyo, 2017).

It was indicated that in the district, the nappies are disposed of in the open land and within the catchments which ultimately contaminate water bodies, for example, in Musina Local Municipality; there is an illegal dumping of waste in the catchment areas and on the roadside. The results of this study are the same as compared to the results of the study conducted in Johannesburg, Ekurhuleni Municipality where, there are heaps of rubbish in the settlements and by the road side (Tembon, 2012). Municipalities provide notice boards which are placed strategically to discourage illegal dumping. The residents continue doing illegal dumping and littering on areas where there is a notice boards. The results of this study are not different from the results of the study conducted in South Africa, Limpopo Province, where there are illegal dump hot spots at Ba-Phalaborwa, Polokwane and Lepelle-Nkumpi Local Municipalities in areas where skip bins were placed to facilitate waste collection (Mudau, 2015). The results of the study conducted in West Rand District Municipality, Gauteng, South Africa reported that illegal dumping of waste is also common as a result of the use of small bins (240L bins) for residential waste storage and the municipality is failing to provide

large bins. The bins get filled up before waste is collected and people illegally dispose waste in open spaces (Ginindza et al., 2016).

There is vandalism of storage facilities which sometimes occur accidentally within the district. Communities also cut steel bins and use them for recreational purposes while others use them to build braai stands, for example, University of Venda students use to break concrete bins and use them to block the roads during the strike and burn the plastic litter bins. The result of this study is not different from the result of the study conducted in Polokwane city, where transfer station facilities are exposed to vandalism by waste pickers and even stray dogs, thus ending up as human and environmental health hazards (Chimuka and Ogola, 2015). The results of the study conducted in Tha Khon Yang, Maha Sarakham Province, northeast Thailand reported that kerb-side waste storage bins for public use in the Tha Khon Yang community were provided but other people took the bins away because they were unsightly and smelled bad, the community remains without having waste storage facilities (Yukalang et al., 2017). Thulamela Local Municipality faced the highest challenge of vandalism of storage facilities due to strike by students from University of Venda.

### **Potential implications of municipal solid waste on the environment and human health**

It was indicated that waste from illegal dump hot spot in the district sometimes block the water channels which lead to flooding during heavy rains. Other waste material is dumped in the catchment areas, thus ultimately contaminates the water bodies and impacts negatively on aquatic life due to the presence of toxicants in the waste. The study conducted in Mexico reported the same results where excessive littering can contaminate waterways and clog drainage systems whereas in agricultural zones, littering also pollute fields, pastures, and irrigation systems, forcing producers to divert time and labour to clean up (Hilburn, 2016). The result of this study is the same as compared to the result of the study conducted in Thulamela Local Municipality, Khakhanwa village, where waste is disposed in open spaces along the road and in valley which provide the surrounding community with water during rainy season (Mabadahanye, 2017).

The results of this study is also supported by the results of the study conducted in Kano Metropolis, Nigeria, where waste materials dumped illegally is moved by storm water to the drainage channels that were made for excess runoff, thus preventing easy flow of water and it leads to devastating flood which washed away the highways and homes, furthermore the obstruction of drainage channels by waste materials such as plastics and tyres usually lead to

a situation whereby dirty stagnant water runs in front of settlements and main roads (Butu and Mshelia, 2014). In Vietnam, many cities and towns suffered from the illegal dumping of waste in rivers, lakes, oceans, drainage channels and roadsides (Luong et al., 2013).

The study indicated that solid waste leads to ill health of children as they ingest some of the food waste material when they are playing in the vicinity of the illegal dumps. The district also faced number of health and environmental issues due to municipal solid waste, rotten food waste attracts mosquitos, flies and rats which lead to the spread of pathogenic diseases to the surrounding communities, for example, in Musina Local Municipality, people generally request the municipality to visit the illegal dump hot spots and spray against mosquitos and other dangerous insects and rodents. The results of this study are the same as compared to the results revealed by the study conducted in Kano Metropolis, Nigeria, where the disease pathways to children commonly occurs through placing of polluted hands in the mouth or sometimes eating food waste materials or through vector insects such as cockroaches and mosquitoes, or by directly inhaling air borne polluted particles. Vectors insects including flies, cockroaches and mosquitoes find illegal dump sites as the suitable place to stay (Butu and Mshelia, 2014).

It was indicated that waste which is not properly managed lead people to be affected by disease such as malaria, diarrhoea, yellow fever cholera, respiratory problem due to flies and cockroaches which carry some of the waste materials to the communities and people can even get injured from waste materials such as bottles, glasses and metals. The results of this study are the same as compared to the results of the study conducted in Zimbabwe, where illegal dumped waste attracts flies and cockroaches; they sometimes carry waste particles from one place to another (Jerie and Tevera, 2014). The results of this study are also supported by the results of the study conducted in Kano Metropolis, Nigeria, where flies spread enteric infections which include diarrhoea, typhoid, dysentery and waste particles also affect eyes and skin infections such as cutaneous ephthera, yaws and incidents of such diseases such as diarrhoea have already happened in the informal enterprises (Butu and Mshelia, 2014).

The study indicated that other municipalities within the district are using sanitary landfill sites whereas other municipalities are using open dumps; for example, Musina Local Municipality is using a quarry as the landfill site, whereas Thulamela, Collins Chabane and Makhado Local Municipalities are using sanitary landfill sites. The quarry used by Musina Local Municipality was developed due to collection of sand to build the Musina road. The

quarry used does not have a sheeting type clay liner to prevent infiltration of leachate from the landfill. This leads to contamination of underground water by leachate when leaking from the landfill site. The results of this study is the same as compared to the results of the study conducted in Zimbabwe, where leaking of toxic substance in areas vicinity to the dumping site leads to ultimately pollution of water sources which result in diarrhoea diseases (Jerie and Tevera, 2014).

## CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

### 6.1 Introduction

In this chapter, conclusion drawn and recommendations are presented to address the problem in the study area. This chapter presents conclusion drawn from the findings based on the specific objectives of the study. It also presents recommendations made based on the findings. The first part of the recommendations made were suggested for further improved municipal solid waste management strategies within the municipalities and the second part of the recommendations were suggested for further research study on municipal solid waste management around the world.

### 6.2 Conclusion

The study was conducted in Vhembe District Municipality. Vhembe District Municipality has four local municipalities which include Makhado, Thulamela, Musina and Collins Chabane. The study therefore focused on selected urban centres of these local municipalities which include Thohoyandou, Malamulele, Messina and Louis Trichardt town and waste management facilities available for data collection. Most of the challenges that the municipalities are encountering when managing waste are the same. Waste management strategies being implemented by municipalities are the same. Municipalities are not yet taken any steps to develop waste recovery, incineration and recycling. Treatment such as recycling is only left to the mercy of the private sectors.

#### Specific objectives

- Investigate the solid waste management practices currently used in Vhembe District Municipality.

In Vhembe District Municipality, it was observed that the bulk of waste generated per month within municipalities is general waste comprising of 64%, as compared to garden waste and building rubbles. There are no equipment and programs in place by municipalities to encourage waste separation at source, for example, municipalities do not have household recyclable receptacles to encourage separation at source. It was observed that Makhado Local Municipality has weighbridge which is not functional to quantify waste entering the site, whereas Musina, Thulamela and Collins Chabane Local Municipalities are not having

weighbridge, hence quantification of waste being collected and disposed to the dumpsite is not accurate.

It was observed that Thulamela and Collins Chabane Local municipalities create compost from garden waste received at the landfill sites, whereas Musina and Makhado Local Municipalities do not create compost from garden waste and it is disposed and compacted with other waste materials in the landfills. The study confirms that transfer stations and drop-off point facilities for Makhado Local Municipality are operational, whereas in Thulamela, Collins Chabane Local Municipalities are not functional due to unavailability of license and Musina Local Municipality does not have drop-off point and transfer station facilities.

- Examine the factors affecting sustainable waste management practices in Vhembe District Municipality.

The study confirmed that there is lack of waste management law enforcement personnel within municipalities in the district and setting and enforcement of laws is very difficult, laws within the municipalities are created by waste managers, superintendents and directors. In Makhado Local Municipality, there is lack of prioritization, money is allocated to other proposed projects by councilors as they do not prioritize waste management, whereas Musina, Thulamela and Collins Chabane Local municipalities are being prioritized. The available vehicles within municipalities are not enough to meet the demand and some of them are too old, for example, tractors and trucks used by Makhado Local Municipality are 20 years old and they often breakdown, whereas Thulamela, Collins Chabane and Musina Local Municipalities are not using old vehicles as they auctioned old vehicles and buy new vehicles.

- Examine the potential impacts of municipal solid waste on the environment in Vhembe District Municipality.

This study confirmed that within the district there is high level of illegal dumping of waste in catchment areas and open spaces at Musina Local Municipality as compared to Makhado, Collins Chanabe and Thulamela Local Municipalities. There is high level of potential impact of waste on the environment especially in Musina Local Municipality as the municipality is using a quarry as disposal site which was not lined and it leads to contamination of underground water by leachate, whereas Makhado, Thulamela and Collins Chabane Local

Municipalities are using landfills sites which are lined to avoid contamination of ground water.

### 6.3 Recommendations

#### ➤ Recommendations for improved municipal solid waste management strategies

- The study recommends that municipalities should manage waste in accordance to the new approach of source separation, waste reduction, reuse and recycling through developing environmental awareness programmes supported by the placement of the recyclable receptacles at strategic points to collect recyclable materials which will reduce large amount of waste which eventually ends in landfills.
- There is a need to develop an integrated waste management plan for Vhembe District Municipality with a prioritization on waste minimization and develop a strategy to support household separation at source to improve recycling activities.
- Waste generation statistics are crucial in waste management; municipalities should install weighbridge to quantify the waste entering the landfill sites as the accuracy of the waste statistics help municipalities in terms of planning for waste generated, municipalities should develop a monitoring system for waste classification, quality and quantity.
- Municipalities should create compost from garden waste receive at the landfill sites as it helps to extended the life span of the landfills because this reduces amount of waste to be landfilled.
- Municipalities should apply for waste management licenses for their facilities at the relevant department as those facilities are not cost effective to operate and it will help municipalities to implement sound waste management system.
- The study recommends that municipalities should have law enforcement structure which will create and enforce the laws/policies as it helps municipalities to implement effective waste management system and monitoring structure to monitor prioritization and budget allocation to avoid waste management budget to be used to other proposed projects.
- Municipalities should prioritise the issue of auctioning all old vehicles and buy new vehicles to avoid breakdown of old vehicles as it affects waste collection, transportation and landfill operation.

- Municipalities should introduce fines to people who are doing illegal dumping to make people contribute on managing waste in a sustainable way through disposing their waste inside the bins and containers provided by municipalities.
- Municipalities should have landfill monitoring committees to facilitate the compliance on the development and operation of the landfills to avoid the use of quarry as landfill sites lead to potential impacts on the environment.

➤ **Recommendations for further research studies**

- Future research study should be carried out on the community's perception and willingness to manage waste produced in their areas as it will help communities to contribute to sustainable way of managing waste through source separation, reduce, reuse and recycling.
- The study recommends that there should be further research studies on the factors affecting sustainable waste management strategies and the best waste management practices/strategies as there are little studies conducted in South Africa.
- It is recommended that future research studies should be carried out on the application of existing waste management policies, acts and regulation as there is lack of application of these legal frameworks by municipalities in South Africa.
- The study recommends that further research studies should be carried out on the long term planning towards zero-waste management strategies.

## REFERENCES

- Alam, P. & Ahmade, K., 2013. *Impact of solid waste on health and the environment*. International Journal of Sustainable Development and Green Economics (IJSDDGE), 2(1), pp.165-168.
- Abdoli, M.A.; Tavakolli, H. & Azari, A., 2013. *Alternatives for solid waste management in Isfahan, Iran: A case study*. Waste Management. Res., 31(5): 532-537 (16 pages).
- Abdoli, M.A., Rezaei, M. & Hasanian, H., 2016. *Integrated solid waste management in megacities*. Global Journal of Environmental Science and Management, 2(3), pp.289-298.
- Abd'Razack, N.T., Medayese, S.O., Shaibu, S.I. & Adeleye, B.M., 2017. *Habits and benefits of recycling solid waste among households in Kaduna, North West Nigeria*. Sustainable cities and society, 28, pp.297-306.
- Adeniyi, A., Dayomi, M., Siebe, P. & Okedeyi, O., 2008. *An assessment of the levels of phthalate esters and metals in the Muledane open dump, Thohoyandou, Limpopo Province, South Africa*. Chemistry Central Journal, 2(1), p.9.
- Adogu, P.O.U., Uwakwe, K.A., Egenti, N.B., Okwuoha, A.P. & Nkwocha, I.B., 2015. *Assessment of waste management practices among residents of Owerri Municipal Imo State Nigeria*. Journal of environmental protection, 6(05), p.446.
- Ahmed, S.A. & Ali, M., 2004. *Partnerships for solid waste management in developing countries: Linking theories to realities*. Habitat International, 28, pp.467-479.
- Aja, O.C., Oseghale, S.D. & Al-Kayiem, H., 2014. *Review and Evaluation of Municipal Solid Waste Management Practices in Malaysia*. The journal of Solid Waste Technology and Management, 40(3), pp.215-232.
- Alekhya, M., Divya, N., Jyothirmai, G., & Reddy, K.R., 2013. *Secured landfills for disposal of municipal solid waste*. Int. J. Eng. Res. Gen. Sci. 1 (1).
- Ahmadi, M., 2017. *Evaluating the Performance of 3Rs Waste Practices: Case Study-Region One Municipality of Tehran*. Advances in Recycling Waste Management, 2(2), p.130.

Anon, 2017. Available at: [https://www.environment.gov.za/sites/default/files/reports/environmentoutlook\\_chapter13.pdf](https://www.environment.gov.za/sites/default/files/reports/environmentoutlook_chapter13.pdf) [Accessed 8 Nov. 2017].

Arbulú, I., Lozano, J. & Rey-Maqueieira, J., 2016. *The challenges of municipal solid waste management systems provided by public-private partnerships in mature tourist destinations: the case of Mallorca*. *Waste Management*, 51, pp.252-258.

Badgie, D., Samah, M.A.A., Manaf, L.A. & Muda, A.B., 2012. *Assessment of Municipal Solid Waste Composition in Malaysia: Management, Practice, and Challenges*. *Polish journal of Environmental Studies*, 21(3).

Bank, A.D. 2013. *Solid waste management in Nepal: Current status and policy recommendations*. Available at: <https://www.adb.org/sites/default/files/publication/30366/solid-waste-management-nepal.pdf> (Accessed: 24 August 2017).

Bouanini, S., 2013. *Assessing municipal solid waste management in China*. *World journal of Social Sciences*, 3(4).

Butu, A.W. & Mshelia, S.S., 2014. *Municipal solid waste disposal and environmental issues in Kano metropolis, Nigeria*. *British Journal of Environmental Sciences*, 2(1), pp.1-16.

Byamba, B. & Ishikawa, M., 2017. *Municipal solid waste management in Ulaanbaatar, Mongolia: Systems analysis*. *Sustainability*, 9(6), p.896.

Cecere, Grazia, Mancinelli, Susanna, Mazzanti, Massimiliano, 2014. *Waste prevention and social preferences: the role of intrinsic and extrinsic motivations*. *Ecol. Econ.* 107, 163e176.

Coelho, L.M.G. & Lange, L.C., 2018. *Applying life cycle assessment to support environmentally sustainable waste management strategies in Brazil*. *Resources, Conservation and Recycling*, 128, pp.438-450.

Cohen, S., Martinez, H. & Schroder, A., 2015. *Waste Management Practices in New York City, Hong Kong and Beijing*. 2017O07O 06]. <http://www.columbia.edu/dsc32>.

Connett, Paul, 2013a. *Zero waste 2020: sustainability in our hand*. In: Lehmann, S., Crocker, R. (Eds.), *Motivating Change: Sustainable Design and Behaviour in the Built Environment*. Earthscan Publication, London.

Chimuka, L. & Ogola, J., 2015. *Leading the way: Directions of municipal solid waste management in South Africa*. Future directions of municipal solid waste management in Africa, p.176e199.

Creswell, J.W. & Creswell, J.D., 2017. *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Curran, T., & Williams, I.D., 2012. *A zero waste vision for industrial networks in Europe*. J. Hazard. Mater. 207–208, 3–7.

Central pollution Control Board. 2000 *Management of municipal solid waste Delhi*. See [http://www.cpcb.nic.in/divisionsofheadoffice/pcp/MSW\\_Report.pdf](http://www.cpcb.nic.in/divisionsofheadoffice/pcp/MSW_Report.pdf) (accessed 15 July 2017).

Cpcb.nic.in, 2017. *Cite a Website - Cite This For Me*. [online] Available at: <http://cpcb.nic.in/wast/> Department of Environmental Affairs, Pretoria.

Department of Environmental Affairs, 2011. *Draft Municipal Waste Sector Plan*. Department of Environmental Affairs, Pretoria.

Department of Environmental Affairs, 2012a. *National Waste Management Strategy*. Department of Environmental Affairs, Pretoria.

Department of Environmental Affairs, 2012b. *National Waste Information Baseline Report*. Department of Environmental Affairs, Pretoria.

Department of Environmental Affairs and Tourism, 2000: *White Paper on Integrated Pollution and Waste Management in South Africa*. Pretoria, South Africa, pp 10-14.

Department of Environmental Affairs and Tourism, 2001: *National Waste Management Strategy*, Version D, Pretoria, South Africa, pp1-158.

Department of Environmental Affairs and Tourism, 2007. *South Africa Environmental Outlook: A report on the state of the environment*, DEA, Pretoria.

Department of Environmental Affairs and Tourism, 2007. *Assessment of the status of waste service delivery and capacity at the local government level*. Directorate: General Waste Management – Draft 3. Government printers: Pretoria.

Environment Africa, 2013. *It's Time to Talk Recycling*. WWW.Environmentafrica.org

European Environment Agency. 2013. *Municipal waste management in the Netherlands*. Prepared by Leonidas Milios.

Faccio M, Persona A, & Zanin G. 2011. *Waste collection multi objective model with real time traceability data*. *Waste Manage*; 31(12):2391–2405.

Familynursing. conferenceseries.com, 2017. *Knowledge of community members regarding household solid waste management within selected villages in South Africa Nursing, 2015* Conferenceseries. Available at: <https://familynursing.conferenceseries.com/abstract/2017/knowledge-of-communitmembers-regarding-household-solid-waste-management-within-selected-villages-in-south-africa> [Accessed 4 Dec. 2017].

Foday, P.S., Ya, X. & Quangyen, T., 2013. *Environmental and health impacts of solid waste disposal in developing cities: A case study of Granville Brook dumpsite, Freetown. Sierra Leone*. *Journal of Environmental Protection*, 4, pp. 665-670.

Ferreira, F., Avelino, C., Bentes, I., Matos, C., & Teixeira, C.A., 2017. *Assessment strategies for municipal selective waste collection schemes*. *Waste Manage*. 59, 3–13.

Fudala-Ksiazek, S., Pierpaoli, M., Kulbat, E., & Luczkiewicz, A., 2016. *A modern solid waste management strategy—the generation of new by-products*. *Waste Management*. 49, 516–529.

Ferronato, N., Gorrity Portillo, M.A., Guisbert Lizarazu, E.G., Torretta, V., Bezzi, M. & Ragazzi, M., 2018. *The municipal solid waste management of La Paz (Bolivia): Challenges and opportunities for a sustainable development*. *Waste Management & Research*, 36(3), pp.288-299.

Gebriil, A.O., Omran, A., Pakir, A.H.K. & Aziz, H.A., 2010. *Municipal solid waste management in Benghazi (LIBYA): Current practices and challenges*. *Environmental Engineering & Management Journal (EEMJ)*, 9(9).

Gharfalkar, M., Court, R., Campbell, C., Ali, Z., & Hillier, G., 2015. *Analysis of waste hierarchy in the European waste directive 2008/98/EC*. *Waste Management*. 39, 305– 313.

Ginindza, B. & Muzenda, E., 2016. *Waste management challenges to opportunities in the west rand district municipality, Gauteng, South Africa: initiatives*.

- Grossoehme, D.H., 2014. *Overview of qualitative research*. Journal of health care chaplaincy, 20(3), pp.109-122.
- Guangyu, Y., 2009. *Amounts and composition of municipal solid wastes*. Point Sources of Pollution: Local Effects their Control-Volume II, p.275.
- Guerrero, L.A., Maas, G. & Hogland, W., 2013. *Solid waste management challenges for cities in developing countries*. Waste management, 33(1), pp.220-232.
- Gupta, N., Yadav, K.K. & Kumar, V., 2015. A review on current status of municipal solid waste management in India. Journal of environmental sciences, 37, pp.206-217.
- Halifax Regional Municipality, 2010. *Restaurants, institutions, apartment properties & other businesses*. Signage requirements. Retrieved from <http://www.halifax.ca/wrms/ici.html#new>
- Hilburn, A., 2016. *Gauging the Material Magnitude, Public Perception, and Governance of Roadside Litter in a Rural Mexican Municipio*. Human ecology, 44(4), pp.479-491
- Hoornweg, D. & Bhada-Tata, P., 2012. *What a waste: a global review of solid waste management*. Urban development series knowledge papers, 15, pp. 1-98..
- ISWA and UNEP (2015). *Global Waste Management Outlook – Draft Version*.
- Islam, K.N., 2017. *Greenhouse gas footprint and the carbon flow associated with different solid waste management strategy for urban metabolism in Bangladesh*. Sci. Total Environ. 580, 755–769.
- Jeswani, H.K. & Azapagic, A., 2016. *Assessing the environmental sustainability of energy recovery from municipal solid waste in the UK*. Waste management, 50, pp.346-363.
- Jerie, S. & Tevera, D., 2014. *Solid waste management practices in the informal sector of Gweru, Zimbabwe*. Journal of waste management, 2014.
- Jha, A.k., Singh, SK., Singh, G.P. & Gupta, P.K., 2011. *Sustainable municipal solid waste management in Low income group of cities: a review*. Tropical Ecology, 52(1), pp. 123-131.
- Joshi, R. & Ahmed, S., 2016. *Status and challenges of municipal solid waste management in India: A review*. Cogent Environmental Science, 2(1), p.1139434.
- Kadafa AY, Latifa A, Abdullahi HS, & Suleiman WA, 2013. *Comparative Assessment of the municipal Solid Waste Management Services*. Nature and Science, 11(6): 154-164.

Kalyani, A. K. & K. K. Pandey. 2014. *Waste to energy status in India: A short review*. Renewable and Sustainable Energy Reviews 31:113–120.

Kassie, K.E., 2016. *The problem of solid waste management and people awareness on appropriate solid waste disposal in Bahir Dar City: Amhara region, Ethiopia*. ISABB Journal of Health and Environmental Sciences, 3(1), pp.1-8.

Kubanza, S.N., 2012. *Perception and issues of solid waste management in South Africa, Johannesburg: case study* (Doctoral dissertation).

Khumalo, S.A., 2016. *Environmental impact of household solid waste disposal practices on plant growth in rural areas of KwaZulu-Natal: a case study of UThukela District Municipality* (Doctoral dissertation).

Kumar, S., Smith, S.R., Fowler, G., Velis, C., Kumar, S.J., Arya, S., Rena, Kumar, R. and Cheeseman, C., 2017. *Challenges and opportunities associated with waste management in India*. Royal society open science, 4(3), p.160764.

Kumar, A., Dixit, G. & Prabhakar, D., 2016. *Analyzing the Factors Affecting the Sustainable Municipal Solid Waste Management*. Indian Journal of Science and Technology, 9(47).

Lee, Jihyun, Branth Pedersen, Anders, Thomsen, Marianne, 2014. *The influence of resource strategies on childhood phthalate exposure: the role of reach in a zero waste society*. Environment. Int. 73, 312e322. <http://dx.doi.org/10.1016/j.envint.2014.08.003>.

Levis, J.W., Barlaz, M.A., De Carolis, J.F., & Ranjithan, S.R., 2013. *A generalized multistage optimization modelling framework for life cycle assessment-based integrated solid waste management*. Environment. Modell. Softw. 50, 51–65.

Limdlgh.gov.za. 2017. Cite a Website - Cite This For Me. [online] Available at: <http://www.limdlgh.gov.za/documents/idp/Vhembe%202011%2012%20IDPs/VHEMBE%20DISTRICT%202011%2012%20IDP%20REVIEW%2026%2003%202011.pdf> [Accessed 3 Nov. 2017].

Limpopo Mirror. 2017. *Vhembe District Municipality declares war against littering*. [online] Available at: <https://www.limpopomirror.co.za/articles/news/25561/2014-07-04/vhembe-district-municipality-declares-war-against-littering> [Accessed 10 Nov. 2017].

- Lumbreras Martín, J., and Fernández García, L., 2014. *Comprehensive solid waste management: The Ciudad Saludable model in Peru*. Retrieved February 10, 2015. <http://idbdocs.iadb.org/wsdocs/getDocument.aspx?DOCNUM=39168981>.
- Luong, N.D., Giang, H.M. and Thanh, B.X., 2013. *Challenges for municipal solid waste management practices in Vietnam*. *Waste Technology*, 1(1), pp.17-21.
- Ma, J. and Hipel, K.W., 2016. *Exploring social dimensions of municipal solid waste management around the globe—A systematic literature review*. *Waste management*, 56, pp.3-12.
- Mabadahanye, V., 2017. *The study of Waste Management Practices within households in Khakhanwa Village, Thulamela Municipality* (Doctoral dissertation).
- Mandevere, B., 2015. *An investigation into effectiveness of household solid waste management strategies in Harare, Zimbabwe* (Doctoral dissertation).
- Moh, Y., 2017. *Solid waste management transformation and future challenges of source separation and recycling practice in Malaysia*. *Resources, Conservation and Recycling*, 116, pp.1-14.
- Mahasa, P.S., 2013. *An assessment of medical waste management practices in North-eastern Free State, South Africa*. Masters dissertation, North-West University.
- Maluleke, P.H., 2014. *A review of solid waste management practices in Polokwane City* (Doctoral dissertation).
- Mani, S. and Singh, S., 2016. *Sustainable municipal solid waste management in India: a policy agenda*. *Procedia Environmental Sciences*, 35, pp.150-157.
- Marshall, R.E. & Farahbakhsh, K., 2013. *Systems approaches to integrated solid waste management in developing countries*. *Waste Management*, 33(4), pp.988-1003.
- Masood, M., Barlow, C.Y. and Wilson, D.C., 2014. *An assessment of the current municipal solid waste management system in Lahore, Pakistan*. *Waste Management & Research*, 32(9), pp.834-847.
- McCusker, K. and Gunaydin, S., 2015. *Research using qualitative, quantitative or mixed methods and choice based on the research*. *Perfusion*, 30(7), pp.537-542.

Memon, M.A., 2010. *Integrated solid waste management based on the 3R approach*. J. Mater. Cycles Waste Management. 12 (1), 30–40 (11 pages).

Medina, M., 2002. *Globalisation, development and municipal solid waste management in Third World Cities*. Tijuana, Mexico: El Colegio de la Frontera Norte  
<http://www.gdnet.org/pdf/2002AwardsMedalsWinners/outstandingResearchDevelopment/martinmedinaMartinezpa per.pdf>.

Mihajlovic, V., 2016. Impact of European Waste Management Targets on Development of Waste Management System-case of Serbia. *Annals of the Faculty of Engineering Hunedoara*, 14(2), p.65.

Mmerekhi, D., Baldwin, A. & Li, B., 2016. *A comparative analysis of solid waste management in developed, developing and lesser developed countries*. *Environmental Technology Reviews*, 5(1), pp. 120-141.

Mudau, N.V., 2015. *A process mapping appraisal of municipal waste management system compliance in Limpopo province South Africa* (Doctoral dissertation).

A., Mundoga, T. and Moyo, F.F., 2017. *Emerging solid waste management issues in Beitbridge border town: evidence from a participatory research*.

Municipalities.co.za., 2017. *Vhembe District Municipality - Overview*. [online] Available at: <https://municipalities.co.za/overview/129/vhembe-district-municipality> [Accessed 30 Nov. 2017].

Mwanza, B.G., Mbohwa, C. and Telukdarie, A., 2018. *Municipal solid waste management in Kitwe City: An engineering management perspective*. *Management of Environmental Quality: An International Journal*.

Nkosi, L.F., 2014. *An evaluation of the municipal solid waste management system within City of Tshwane Metropolitan Municipality, in Mamelodi East Township, Gauteng province South Africa* (Doctoral dissertation, University of Pretoria).

Ogola, J.S., Chimuka, L. & Tshivhase, S., 2011. *Management of Municipal Solid Wastes: A Case Study in Limpopo Province, South Africa*. In *Integrated Waste Management-Volume I*. InTech.

Onu, B., Surendran, S.S. and Price, T., 2014. *Impact of inadequate urban planning on municipal solid waste management in the Niger Delta Region of Nigeria*. Journal of sustainable Development, 7(6), p.27.

Othman, S.N.; Noor, Z.Z.; Abba, A.H.; Yusuf, R.O.; & Hassan, M.A.A., 2013. *Review on life cycle assessment of integrated solid waste management in some Asian countries*. J. Journal of Cleaner Production. 41: 251–262 (12 pages).

Otchere, A.F., Anan, J. & Bio, M.O., 2015. *An assessment of solid waste management system in the Kumasi Metropolis*. Journal of Arts and Humanities, 4(3), p.27.

OWM, 2015. *Quantitative and qualitative analysis of Isfahan's wastes*. International Report, Municipality of Isfahan, Organization of Waste management, Iran (In Persian).

Özbay, İ., 2015. *Evaluation of Municipal Solid Waste Management Practices for an Industrialized City*. Polish Journal of Environmental Studies, 24(2).

Pandey B.K., Vyas, S., Pandey, M. & Gaur, A., 2016. *Characterisation of municipal solid waste generated from Bhopal, India*. Curr. Sci. perspect., 2, pp. 52-56.

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N. & Hoagwood, K., 2015. *Purposeful sampling for qualitative data collection and analysis in mixed method implementation research*. Administration and Policy in Mental Health and Mental Health Services Research, 42(5), pp.533-544.

Permana, A.S., Towolioe, S., Aziz, N.A. & Ho, C.S., 2015. *Sustainable solid waste management practices and perceived cleanliness in a low income city*. Habitat International, 49, pp.197-205.

Phillips, P.S., Tudor, T., Bird, H., & Bates, M., 2011. *A critical review of a key waste strategy initiative in England: zero waste places projects 2008e2009*. Resour. Conserv. Recycl. 55, 335e343.

Pikitup.co.za.(2019). [online] Available at: <http://www.pikitup.co.za/wp-content/uploads/2015/10/Polokwane-Declaration-on-Waste-Management-2001.pdf>

[Accessed 26 Jun. 2019].

Proboretno, N., 2018. *Practising sustainable waste management: a case study on a zero waste community in Bandung, Indonesia: a thesis presented in partial fulfilment of the requirements for the degree of Master of International Development at Massey University, Palmerston North, New Zealand (Doctoral dissertation, Massey University).*

Rada, E.C. & Cioca, L., 2017. *Optimizing the methodology of characterization of Municipal Solid Waste in EU under a circular economy perspective.* Energy Procedia, 119, pp.72-85.

Regassa, N., Sundaraa, R.D. & Seboka, B.B., 2011. *Challenges and opportunities in municipal solid waste management: The case of Addis Ababa city, central Ethiopia.* Journal of human ecology, 33(3), pp.179-190.

Saidan, M.N., Drais, A.A. & Al-Manaseer, E., 2017. *Solid waste composition analysis and recycling evaluation: Zaatari Syrian Refugees Camp, Jordan.* Waste management, 61, pp.58-66.

Sakawi, Z. 2011. *Municipal solid waste management in Malaysia: solution for sustainable waste management.* Journal of Applied Science and Environmental Sanitation 6: 29–38

Sallwey, J., Hettiarachchi, H. & Hülsmann, H., 2017. *Challenges and opportunities in municipal solid waste management in Mozambique: A review in the light of Nexus thinking.* AIMS Environ. Sci, 4, pp.621-639.

Sankoh, F.P. & Yan, X., 2013. *Problems of solid waste management in developing urban cities: a case study of Freetown, Sierra Leone.* American Journal of Environmental Protection, 2(5), pp.113-120.

Sauvé, S., Bernard, S., & Sloan, P., 2016. *Environmental sciences, sustainable development and circular economy: alternative concepts for trans-disciplinary research.* Environ. Dev. 17, 48 56.

Sepenoo, J.A.K., 2018. *Evaluation of Existing Sanitary Infrastructures within the Kpone Township in the Greater Accra Region of Ghana (Doctoral dissertation, University of Ghana).*

Simelane, T., 2011. *Interpreting the transformation of the city centres of South Africa through system dynamics: How different are they from other African cities?* Africa Insight, 40(4), pp.168–186.

Singh, R.P., Singh, P., Araujo, A.S., Ibrahim, M.H. & Sulaimman, O., 2011. *Management of urban solid waste: Vermicomposting a sustainable option*. Resources, Conservation and Recycling, 55(7), pp.719-729.

Singh, G.K., Gupta, K. & Chaudhary, S., 2014. *Solid waste management: its sources, collection, transportation and recycling*. International Journal of Environmental Science and Development, 5(4), p.347.

Smahi, D., Hammoumi, O.E., & Fekri, A., 2013. *Assessment of the impact of the landfill on groundwater quality: a case study of Mediouna Site, Casablanca, Morocco*. J. Water Resource. Prot. 5, 440–445

Sridevi P, Modi M, Lakshmi MVVC, & Kesavarao L., 2012. *A review on integrated solid waste management*. Int. J. Eng. Sci. Adv. Technol. 2, 1491–1499.

Srivastava R, Krishna V, & Sonkar I., 2014. *Characterization and management of municipal solid waste: a case study of Varanasi city, India*. Int. J. Curr. Res. Acad. Rev. 2, 10–16.

Srivastava, V., Ismail, S.A., Singh, P. & Singh, R.P., 2015. *Urban solid waste management in the developing world with emphasis on India: challenges and opportunities*. Reviews in Environmental Science and Bio/Technology, 14(2), pp.317-337.

Statistics South Africa., 2012. General Household Survey.

Surroop, D. & Mohee, R., 2011. *Power generation from refuse derived fuel*. International Proceedings of Chemical, Biological and Environmental Engineering, 17, pp.242–246.

Sudiby, H., Pradana, Y.S., Budiman, A. & Budhijanto, W., 2017. *Municipal Solid Waste Management in Indonesia-A Study about Selection of Proper Solid Waste Reduction Method in DI Yogyakarta Province*. Energy Procedia, 143, pp.494-499.

Tacoli, C., 2012. *Urbanization, Gender and Urban Poverty: Paid Work and Unpaid Carework in the City*. International Institute for Environment and Development: United Nations Population Fund, London, UK.

Tembon, M.N.F., 2012. *An evaluation of the gaps and barriers that exist between the national waste management policy and its implementation in formal and informal urban areas in the Ekurhuleni Municipality, South Africa* (Doctoral dissertation).

Traven, L., Kegalj, I. & Šebelja, I., 2018. *Management of municipal solid waste in Croatia: Analysis of current practices with performance benchmarking against other European Union member states. Waste Management & Research*, 36(8), pp.663-669.

Tseng, Ming-Lang, 2013. *Modeling sustainable production indicators with linguistic preferences. J. Clean. Prod.* 40, 46e56. <http://dx.doi.org/10.1016/j.jclepro.2010.11.019>.

Tudor, T., Robinson, G., Riley, M., Guilbert, S., & Barr, S. 2011. *Challenges facing the sustainable consumption and waste management agendas: perspectives on UK households. Local Environment*, 16(1), 51-66. doi: 10.1080/13549839.2010.548372.

UN-HABITAT, 2010. *Solid waste management in the world's cities, Nairobi: UN-HABITAT*, 2010.

United Nations Environment Programme Report., 2015. *Global waste management outlook. UNEP*

United Nations (undated) Urban and rural areas 2009. <http://www.un.org/en/development/desa/population/publications/urbanization/urban-rural.shtml>. Accessed 4 Aug 2017

U.S Environmental Protection Agency. 2010. *Reduce, Reuse, Recycle. Wastes - Resource Conservation*. Retrieved July 29, 2017, from <http://www.epa.gov/wastes/conservation/rrr/>

US-EPA., 2012, *Wastes Non-Hazardous Waste - Municipal Solid Waste*. Available: <http://www.epa.gov/osw/nonhaz/municipal/landfill.htm>

Wahab, Bolanle. 2013. 'Disaster Risk Management in Nigerian Human Settlements'. In: B. Wahab, N. Atebije and I. Yunusa (Eds.), *Disaster Risk Management in Nigerian Rural and Urban Settlements*. ISBN: 978-978-935-509-9, Pp. 1-37. Abuja: Nigerian Institute of Town Planners and Town Planners Registration Council.

Widomski, M.K., Stepniewski, W. & Horn, R., 2016. *Sustainability of compacted clays as materials for municipal waste landfill liner. Rocznik Ochrona Środowiska/Annual Set Environment Protection*, 18(2), pp.249-257.

Wisdom, J. & Creswell, J.W., 2013. *Mixed methods: integrating quantitative and qualitative data collection and analysis while studying patient-centered medical home models*. Rockville: Agency for Healthcare Research and Quality.

World Bank, 2012. *What a Waste: A Global Review of Solid Waste Management*. Urban Development Series Knowledge Papers. <<http://documents.worldbank.org/curated/en/2012/03/16537275/waste-global-review-solid-waste-management>> (accessed 09.07.17).

World Bank., 2014). “*Results – Based Financing for Municipal Solid Waste*” Urban Development Series – World Bank- 91861 v2

Xue, B., Geng, Y., Ren, W.X., Zhang, Z.L., Zhang, W.W., Lu, C.Y. & Chen, X.P., 2011. *An overview of municipal solid waste management in Inner Mongolia Autonomous Region, China*. *Journal of Material cycles and Waste Management*, 13(4), pp. 283-292.

Yadav, P. and Samadder, S.R., 2018. *Environmental impact assessment of municipal solid waste management options using life cycle assessment: a case study*. *Environmental Science and Pollution Research*, 25(1), pp.838-854.

Young, C.Y., Ni, S.P. & Fan, K.S., 2010. *Working towards a zero waste environment in Taiwan*. *waste Management & research*, 28(3), pp.236-244.

Yukalang, N., Clarke, B. & Ross, K., 2017. Barriers to effective municipal solid waste management in a rapidly urbanizing area in Thailand. *International journal of environmental research and public health*, 14(9), p.1013.

Zaman, A.U., 2014. *Measuring waste management performance using the ‘ZeroWaste Index’*: the case of Adelaide, Australia. *J. Clean. Prod.* 66, 407–419.

Zaman, A.U., 2015. *A comprehensive review of the development of zero waste management: lessons learned and guidelines*. *Journal of clean production*, 91, pp. 12–25.

Ziout, A., Azab, A., & Atwan, M., 2014. *A holistic approach for decision on selection of end-of-life products recovery options*. *J. Clean. Prod.* 65, 497e516. [Municipal wast/Action\\_plan.pdf](#) [Accessed 30 Nov. 2017].

Zhang, D.Q., Tan, S.K. & Gersberg, R.M., 2010. *Municipal solid waste management in China: status, problems and challenges*. *Journal of environmental management*, 91(8), pp.1623-1633.

Department of Environmental Affairs and Tourism, 2000. *White Paper on Integrated Pollution and Waste Management in South Africa*. Pretoria: DEAT, pp.10–14.

Department of Environmental Affairs and Tourism, 2001. *National Waste Management Strategy*), Version D. Pretoria, DEAT, pp.1–158.

Department of Environmental Affairs., 2009a. *National waste quantification and waste information system*

## APPENDICES