EVALUATION OF ENVIRONMENTAL COMPLIANCE WITH SOLID WASTE MANAGEMENT PRACTICES FROM MINING ACTIVITIES: A CASE STUDY OF MARULA PLATINUM MINE

BY

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DECLARATION

I, Manyekwane Dikeledi Lethabo, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that where I used other people's work I have acknowledged their work. This dissertation is submitted in fulfilment of a Master's degree in Geography at the University of Limpopo and has not been submitted before for any degree or examination at any other university.

Signature: ___________________________

Manyekwane Dikeledi Lethabo

Date:______________________________

DEDICATION

I would like to dedicate this work to my mother (K.Q. Manyekwane) and sister (T.B Manyekwane) who have been supportive throughout my academic journey. Their love, support and prayers got me through when I felt like I was stuck between a hard place and a rock and a time when completing this dissertation seemed like the impossible. I would also like to dedicate this work to all the women out there who aspire for greatness in the academic field, especially in a time wherein women are being brutally murdered, abused and assaulted. Regardless of life challenges, we are warriors. Anything is possible through hard work, perseverance and determination.

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ABSTRACT

Global production of Platinum Group Metals (PGMs) is dominated by South Africa due to its large economic resources base in the Bushveld Igneous Complex (BIC). PGMs are used in a wide range of high technology applications worldwide including medicinal, industrial and commercial purposes, and its contribution to the Gross Domestic Product (GDP) and creating jobs for many. In an area where mining activities dominate, there are likely to be problems that need effective environmental management approaches, which can be facilitated through legislations. Marula Platinum Mine (MPM) is located in Limpopo province BIC which has the second largest number of mining productivity in South Africa. Environmental legislations have been put in place by the South African government in order to avoid or minimise the footprints caused by PGM mining.

This study looked at environmental compliance with solid waste management practices by Marula Platinum Mine (MPM) as guided by Mineral and Petroleum and Resource Development Act (MPRDA) and National Environmental Management Act (NEMA) as well as the environmental impacts of MPM in the surrounding communities. Both primary (questionnaires, field observations and key informant interviews) and secondary (NEMA, MPRDA, journals, reports, pamphlets, internet and books) data was used to address the objectives of the study. Descriptive method and Statistical Package for Social Sciences (SPSS) version 25 were used for the analysis of data. The key research results revealed that MPM was compliant with 65% and 21% partially compliant with solid waste management practices. Only 14% of information on solid waste management practices could not be accessed because MPM is still operational. MPM had also had negative footprints on the surrounding villages such as dust generation and cracks on walls and floors on houses of community members, strikes and increase in the usage of substance abuse.

Recommendations of the study are that MPM should address challenges that hinder environmental compliance so as to be 100% compliant with MPRDA and NEMA regulations. MPM should also provide other mitigation measures for blasting of explosives to reduce dust generation and problems of cracks on houses of surrounding village members.

Keywords: Environmental compliance, environmental management, Platinum Group Metals (PGMs), Marula Platinum Mine (MPM), Bushveld Igneous Complex (BIC), National Environmental Management Act (NEMA), Mineral Petroleum Resource Development Act (MPRDA), Environmental Management Performance Assessment Report (EMPAR) and solid waste management.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

BEE	Black Economic Empowerment
BIC	Bushveld Igneous Complex
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DMR	Department of Mineral Resources
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMPAR	Environmental Management Performance Assessment Report
EMS	Environmental Management System
GDP	Gross Domestic Product
GSDM	Greater Sekhukhune District Municipality
GTLM	Greater Tubatse Local Municipality
ISO	International Organisation for Standardization
IMS	Integrated Management System
IWMP	Integrated Waste Management Plan
LEDET	Limpopo Department of Economic Development Environment and Tourism
MPM	Marula Platinum Mine
MPRDA	Mineral and Petroleum Resource Development Act
NEMA	National Environmental Management Act
NEMAQA	National Environmental Management Air Quality Act
NEMWA	National Environmental Management Waste Act
NOSA	National Occupational Safety Association
OSHAS	Occupational Health and Safety Act System
PGMs	Platinum Group Metals
SIA	Social Impact Assessment

SHE	Safety, Health and Environmental
SWOT	Strength, Weakness, Opportunity and Threat
TSF	Tailing Storage Facility
WUL	Water Use License

CHAPTER 1

INTRODUCTION

1.1 Background

Many countries resort to various activities to exploit natural resources towards achieving rapid economic development. One such activity is mining. Consequently, mining is an important economic activity, which has the potential of contributing to the development of areas endowed with the resource (Yeobah, 2008). Many countries consider mineral wealth an asset, which could be used to stimulate or enhance economic growth potential and also to steer their economies into greater levels of development such as increased Gross Domestic Product (GDP) and social well-being of its people etc. In countries such as Mongolia, the mining sector is said to account for about 17% of GDP, 65% of industrial value added and 58% of export, hence making it the largest contributor to the Mongolian national economy (World Bank, 2006). Furthermore, mining has played a significant role in the development process of countries like South Africa in terms of mineral production which is rated number one, followed by Ghana in the African continent (Akabzaa and Darimani, 2001).

1.1.1 Mining and its importance

Mining has helped to shape South Africa to a greater extent than any other industry. It turned a largely pastoral economy into an industrial one. It led to the establishment of Kimberley and Johannesburg and other towns. It attracted vast quantities of foreign capital, necessitated the establishment of stock markets, universities, and other modern institutions (FSD, 2018). South Africa's political, social and economic landscape has been dominated by mining in many ways. The sector has been the mainstay of the South African economy for many years. Although gold, diamonds, platinum and coal are the most well-known amongst the minerals and metals mined, South Africa also hosts chrome, vanadium, titanium and a number of other lesser minerals (Chamber of mines South Africa, 2017). The industry contributes R8 for every R100 produced by the national economy and employs one in every 40 working individuals. The year 2016 was not a good one for South African mining, since only diamond production recorded positive growth of just under 1%. All other minerals found themselves in negative territory in 2016, with copper the worst performer, recording a 16% fall in production (Stats SA, 2017). In 2017 mining production increased by 0.1% year-on-year in December. The main positive contributors were iron ore with 15.9%, gold 12.4% and coal 5.5% (Stats SA, 2017).

Mining is the largest industry in four of South Africa's nine provinces, namely North West, Limpopo, Mpumalanga and Northern Cape. Mining contributed R33 for every R100 produced by North West's economy in 2015 and the industry employed one in every 6 working individuals or 16% of the provincial workforce (Stats SA, 2017). North West contributed the most value added by the mining industry in South Africa in 2015 at 27.8% followed by Limpopo at 24.6% and Mpumalanga at 21.7%. Western Cape and Eastern Cape contributed the least to value added by the mining industry at 0.4% and 0.2% respectively. According to REB (2016), Limpopo's growth since 2003 has been dominated by the mining sector, especially PGMs and by national construction projects.

1.1.2 Minerals, PGMs and distribution

The global production of Platinum Group Metals (PGMs) is dominated by South Africa due to its large economic PGM resources in the Bushveld Complex located in Greater Sekhukhune. Other countries such as Russia, Canada, Zimbabwe and the United States play a minor but important role (Glaister and Mudd, 2010). South Africa accounted for 75% of PGM production and supply in the worlds market in 2011 (Johnson, 2013). In 2014 the percentage of PGMs increased by 10% in South Africa and accounted for 85% production and supply globally (Chamber of mines South Africa, 2015). Over the past years the platinum price increased from $474/oz. (January 2002) to $1586/oz. (December 2012). The value of the cumulative production of 3900 tons for the years 1975 to 2012 was, at the December 2012 price, about $200 billion (Johnson, 2013). PGMs as an entity are the second largest export revenue generator (after gold) for South Africa. Looked at more broadly, minerals made up 38% of South Africa's total merchandise exports in 2012 with PGMs contributing 8.3% and one in every R12 of South Africa's merchandise sold abroad (DMR, 2014). As a group, the country's platinum mines provided direct employment to approximately 136 000 people or 26% of all mining employees. Taking into account the businesses that serve and sell to the mines, the platinum sector supports a further 325 000 jobs combined, this would account for more than 450 000 individuals, each with at least four to ten dependent's.

1.1.3 Types of waste generated from mining industry

There are different types of mine waste materials, which vary in their physical and chemical composition, potential for environmental contamination and how they are managed at mine sites (Joseph, 2016). Types of mine waste can be found in all three states of matter and include tailing, overburden, waste rock, sludge, and slags among others. The common waste management practices expected from the mining industry are: to separate mine wastes at points of generation, have proper containers and temporary storage facilities, have the mine wastes treated and disposed by persons authorised and qualified to handle mine wastes and to have rehabilitation and closure plans (Rankin, 2011).

1.1.4 Impact of mining

Mining operations can have severe impacts on the physical, social and economic environment. Economically, mining has helped to shape the country's labour markets and drew huge numbers of South Africans from subsistence economies into paid employment. However, in some cases it has led to strikes due to low labour wage and community conflicts. Socially, mining has helped in the development of infrastructure and accessibility of basic needs, especially in rural communities, such as water, houses and healthcare. On the negative side, it is sometimes associated with political hostility and relocation of community members close to mining sites. Environmentally, mining can cause pollution of natural entities, vegetation clearance and habitat destruction resulting in ecological disturbance (FSD, 2018). Various laws and legislations have been put in place in order to minimise impacts on the environment. In South Africa, The Constitution of the Republic of South Africa (1996) is the mother of all laws and under it there are environmental policies that promote sustainable resource development and protect the well-being of the environment as well as its inhabitants.

1.2 Problem statement

The mining industry plays an important role in the South African economy. According to the Department of Mineral Resources (DMR) (2012), South African minerals sales contributed 5.2% to the Gross Domestic Product (GDP) with 2.2% generated from Platinum Group Metals (PGMs). PGM mining activities, like all other mining operations, lead to the generation of waste that result into negative impacts to the environment and humans (Yeobah, 2008; Chamber of mines South Africa, 2012; Joseph, 2016).

Unfortunately the nature of mining activities towards exploration and beneficiation of the metals, lead to the generation of large quantities of waste. The wastes generated are solid, liquid and gaseous. However, solid wastes are generated in larger quantities compared to liquid and gaseous wastes and thus pose huge challenges in terms of its management. The improper management of mine waste in contrast to the stipulated regulations and guidelines as provided by the relevant Acts regulating mining activities, result into negative impacts on the environment and communities residing next to the mine.

To address the inadequacies with regard to the laws, this research seeks to evaluate the environmental compliance of solid waste management practices in Marula Platinum Mine (MPM) and to assess the possible socio-economic and environmental impacts that can arise from the mining activities.

1.3 Rationale of the study

Mining is the extraction of minerals from the earth's surface and by nature, it involves the production of large quantities of waste contributing significantly to a nation's total waste output (Matthews *et al*., 2000). The different types of waste generated in a mine can be found in all states of matter, that is solid, liquid and gas and in different quantities. The wastes include: overburden, waste rock, tailings, slags, wastewater treatment sludge, mine water and gaseous waste (Rajaram and Melchers, 2005). Var (2009) for example, reported that Anglo Platinum Mine cumulative waste was 730.8 metric tons of tailings and 665.4 metric tons of waste rock in 2008. The large volumes of tailings and waste rock are both deposited on land, thus they require active planning and management in order to prevent major environmental or social impacts (Van Niekerk and Viljoen, 2005).

This study is grounded in the human-environment interaction theory which can be defined as interactions between the human social system and the ecosystem. Peoples' actions have consequences on the environment, but in turn the environment influences human activities (Lill and Gräber, 2006). In recent times, technological innovations and advances have brought people new potential threats from the environment, which are man-made. These threats are physically harmful and stressful (NOSA, 2011). The threats include pollution, loss of biodiversity and degradation of the environment which in turn affects the quality of human life. Mining activities are among the human-environment interactions and thus need to be appropriately managed in order to minimise their impacts on the environment.

South Africa has developed laws to regulate and monitor the extraction of mineral resources and their impact on the environment and people. These laws include, among others: the Constitution of the Republic of South Africa (1996), the National Environmental Management Act (NEMA) (107 of 1998) and the Mineral and Petroleum Resource Development Act (MPRDA) (28 of 2002). All these three laws provide for environmental management principles that consider avoidance of disturbance of ecosystems, pollution and environmental degradation. They lay emphasis on proper waste management (Constitution, 1996; NEMA, 1998; MPRDA, 2002).

A license holder is expected to hire an authorised contractor for the collection, treatment and disposal of hazardous wastes generated within the mining facility. The license holder is also expected to have rehabilitation and closure plans in order to prevent environmental degradation (NEMWA, 2008). In addition, sections 51 and 52 of the MPRDA (2002) require mining activities to have environmental management programs and plans, respectively. In addition to legislated practices, mining companies are now steadily adopting other waste management practices, such as Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) (Nyirenda, 2014).

Limited studies on the adherence of mining companies to these various legislations that govern the mining industry have been reported. Therefore, environmental compliance by the mining industry is important as it looks into environmental, social and economic impacts from the mine and ways to prevent/mitigate impacts which in turn protect the environment and the community throughout the life cycle of the mine.

1.3.1 Aim

The aim of the study was to evaluate the environmental compliance with solid waste management practices from mining activities at Marula Platinum Mine.

1.3.2 Objectives

The objectives of the study were to:

i. examine the level of environmental compliance of solid waste management practices at Marula Platinum Mine;
ii. assess challenges that hinder environmental compliance of solid waste management practices in Marula Platinum Mine;
iii. evaluate effects of waste management practices on the communities surrounding Marula Platinum Mine.

1.3.3 Research questions

I. Is Marula Platinum Mine environmental compliant with solid waste management practices?
II. What are the challenges that hinder environmental compliance of solid waste management practices in Marula Platinum Mine?
III. What are the effects of waste management practices on the communities surrounding Marula Platinum Mine?

1.4 Hypothesis

I. Marula Platinum Mine is compliant with environmental legislation for solid waste management practices in its operation.

1.5 Scientific contribution

Peoples' interaction with the environment can cause severe environmental damage, if uncontrolled and poorly managed. Mining operations, if improperly managed, can alter the natural environment because of the nature of the activity resulting in contamination of natural entities, loss of biodiversity and environmental fragmentation. The results from the research will be useful to recommend policy directives to improve the already instituted policies by the Marula Platinum Mine Company and other mining companies. The findings will serve as a guide to other mines in the country. The research results will add to existing literature on environmental compliance with mining waste management practices that can be used for academic purposes. Furthermore, it will help policy makers in assessing if the current instituted policies are applicable to all types of mining environment as well as mitigating legal gaps such as poor waste management practices and improper disposal of waste from mining activities.

1.6 Ethical considerations

Ethical consideration comprises of clearance, informed consent, anonymity, confidentiality and respect. Ethical clearance was obtained from the University of Limpopo TREC committee, as it is required for any research that involves the participation of humans. The research was purely for academic purposes hence all participants and respondents were made aware of that fact, and as such, consent was obtained before subjects were interviewed or completed the questionnaire. No one was forced to participate against their free-will nor was there bribery to access any information. Anonymity and confidentiality were maintained throughout the study. In this study, anonymity was ensured by not disclosing the participants' names on the questionnaire. Confidentiality was maintained by keeping the collected data confidential and not revealing the subjects' identities when reporting or publishing the study. Participants were treated with respect regardless of their age, gender or occupational status.

1.7 Limitations of the study

In research, the tendency as a researcher to face certain problems on the field of the study cannot be overlooked. The truth is that certain conditions and constraints exist that may invariably impact and challenge the work of the researcher (Jones, 2010). These challenges may be experienced in many ways and can for instance be in the methods that would be used in the collection of the data itself or in the social setting where the research is being carried out.

One of the major challenges faced in the research was that a mine related study is sensitive in nature, and in essence makes it difficult to access certain information. Furthermore, most mining operations are private and as such mines fear that research like this could reflect badly on their image and reputation and hence refused any entry.

Not being granted permission inside the mine meant that field observations within the mine and soil sampling of the rehabilitated area could not be performed anymore and consequently this section had to be removed. To overcome this challenge there was alteration of data collection method from primary to secondary method. Instead of collecting data straight from the mine, the researcher had to go to provincial local authorities such as Department of Mineral Resources (DMR) and Limpopo Department of Economic Development Environment and Tourism (LEDET). Legislative gazettes and annual reports from the mine were accessed from the above local authorities. The legislative gazettes covered laws (NEMA and MPRDA) and practices (classification, separation, collection etc.) expected from mining operations in South Africa. Annual reports covered implementation of waste practices which were both mandatory (classification of waste based on chemical and physical properties) and voluntary (NOSA, SWOT analysis).

A challenge faced in the community where the research was undertaken was the inaccessibility to information from the people concerned in the study. Usually, rural communities are skeptical of outsiders who come to them for information. Due to low levels of literacy and education, some people felt as if they were discriminated against, although they were told that there was no correct or wrong answer. Such a situation therefore posed a great challenge because some people would refuse to be part of the survey while others would not complete the questionnaire which in turn posed a risk to the skip factor in sampling method. Fortunately in this case, the researcher asked for another family member to take the spot for the person who refused to complete the questionnaire. Another challenge was that people wanted some sort of remuneration for filling in the questionnaire. To overcome the above challenge, the researcher tried to be understanding and did not force people to fill in the questionnaire if they were uncomfortable. For those who were hesitant, the researcher explained the purpose of the research thoroughly and made them feel at ease.

Another challenge faced in the community during data collection was with technical questions, especially with environmental and social impacts of the mine on surrounding communities. Questions such as impacts of health, social norms and environmental degradation were hard to link if they were directly caused by the mine activity or by other factors. To overcome this challenge the researcher had to ask about the state of the environment, health issues and way of living of community members prior to the establishment of the mine as well as what prompted the respondents in believing that the mining activity was the cause of the impact. Again, there was attempt on the part of the local community members to give the researcher biased information. Some of the information given was exaggerated and as such did not reflect the real situation on the ground. Coupled with this, there were some differences in some of the information provided by the respondents and what the researcher observed personally. In line with observation, chances were that personal biases may influence the outcome of information that was available since personal observation may give a different impression about the real issues on the ground as against what the people gave the researcher. Hence, bias and personal introspection could influence an objective research outcome. For example, there was a lady that was selling food to the workers (vendor) at the mine and had relatives who worked in the mine but claimed that she didn't make any financial gain from the mine while filling in the questionnaire. Based on personal observation by the researcher, responses like these could be based on personal feelings towards the mine and failed expectations from the mine by respondents. In cases like these, there was nothing the researcher could do as stated above and "there was no right or wrong answer" as any opinion of the respondent were the required ones.

1.8 Definition of terms

Mining: It is the extraction of valuable minerals or other geological materials from the earth usually from an ore body, lode, vein, seam, reef or placer deposits. These deposits form a mineralized package that is of economic interest to the miner (Wikipedia, 2017).

Solid waste: Department of Environmental Conservation (2017), defines solid waste as any garbage, refuse, sludge or any other discarded materials which is solid or semi-solid resulting from industrial, commercial, mining and agricultural operations as well as from community activities.

Solid waste management: It is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economic, aesthetic, engineering and other environmental considerations (LeBlanc, 2017).

Compliance: ISO 14001 (2015) defines compliance as legal requirements that an organization has to comply with and other requirements that an organization has to or chooses to comply with. There are two kinds of compliance obligations, that is, mandatory compliance obligations and voluntary compliance obligations. Mandatory compliance obligations include laws and regulations while voluntary compliance obligations include contractual commitments, community and industry standards, ethical codes of conduct, and good governance guidelines (ISO 14001, 2015).

Environment: According to Robertson (2013), environment comprises the set of natural, social and cultural values existing in a place and at a particular time, that has an influence in the life of the human being and in the generations to come.

Environmental management: It can simply be defined as sound environmental practices that lead to a safe and friendly environment (Chapuka, 2011).

Environmental impacts: It is a change to the environment that is caused either partly or entirely by one or more environmental aspects (ISO 14001, 2015). They can be both negative and positive.

Environmental policy: It is defined as the overarching statement that describes the organisation's intent and position on the environment (Chapuka, 2011).

1.9 Overview of the dissertation

This dissertation consists of five chapters as laid out in the sequence below.

Chapter 1 presents the introduction and background information looking at the importance of mining, its impacts as well as laws and legislations per the South African government that govern mining operations. It is in this chapter that the main aim of the study is expounded, together with the subsequent objectives developed to achieve the main aim. Scientific contributions, ethical considerations, limitations of the study and definition of terms are also covered in this chapter.

Chapter 2 is where literature relevant to the research problem is discussed, including general impacts of mining on the environment as well as specific contributions of PGMs and environmental impacts of PGMs. Solid wastes generated from PGM mining and waste management practices are also discussed in this chapter. The different strategies in environmental management, both mandatory (NEMA, MPRDA) and voluntary practice (ISO 14001, NOSA) are also outlined.

Chapter 3 presents the methodology used in the collection of empirical data. These methods include research design, sampling method, collection of primary data (questionnaire surveys, field observations and key informant interviews) and secondary data (practical assessment of legal compliance) as well as data analysis.

Chapter 4 is where the research results are presented and discussed in accordance with the main aim and objectives of the study looking at the environmental compliance side from the mine and how the mine has affected the surrounding communities.

Chapter 5 is the final chapter of the dissertation and outlines the summary, conclusions, and ends with recommendations of the study.

1.9 Summary of the chapter

This chapter has laid the foundation for the dissertation and given a general introduction of the entire study. Sections covered in this chapter include background of the study, problem statement, rationale of the study, scientific contribution, ethical considerations, limitations of the study, definitions of terms and lastly overview of the dissertation. The next chapter is on the review of literature.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Mining operations have played a huge role in shaping the economy of many countries globally. These operations have resulted in the economic upliftment through job creation, exporting of minerals, poverty alleviation and other socio-economic benefits. However, these activities are also associated with negative environmental consequences such as pollution and land degradation, especially when operating unlawfully. This chapter contains a review of literature and sections that are covered in this chapter include: mining and its importance, Platinum Group Metals (PGMs), uses of PGMs, distribution of PGMs in South Africa, mining life cycle stages of PGMs, methods of mining PGMs, extraction and refining of PGMs, types of wastes generated from mining activities, waste management practices at a mine, impacts of mining, environmental compliance from mining operations, self-regulatory/voluntary practices from mining industries and ends with the summary of the chapter.

2.2 Mining and its importance

Mining is one of the biggest industries which is significantly contributing to the national, continental and global economy. It has been practiced for centuries for different uses that benefit human needs and wants. With the growth of population and technological advancements, the demand for mining minerals and natural resources is increasing at an alarming rate (Miller and Spoolman, 2011). The International Council on Mining (ICMM) (2012), stated that the mining industry is a major force in the world economy. This is because of the contribution of global mining to the total Foreign Direct Investment (FDI) and to the Gross Domestic Product (GDP) of a country.

Mining is considered as a mineral wealth asset to many countries globally (Jones, 2010). In North America, raw mineral production in 1998 was valued at approximately $70 billion and the industry employed approximately 1 million people (Mbendi, 2004). In Peru, the mining sector accounted for 50% of the country's annual export earnings and 11% to the GDP (Acheampong, 2004). In India, the GDP contribution of the mining industry varied from 2.2% to 2.5% In Mongolia, the mining sector was said to account for about 17% of

Gross GDP, 65% of industrial value added and 58% of export, hence making it the largest contributor to the Mongolian national economy (World Bank, 2006). Furthermore, mining has played a significant role in the development process of African countries in terms of gold production (Akabzaa and Darimani, 2001). Ghana's mining industry contributed in no small measure to the impressive 14.4% GDP growth in the economy chalked in 2011. According to the Gold Fields Mineral Survey, Ghana was the 9th leading producer of gold in the World and the 2nd in Africa (Ghana Chamber of Mines, 2008).

Historically, South Africa's mining industry has been at the heart of the economy's development, given the country's competitive position as one of the most naturally resource-rich nations in the world. The industry has played a key role in attracting foreign investment and creating leading global enterprises, and remains South Africa's most critically observed economic sector (Antin, 2013). The South African mining industry is the fifth largest in the world (Chamber of Mines SA, 2012). South Africa is still considered to be the country with the world's largest mineral endowment (Carroll, 2012). Citibank has estimated that the remaining resource base in the world is at $2.5 trillion (Government Communication and Information System (GCIS), 2012). According to Antin (2013), mining in South Africa contributes an average of 27% to the country's GDP. The sector employs more than one million people in mining-related employment and is the largest contributor by value to black economic empowerment in the economy. For years, the four main mineral commodities in terms of sales and employment have been PGMs, gold, coal and iron ore (PricewaterhouseCoopers, 2012). PGMs sector employs 96 000 people on the mines and process plants. Export sales reached nearly R25 billion in 2000, compared to R5 billion in 1990, and are set to increase further (Conradie, 2002).

2.3. Platinum Group Metals (PGMs)

2.3.1 Description of PGMs

The PGMs are a family of six greyish to silver-white metals with close chemical and physical affinities. The three heavier metals, namely, platinum (Pt), iridium (Ir), and osmium (Os), have densities of about 22 g/cm^3; while the three somewhat lighter metals, namely palladium (Pd), rhodium (Rh), and ruthenium (Ru), have densities of about 12 g/cm^3 (Jones, 2005). Platinum and palladium are the most important metals in the PGM mix and also the main products. Rhodium, ruthenium, iridium and osmium are mined as co-products of platinum and palladium (Johnson, 2013).

Platinum was originally called “platina” or “little silver” in Spanish, as it was considered a poor-quality by-product of silver mining operations 400 years ago in Colombia (Jones, 2005). However, its great scarcity classifies it as a precious metal. Only about one thirteenth as much platinum is produced as gold, itself a very rare metal. Approximately 5 million times as much iron as platinum is produced in the world. The PGMs are very rare elements and most PGM-bearing ores are extremely low-grade, with mined ore grades ranging from 2 to 6 grams per ton (Johnson, 2013). As of 2014, the annual production of PGMs amounted to around 400 tons, several orders of magnitude lower than many common metals (Zientek and Loferski, 2014).

PGMs have extraordinary physical and chemical properties that have made them indispensable to the modern industrial world (Jones, 2005). The PGMs have very high melting points, and are chemically inert to a wide variety of substances (even at very high temperatures), and thus resist corrosion. The PGMs are highly resistant to wear, tarnish, chemical attack and high temperature and have outstanding catalytic and electrical properties (Zientek and Loferski, 2014). All these unique characteristics have made them indispensable in many industrial applications.

2.3.2 Uses of PGMs

As precious and noble metals, PGMs have shown one of the highest long term growth rates of numerous mineral commodities over the past 50 years. Their properties make them ideal for a wide variety of technologies (Mudd and Glaister, 2009). As precious and noble metals, PGMs are chemically more versatile than gold, and have found numerous industrial applications. They are also the only competitors for gold as investment metals and for jewellery purposes. According to Jones (2005), the most economically important of the PGMs are platinum, palladium, and rhodium, with ruthenium, iridium, and osmium being less prevalent and less in demand. The base metals nickel, copper, and cobalt commonly occur together with the PGMs and are produced as co-products in the smelters and refineries. The PGM market is fundamentally strong, particularly in platinum, where recent years have shown good growth in jewellery demand, and in auto catalysts, especially for the diesel vehicles that now make up 50% of new car sales in Europe.

The PGMs are found in numerous products, from hard disks to aircraft turbines, anticancer drugs to mobile phones, industrial catalysts to ceramic glazes. Other uses of PGMs include catalysts for chemical process facilities (eg. oil refineries), catalytic converters for vehicle exhaust control, hydrogen fuel cells, electronic components, jewellery, and a variety of specialty medical uses (Bossi and Gediga, 2017).

When PGMs are used as industrial catalysts they enable chemical reactions to take place at reduced temperature and pressure compared to other materials and therefore at reduced cost and environmental impact (Mudd, 2012). Catalysts based on PGMs are used to produce ammonia, acetic acid, silicones, chlorine, nitric acid and many other chemicals which are ingredients of everyday goods, such as polyester, nylon, fertiliser and synthetic rubber. Platinum-rhenium catalysts are essential for reforming naphtha into high octane blending components for producing gasoline. Platinum-rhodium alloys which are highly resistant to corrosion are used in the production of flat screen glass for mobile phones, computers and television displays (Bossi and Gediga, 2017).

The PGMs are also used inside the human body in devices such as pacemakers, defibrillators and catheters for the treatment of heart disease; neuromodulation devices to treat Parkinson's disease and hearing loss; and in coils and catheters for the treatment of brain aneurysms. Platinum's high resistance to corrosion makes it a good candidate for biomaterials as it is stable in the changing environment formed by the body's naturally occurring fluids. Specific compounds of platinum are effective in the treatment of a range of cancers, while palladium and other PGMs are used in alloys suitable for dental inlays, crowns and bridges (Bossi and Gediga, 2017).

PGMs can also be used to meet environmental challenges such as resource efficiency and pollution control (Mudd and Glaister, 2009). The largest use of PGMs today is for automobile catalytic converters (autocatalysts), a pollution control device fitted to cars, trucks, motorcycles and non-road mobile machinery. In catalytic converters, PGMs are coated onto a substrate housed in the exhaust system where they act as catalysts to reduce harmful emissions to legislated levels. Autocatalysts convert over 90% of hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx) from gasoline engines into less harmful carbon dioxide (CO_2), nitrogen and water vapour. In diesel cars, oxidation catalysts are used to convert HC and CO to water and CO_2, and catalysed soot filters, traps and oxidises particulate matter (PM). The PGMs enable car manufacturers to comply with emission standards (Bossi and Gediga, 2017). Figure 2.1 shows how PGMs are used in different industries and usage percentage in the particular industry.

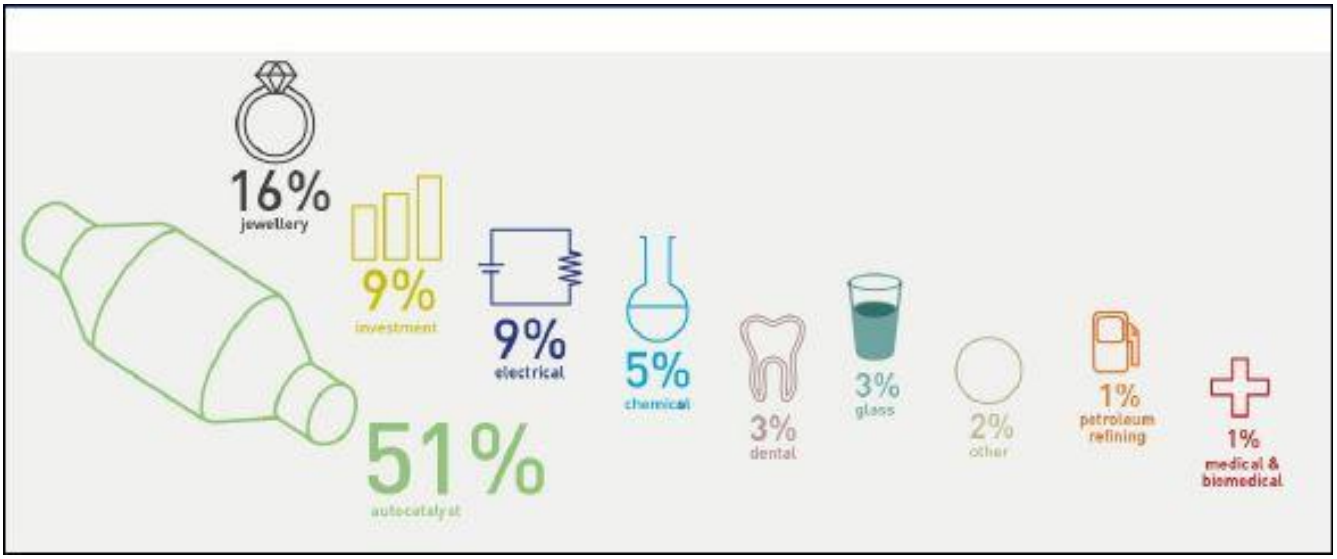


Figure 2.1: PGM uses per industry in 2010 (Bossi and Gediga,2017)

2.3.3 Distribution of PGM mines in South Africa

South Africa is the world's top producer of PGMs, accounting for 61.7% of total world supply (DME, 2003). It also has 56% of the world's identified resources, showing the potential for sustained future production and continued world dominance. According to DME (2003), in 2002 South Africa's known reserve base of PGMs represented 87.7% of the world, followed by Russia with 8.3%, Canada with 0.5%, USA with 2.5% and other countries with 1.1%. In 2016, South Africa hosted 95% of the known world reserves, currently estimated at 66,000 tons (USGS, 2016). The largest known platinum group metal (PGM) deposit in the world is the Bushveld Complex in South Africa, with the Great Dyke in Zimbabwe also being one of the biggest. The vast platinum resources occur together with the world’s largest reserves of chromium and vanadium ore in the unique

Bushveld Complex geological formation (Jones, 2005). Table 2.1 shows global resource base, production of PGMs and ranking.

Table 2.1 World reserves of PGMs in 2002 (DME, 2003)

Country	**Reserve base**		
	Ton (t)	**%**	**Rank**
South Africa	70 000	87.7	1
Russia	6 600	8.3	2
USA	2 000	2.5	3
Canada	390	0.5	4
Other	850	1.1	-
Total	79 840	100	

South Africa currently has four integrated primary platinum producers, namely Anglo American Platinum Corporation Ltd (formerly Rustenburg Platinum Holdings Ltd), Impala Platinum, Lonmin Platinum (which includes Western Platinum), and Northam Platinum. Their range of operations includes open-cast and underground mining, followed by milling, flotation, drying, smelting, converting, refining, and marketing. Anglo Platinum, Impala Platinum, and Lonmin Platinum, all under Bushveld complex, are the three largest producers of platinum in the world. Since 1971, these operations have established South Africa as the world's largest producer of PGMs (Jones, 2005). Figure 2.2 shows mining organisations that are found in the Bushveld complex.

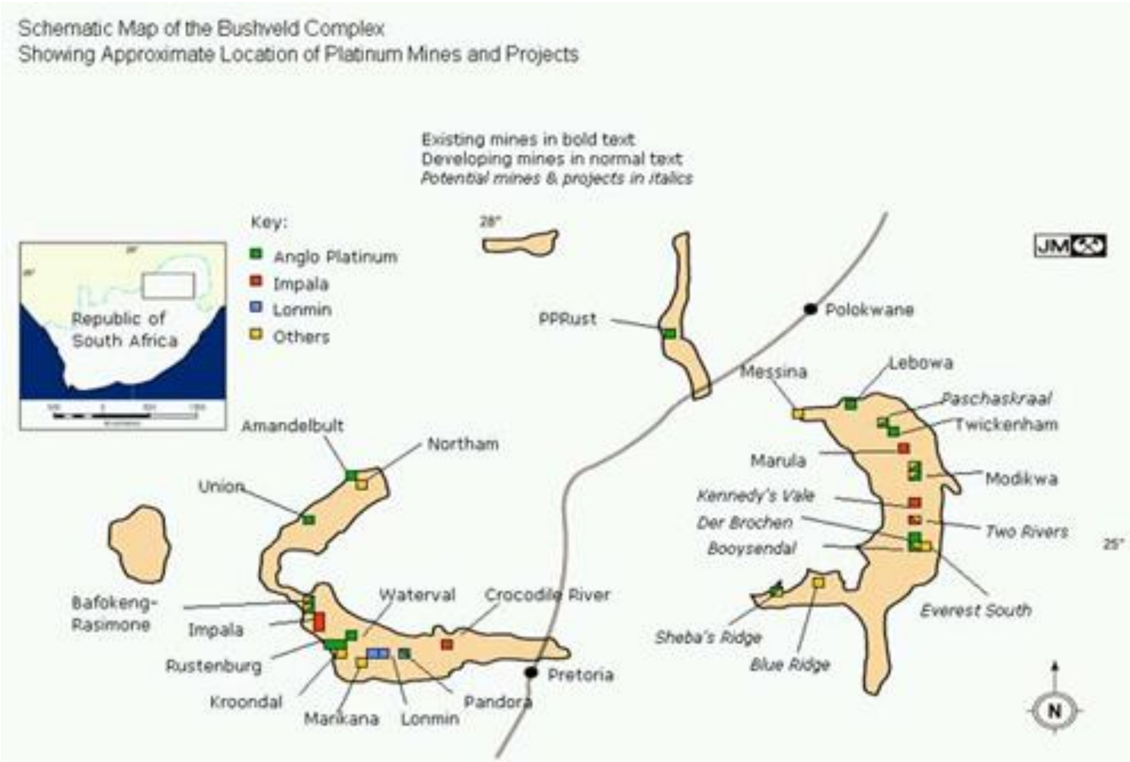


Figure 2.2 Distribution of PGM mining in BIC, South Africa (Matthey, 2013)

2.4 Mining life cycle stages of PGMs

Mining may well have been the second of humankind's earliest endeavors granted that agriculture was the first. The two industries ranked together as the primary or basic industries of early civilization (Hagler, 1998). Mining is the removal of minerals from the earth's crust in the service of man (Down and Stocks, 1977; Acheampong, 2004). The Encarta encyclopaedia also defines mining as the selective recovery of minerals and materials, other than recently formed organic materials from the crust of the earth (Encarta, 2005). Mining has also been defined as the extraction of valuable minerals or other geological materials from the earth, usually from an ore body, vein, or coal seam. Any material that cannot be grown from agricultural processes must be mined. Mining in a wider sense can also include extraction of petroleum, natural gas, and even water (Wikipedia, 2006).

There are different phases of a mining project, beginning with mineral ore exploration and ending with the post-closure period. Each phase of mining is associated with different sets of environmental impacts (IFC/World Bank, 2007). Life cycle stages of a mine include exploration, development, operation as well as rehabilitation and post closure stage. These stages are applicable to PGMs mining.

2.4.1 Exploration stage

A mining project can only commence with knowledge of the extent and value of the mineral ore deposit. Information about the location and value of the mineral ore deposit is obtained during the exploration phase. This phase includes surveys, field studies, drilling test boreholes and other exploratory excavations (IFC/World Bank, 2007). The first stage of exploration phase may involve clearing of wide areas of vegetation (typically in lines) and to allow the entry of heavy vehicles mounted with drilling rigs (IFC/World Bank, 2007). The second phase of exploration stage involves more detailed surveys including mapping, sampling and diamond drilling (often at great depths) to determine the size and shape of the mineral deposit. In addition, Environmental Impact Assessment (EIA) begins at this stage (Mining global, 2015).

According to Mining global (2015), companies enlist geologists and others to prospect remote areas in search of mineral deposits in this stage. Mineral exploration geoscientists use diverse types of datasets to search for new economic deposits (Esri, 2007). Data sources vary from geologic maps, hyperspectral airborne and multispectral satellite images and geophysical images to databases in many formats. GIS is an ideal platform to bring them together in a geoscientist's computer and deliver meaningful outcomes (Esri, 2006).

Methods such as geological mapping and geological survey are often applied at an early stage to pin out potential deposits (Mining global, 2015). These methods also increase the spatial context of the information available to mining planners and give them a more thorough understanding of the geography of prospective sites (Esri, 2006). Geological mapping is commonly the first mineral exploration method undertaken on the ground (Madison, 2013). This involves a visit by a geologist to look at rock outcrops and to observe the location, orientation and characteristics of the rocks or sediments exposed at the surface. It may involve vehicle access to a property, taking and recording measurements and walking across the area. It may also involve gathering small samples from rock outcrops, soils or streams for chemical analysis. This information can then be used to prepare a geological map of the exploration area, recording the rock types and structures (Madison, 2013).

Madison (2013), further indicated that geochemical surveys are undertaken to target areas for further exploration. The surveys usually involve the collection of soil, rock and/or sediment samples and channel sampling. These samples are sent for laboratory analysis to identify areas of potential mineralization. Geological mapping and geochemical surveys are strictly regulated in the conditions of all exploration licenses. As most geological mapping and geochemical survey work has minimal, if any, surface disturbance, further approvals for this work are only required in sensitive areas. On private land, this work must be covered in an access agreement with the landholder before work begins.

2.4.2 Development stage

The development stage, also known as the construction phase is associated with construction of buildings, as well as necessary infrastructure such as roads, bridges, and airports (IFC/World Bank, 2007). According to Mining global (2015), the construction process occurs after research, permitting and approvals are complete. Construction of mining sites also involves processing facilities, environmental management systems, employee housing and other facilities. Mine development can take anywhere from 5 to 10 years and often much more. The time needed depends on where the mine is located, how large and complex the development is (including infrastructure needs and availability), and the complexity of regulations and review processes (Mining global, 2015).

This phase of the mining project has several distinct components. The construction of access roads, either to provide heavy equipment and supplies to the mine site or to ship out processed metals and ores, can have substantial environmental impacts, especially if access roads cut through ecologically sensitive areas or are near previously isolated communities. If a proposed mining project involves the construction of any access roads, then the environmental impact assessment (EIA) for the project must include a comprehensive assessment of the environmental and social impacts of these roads (IFC/World Bank, 2007). If a mine site is located in a remote, undeveloped area, the project proponent may need to begin by clearing land for the construction of staging areas that would house project personnel and equipment. Even before any land is mined, activities associated with site preparation and clearing can have significant environmental impacts, especially if they are within or adjacent to ecologically sensitive areas. The EIA must assess, separately, the impacts associated with site preparation and clearing (IFC/World Bank, 2007).

2.4.3 Operation stage

Once a mining company has constructed access roads and prepared staging areas that would house project personnel and equipment, mining may commence. All types of active mining share a common aspect: the extraction and concentration (or beneficiation) of a metal from the earth. Proposed mining projects differ considerably in the proposed method for extracting and concentrating the metallic ore (IFC/World Bank, 2007).

In preparation for mine operations, recruitment, hiring and training of a wide range of personnel is required. Mine operation involves the extraction of ore, separation of minerals, disposal of waste and shipment of ore minerals (Mining global, 2015). In the operation process, mining methods such as surface, underground and placer mining are used (IFC/World Bank, 2007). Additional exploration may lead to the discovery of additional mineralization that leads to expansion of the operation during the mine life. These expansions involve the full cycle studies, evaluations and permitting processes that are required for a new mine development (Mining global, 2015).

2.4.4 Closure stage and rehabilitation

Mine closure is the last phase of the mining cycle. Shutdown and decommissioning involves the removal of equipment, the dismantling of facilities and the safe closure of all mine workings (Mining global, 2015). Mine closure also requires reclamation, which in fact occurs at all stages of the mine life cycle, involves earth work and site restoration including revegetation of waste rock disposal areas. The final stage is monitoring, which includes environmental testing and structural assessments that commonly continue long after the mine is closed (Mining global, 2015).

When active mining ceases, mine facilities and the site are reclaimed and closed. The goal of mine site reclamation and closure should always be to return the site to a condition that most resembles the pre-mining condition (IFC/World Bank, 2007). Mines that are notorious for their immense impact on the environment often make impacts only during the closure phase, when active mining operations cease. These impacts can persist for decades and even centuries. The EIA for every proposed mining project must therefore include a detailed discussion of the mine Reclamation and Closure Plan offered by the mining proponent. Mine reclamation and closure plans must describe in sufficient detail how the mining company will restore the site to a condition that mostly resembles pre-mining environmental quality; how it will prevent the release of toxic contaminants from various mine facilities such as abandoned open pits and tailings impoundments and how funds will be set aside to ensure that the costs of reclamation and closure will be paid for (IFC/World Bank, 2007).

2.5 Methods of mining PGMs

The methods used in mining depend on the type of mineral resource that is mined, its location at or beneath the surface, and whether the resource is worth enough money to justify extracting it. Each mining method also has varying degrees of impact on the surrounding landscape and environment (AGI, 2017). The mining of PGM ores is through conventional surface or underground techniques (Mudd, 2010). The majority of PGM ores in South Africa is sourced by underground mining. The 2009 production data shows that for the Bushveld, Great Dyke and Stilwater underground mining represents 85% of the ore milled and 15% by open cut mining (Mudd and Glaister, 2009). The next stage is grinding and gravity based (dense media) separation, followed by flotation to produce a PGM-rich concentrate. The concentrate is then smelted to produce PGM-rich Ni-Cu matte, with the PGM extracted and purified at a precious metal refinery (Mudd, 2010). The two main ways of mining PGMs are discussed below.

2.5.1 Surface mining

Surface mining involves stripping surface vegetation, dirt, bedrock and other layers of the earth to reach ore deposits underneath. In general, there are four basic unit operations common to most surface mining operations: drilling, blasting, loading, and hauling. Surface mining usually requires extensive blasting of both overburden and the ore. If the rock types are soft enough to permit excavation without blasting, the first two unit operations may not be performed.

There are three general methods of surface mining, namely: open-pit mining, contour mining, and area mining (Hagler, 1998). Open-pit mining is a type of strip mining in which the ore deposit extends very deeply in the ground, necessitating the removal of layer upon layer of overburden and ore. It often involves the removal of natively vegetated areas, and is therefore among the most environmentally destructive types of mining, especially within tropical forests.

Contour mining is commonly in mountainous terrain where the ore outcrops are on the mountain slopes. The most popular and environmentally acceptable method of contour mining is haul back mining. Haul back mining permits the reclamation of the back-filled sections by grading, replacing the topsoil, and seeding with grasses. These operations are performed on a continuous cycle along with the removal of the overburden and ore. Problems associated with water quality control, such as acid mine drainage, can be minimized by selective replacement of toxics (Hagler, 1998).

Hagler (1998), further indicated that area mining is used mostly where the terrain is flat or only slightly rolling and where the mine site includes large stretches of land. The first cut results in a long pit with a high wall on both sides of the pit. Overburden from this first pit is stored to be available to fill the final cut. A second cut is started adjacent to the first cut, into which the second cut’s overburden is placed. Strip by strip, the mining thus proceeds across the property.

On the surface, the PGM ore is crushed and milled into fine particles. Wet chemical treatment known as froth flotation produces a concentrate which is dried and smelted in an electric furnace at temperatures over 1 500°C. A matte containing the valuable metals is transferred to converters to remove iron and sulphur. PGMs are then separated from the base metals nickel, copper and cobalt, and refined to a high level of purity using a combination of solvent extraction, distillation and ion-exchange techniques (Johnson, 2013).

2.5.2 Underground mining

Underground mining refers to the extraction of ore from beneath the surface of the earth. A decision to use underground mining methods is based on economic profitability criteria, depth, size, dimensions and distribution of the ore. In underground mining, a minimal amount of overburden is removed to gain access to the ore deposit. Access to this ore deposit is gained through tunnels or shafts. Tunnels or shafts lead to a more horizontal network of underground tunnels that directly access the ore (Hagler, 1998).

Underground mining methods include: naturally supported openings, artificially supported openings and caving methods. Naturally supported openings are used when strong ore and wall rock are present, permitting the stopes to remain open, essentially by their own strength, during ore extraction. These relatively low-cost methods of mining include: open stoping, sub-level stoping, vertical crater retreat, room-and-pillar mining, and shrinkage stoping. Artificially supported openings and caving methods are used when ore and wall rock are not strong. Waste material, timbers, or mechanical means are used to keep the stopes open during mining. After the extraction of the ore, the stopes are either filled to maintain stability or allowed to cave. These more expensive methods include: cut-and-fill stoping, square set stoping, long wall mining, and top slice stoping. Caving methods are used where there are large ore deposits with weak wall rocks that will collapse as the ore is removed. They have a high ore recovery when the ore is fractured enough to be handled in draw points. Capital investment is high but caving methods are low-cost. They include sub-level caving and block caving (Hagler, 1998).

2.6 Extraction and refining of PGMs

Extraction, concentration and refining of PGMs require complex, costly and energy-intensive processes that may take up to six months to produce refined metal from the time the first PGM-bearing ore is broken in a mine (Chamber of mines SA, 2012: Bossi and Gediga, 2017). For example, in South Africa, PGM-bearing ores generally have a low PGM content of between 2 and 6 grams per ton and it will typically take up to six months and between 10 and 40 tons of ore to produce one ounce (31.1035g) of platinum (Johnson, 2013).

2.6.1 Primary Production

In this stage, ore bearing the PGMs is typically mined underground or, less usually, from open pits. The ore is blasted before being transported to surface. Crude ore is crushed, milled and concentrated into a form suitable for smelting, which takes place at temperatures that may be over 1 500ºC (Glaister and Mudd, 2010). Unwanted minerals such as iron and sulfur are removed leaving a matte containing the valuable metals which are separated in a series of refining processes. Nickel, copper, cobalt, gold and silver may be extracted in the refining process as co-products (Mudd, 2012). Electricity consumption is high, not only for ore haulage but also to drive compressed air to the miners' hand-held pneumatic drills and, because the hard rock in platinum mines has a high thermal gradient, to refrigerate the working areas. In a study conducted by Bossi and Gediga (2017), the electricity use in primary production amounted to 85-90% of total Global Warming Potential (GWP), depending on the PGM. Due to the high proportion of electricity use in primary PGM production, a considerable shift to renewable energy projects like solar thermal or photovoltaics to progressively replace existing coal-based electricity could result in a significant reduction in emissions. However, to a great extent, the national electricity grid mix is beyond the control of South African PGM producers (Glaister and Mudd, 2010).

2.6.2 Secondary production (recycling)

The PGMs can be recycled from a variety of end-of-life products, such as spent autocatalysts, and even from residues created during primary production. Secondary production processes can vary widely depending on the specific material or combination of materials treated (Bossi and Gediga, 2017). Some secondary producers of PGMs use a dissolving process to create a PGM-rich solution for refining, while others may use a smelting process to create a matte. In both cases, the final PGM products are identical in quality and purity to those refined from mined material. Bossi and Gedigas (2017) study showed that the electricity use in secondary production amounted to 17-23% of the GWP, other parameters of GWP were fuels, ancillary materials and process emissions. Figure 2.3 shows the process of production of PGMs in South Africa.

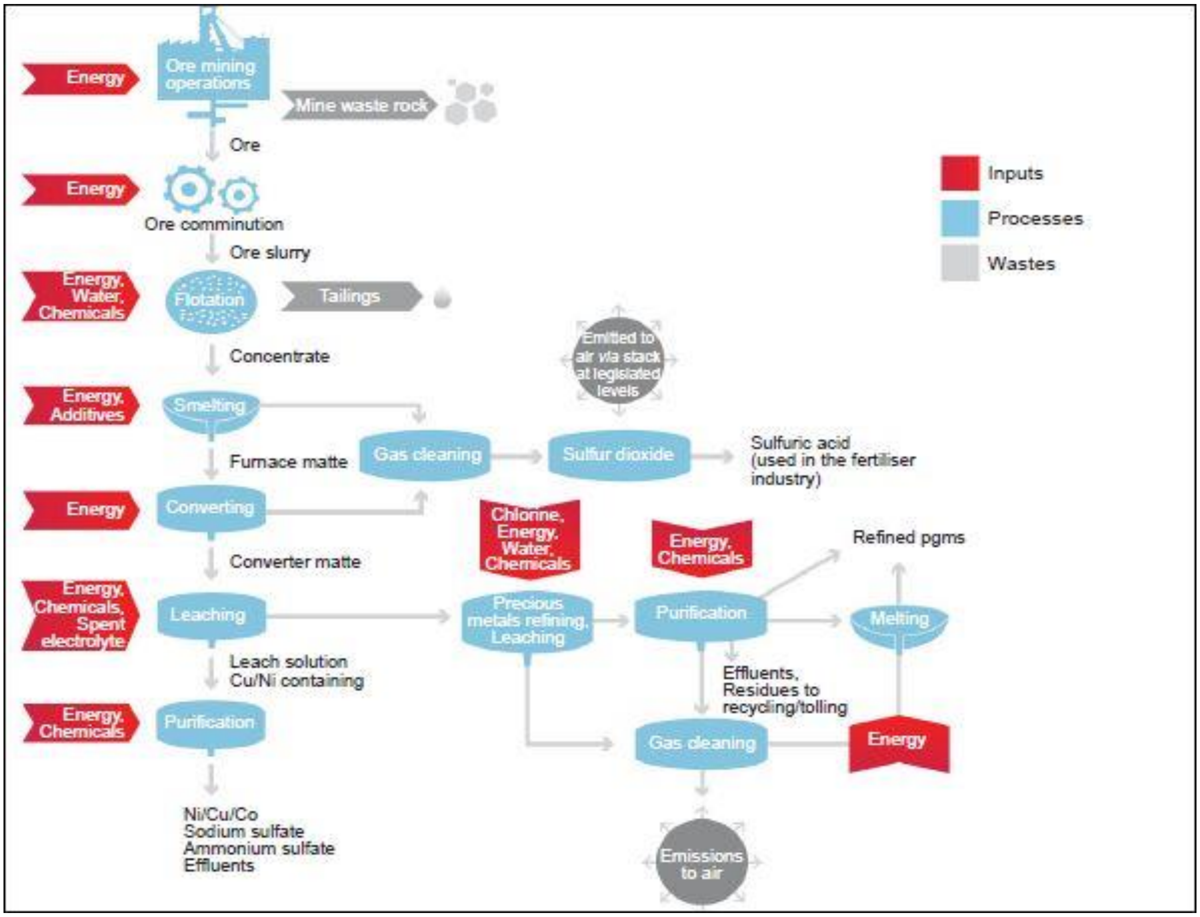


Figure 2.3 Generic flow chart for PGM production in South Africa (Lonmin, 2014)

2.7 Type of wastes generated from mining activities

The wastes generated by the mining industry are mainly during the process of extraction, beneficiation and processing of minerals. Extraction, which is the first phase, consists of initial removal of ore from the earth's crust which is done by the process of blasting. This phase results in generation of large volumes of waste such as soil, debris and other material which is useless for the industry and is just stored in big piles within the mine lease area, and sometimes, on public land (Das and Choudhury, 2013).

Wastes produced from the mining and extraction of metal, industrial mineral and energy resources constitute one of the largest waste streams on earth. The volumes of these 'mine wastes' are predicted to increase at least two-fold over the next 100 years due to increasing demands for minerals and energy, and lower ore grades (Hudson-Edwards, 2012). Mine wastes can be categorised into gaseous, liquid and solid waste and includes both general and hazardous wastes.

2.7.1 Gaseous waste

Reference.com (2018) defines gaseous waste as a waste product in gas form resulting from various human activities, such as manufacturing, processing, material consumption or biological processes. It is a significant type of waste during excavation of the ore deposits and transportation from the mine to the ore processing facility. Dust particles are the main concern in air pollution related to mining and extraction operations. The main air pollutants are dust particles and exhaust fumes. Dust particles are generated at many stages of the mining process and can result in great environmental hazards depending on site conditions, management practices, and type of ore being mined. The most effective way to control or minimize dust emissions is to increase the surface moisture in places where dust is produced. Common sources of dust particles are ore and waste loading points, trucks, railroad cars, ore chutes in haulage systems, exhaust fumes from de-dusting installations, waste dumps, ore stock piles, haulroads, road traffic, blasting, drilling, and hauling equipment and rock crushers. Dust emissions can be categorized as either point source dust or fugitive dust (Hagler, 1998).

During operation, mining companies can generate particulate matter (PM). Particulate matter (also called particle pollution) refers to a mixture of solid particles and liquid droplets found in the air, they can be both organic and inorganic. These particles include dust, dirt, soot or smoke and some are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope. The concentration of PM is measured in terms of their size in diameter in micrometers. The size of dust particles is directly linked to their potential for causing health problems (EPA, 2017).

Particle pollution includes PM10 which are inhalable particles with diameters that are generally 10 micrometers and smaller. This particulate matter can be found near roadways and dusty industries, but also in some livestock barns. PM2.5 are very fine inhalable particle matters below 2.5 micrometers and are often referred to as fine particles. They are emitted from forest fires, automobiles and some agricultural settings. Particulate matters of 2.5 or smaller are able to pass the nose, mouth and larynx, penetrate into the thorax and some even into the lung tissues, causing adverse respiratory and cardiovascular health effects (EPA, 2017).

Exhaust fumes are usually produced by diesel engines and blasting agents. These fumes can be a serious hazard to the environment and to the health of those working in underground mines (Hagler, 1998). PGM mining operation results in the release of sulphur dioxide (SO_2) into the atmosphere (Mudd, 2010).

2.7.2 Liquid waste

Liquid waste is any form of liquid residue that is hazardous to people and the environment. It can be bulky, sludgy or purely liquid. Liquid waste can be produced by all sectors of society and includes sewage as well as wastewater from industrial processes such as food and agriculture, manufacturing and mining (EPA, 2017).

These types of waste can be a significant problem at many mines as continuous pumping and monitoring of great volumes of water are usually required. Mine water is the water that is removed from the mine to gain and maintain access to the ore deposit. It can originate from precipitation and/or from a groundwater aquifer intercepted by the mine. One of the major concerns regarding mine water is the potential for acid generation and metal mobilization in waste associated with mining operations. In surface mining operations, the volume of mine water depends on the ingress of groundwater and the precipitation onto the surface area of the pit. The control systems depend significantly on the topography of the site (Hagler, 1998).

Hagler (1998) added that mine water is usually collected at the lowest point and pumped out of the mine and if the mine is located on hillsides, ditches can be used to intercept the runoff. For underground operations, the volume of mine water is significantly influenced by the local hydrogeologic conditions and the infiltration of surface water into the mine. Mine water is pumped to the surface from collection sumps where suspended solids are decanted. It is recommended that all mine water be collected at a single point where it can be directed to be processed to the environment or for treatment.

Acid drainage is common in areas where mine openings intersect the water table and where the rocks contain iron or other sulfides. A severe pollution hazard in many mining operations occur when sulfide minerals, catalyzed by bacteria, oxidize to create ferrous iron and sulfuric acid, often accompanied by cations of a variety of other metals, as well as anions. It is called acid mine drainage when it occurs inside the mine, and acid rock drainage when it occurs on waste rock and tailings piles (Hagler, 1998).

2.7.3. Solid waste

Environment Conservation Act (1989) defines solid waste as undesirable or superfluous by-product, residue or remainder of any process or activity. It can also be defined as any matter which is semi-solid, solid or a combination thereof originating from any residential, commercial or industrial area. The waste is accumulated and stored by any person with the purpose of eventually discarding it with or without prior treatment connected with the discarding thereof, or which is stored by any person with the purpose of recycling, reusing or extracting a useable product from such matter (Environment Conservation Act,1989). Solid waste can be classified in two main categories, that is, general waste and hazardous waste. Solid wastes generated at a mine include overburden, slag, waste rock and tailings. The above mentioned solid wastes are hazardous in nature.

2.7.3.1 Overburden

Overburden is a mantle of soil, rock, gravel, or other earth material covering a given rock layer or bearing stratum (Haering *et al.,* 1993). According to Jacobs (2012), overburden includes the soil and rock that is removed to gain access to the ore deposits at open pit mines. It is usually piled on the surface at mine sites where it will not impede further expansion of the mining operation. Overburden is generated during the extraction process of minerals using surface mining method. Large amounts of land has to be removed before the PGM bearing ore can be accessed.

2.7.3.2 Slag

Slag is the glass-like by-product left over after a desired metal has been separated (i.e. smelted) from its raw ore. Slag is usually a mixture of metal oxides and silicon dioxide. However, slags can contain metal sulfides and elemental metals. While slags are generally used to remove waste in metal smelting, they can also serve other purposes, such as assisting in the temperature control of the smelting, and minimizing any reoxidation of the final liquid metal product before the molten metal is removed from the furnace and used to make solid metal (Wikipedia, 2017).

2.7.3.3 Waste rock

In order to get at the rock or "ore" that holds the mineral or minerals of economic interest, a mining operation must move and dispose of a large amount of blasted rock that does not have useful concentrations of minerals which is called "waste rock". Waste rock is typically dumped into large piles within the mines waste rock storage area, which can spread over an area of several square kilometres. Both the physical and chemical characteristics of the waste rock must be considered if it is to be properly disposed of (Mitchell and Balley, 2010). Waste rock, just like overburden, is generated during the extraction process. PGM waste rock is generated once ore bearing rocks have been blasted using explosives and the desired element is extracted (Jacobs, 2012).

2.7.3.4 Tailings

Tailings are an output of mineral beneficiation processes. They are generally in the form of a slurry which contains certain hazardous contents such as arsenic, barite, calcite, cyanide, fluorite, mercury, pyrite and quartz. The tailings is stored in a storage area called tailings dam or a tailings management facility (Das and Choudhury, 2013). The combination of liquids and fine-grained solids make many tailings physically unstable. If left exposed to the air and dried, tailings can also be blown by the wind causing air pollution and washed into waterways, thus harming aquatic ecosystems (Mitchell and Balley, 2010).

The large volumes of solid wastes generated in PGM mining operations require active assessment, planning and management to prevent major environmental, social or financial impacts (Mudd, 2010). Given that the ratio of ore to concentrate is typically around 30:1 to 50:1, this means that some 96-98% of the ore becomes tailings. For mining, waste rock to ore ratios are typically much greater than the unit for open cut mining (5:1 to 20:1) and the reverse for underground mining (Mudd and Glaister, 2009). At present, there is no data available on underground waste rock generation in the Bushveld or other mines but it could be expected to be around 1:10 to 5:10 and given the narrow nature of the reefs, waste rock to ore ratios could be expected to be higher than bulk and high tonnage methods. The waste ore ratios reported for Mogalakwena, Kroondral and Marikana joint venture open cut mines range from 6.9:1 to 23.7:1, leading to waste rock ranging from 2.6 to 94.6 metric tons per year. At present, it is rare for mine companies to report total mine wastes under their control and active management. One exception, however, is Anglo Platinum reporting which indicated that in 2008 their cumulative mine wastes were 730.8 metric tons of tailings and 665.4 metric tons of waste rock (Mudd, 2010).

2.8 Waste management practices at a mine

Mine waste, even in small amounts, has the ability to negatively affect the environment because of the chemical properties (toxic elements) the waste possesses. Should the wastes get in contact with air, water or land, it changes the natural constitution it has hence becoming intoxicated. Because of the large volume of wastes generated at mine sites, and their potential for negative environmental impacts, managing waste rock and tailings can be one of the greatest challenges in responsibly operating a mine (Mitchell and Balley, 2010). According to Lu and Cai (2012), the important issues on disposal of solid wastes from metal mines are to choose the right varieties for the comprehensive utilization of mining waste and to control contamination from waste rocks and tailings. Environment friendly waste management practices, such as separation of solid wastes from mines at point of generation is the key pathway to a clean and safe environment.

2.8.1 Classification and separation

Classification and separation of waste is the first step for a good waste management system. Waste should be classified by its source and by its properties, both physical and chemical properties. It is advisable that all wastes generated within the mining facility must be separated at point of generation. That is, general wastes should be separated from hazardous wastes. The wastes should then be classified into different catergories: corrosive, ignitable, toxic, flammable etc. When the wastes are being separated, they should be stored in their appropriate storage containers. Segregation methods include storing in separate cabinets, hoods or secondary containment containers such as 5-gallon buckets or tubs which is equivalent to18 liters (VEHS, 2017).

2.8.2 Containers and storage

All waste storage containers must be best suitable for the type of waste, whether general or hazardous. Hazardous waste must be stored in containers (including lids) made of materials that are compatible with the waste. Hazardous waste containers must be in good condition and free of leaks or any residue on the outside of the container. Containers should be sealed with a screw-type lid or other appropriate devices (VEHS, 2017). All hazardous waste containers need to be closed except for when adding or removing waste. The containers must be kept in good condition to help prevent leaks and spills and it should be ascertained that the drums are not rusting or damaged. Under the rules, all containers holding hazardous waste must be labeled with the words "Hazardous Waste" and/or have a biohazard sign. Another important part of container labeling is to have a tag which provides specific information including name, telephone number, building, room number, exact contents of the container and accumulation start date (OEPA, 2015; VEHS, 2017). Figures 2.4 and 2.5 show examples of how a container carrying hazardous wastes should be labeled.

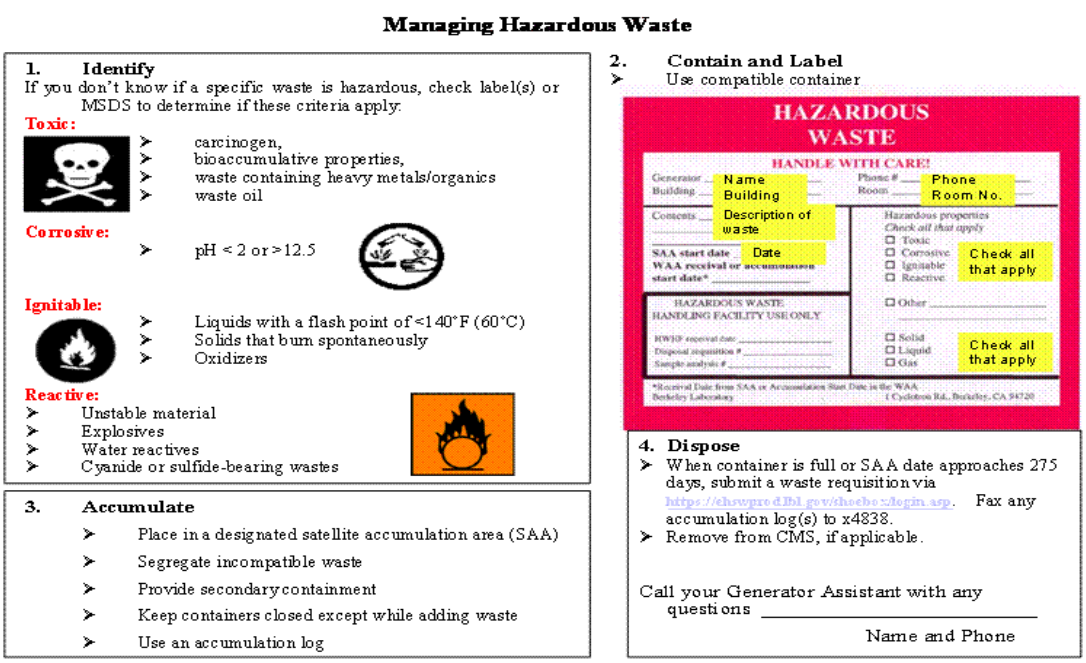
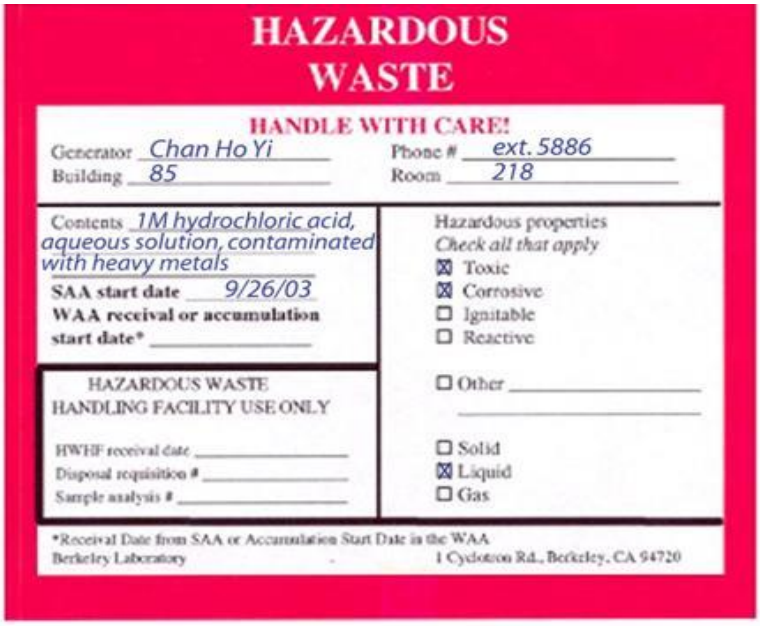


Figure 2.4 Example of biohazardous sign and label tag for hazardous waste container (https://www.google.com/search?rlz=biohazard+signage&chips, 2017)


HAZARDOUS WASTE

HANDLE WITH CARE!

Generator Chan Ho Yi	Phone # ext. 5886

Building 85	Room 218

Contents 1M hydrochloric acid, aqueous solution, contaminated with heavy metals

SAA start date 9/26/03

WAA receival or accumulation start date*

Hazardous properties

Check all that apply

☒ Toxic

☒ Corrosive

☐ Ignitable

☐ Reactive

☐ Other

HAZARDOUS WASTE HANDLING FACILITY USE ONLY

HWHF receival date

Disposal requisition #

Sample analysis #

☐ Solid

☒ Liquid

☐ Gas

*Receival Date from SAA or Accumulation Start Date in the WAA

Berkeley Laboratory	1 Cyclotron Rd., Berkeley, CA 94720

Figure 2.5: Example of label tag for hazardous container (https://www.google.com/search?q=hazardous+waste+tag, 2017)

Vanderbilt Environmental Health and Safety (VEHS) (2017) further indicated that a storage location for waste should be designated inside or near the facility. The waste, in bags or containers, should be stored in a separate area, room, or building of a size appropriate to the quantities of waste produced and the frequency of collection. Hazardous wastes must be stored with secondary containment so that spills cannot reach sink, hood, or floor drains. Incompatible hazardous wastes must be segregated to prevent reaction.

2.8.3 Collection and transportation

After on-site storage, the next step is collection. Waste collection involves waste bins allocation and collection routing (Zotos *et al*., 2009). Wastes are transported inside or outside (near-by) the facility by using a trolley, hand-cart or tractor. Thereafter, the wastes can be taken by authorised persons for treatment and disposal by using a vehicle (compactor, truck fitted bin lifter or enclosed light truck) (Clarkson, 2017). Generally, collection and transportation are the most important and costly aspects of the process because of the labour intensity of the work and the massive use of vehicles in the collection and transportation process (Amponsah and Salhi, 2004). Hazardous mine waste, is the responsibility of the generator who must hire competent persons for treatment and disposal of wastes.

2.8.4 Treatment and disposal

Treatment and disposal is the final stage of a good waste management practice system. Wastes that cannot be recycled must be treated and disposed in a manner that is not harmful to the environment and its inhabitants. The following treatment and disposal methods are discussed: impoundments, ocean dumping, dry land disposal and co-disposal of waste rock and tailings (Mitchell and Balley, 2010).

2.8.4.1 Impoundments

An impoundment is a disposal area with raised embankments that contains both the solid and liquid components of the tailings and may also be used to dispose of waste rock. The embankments may surround the full impoundment or natural landscape features may be used in combination with impoundments to contain the waste. Once released, the solids in the PGM tailings slurry settle to the bottom and a pond will usually form over a portion of the tailings. This ponded water can be recycled to reduce the demand for additional water at the mill and to reduce the amount of water that is discharged from the impoundment. If the tailings are acid generating then additional water will be added or retained within the impoundment to keep the PGM tailings under water (Mitchell and Balley, 2010).

2.8.4.2 Ocean dumping

Mitchell and Balley (2010) further indicated that disposal of mine waste into the ocean is a preferred option for mining companies operating in coastal areas with more permissive governments. Ocean dumping, also known as Submarine Tailings Disposal (STD) or Deep Sea Tailings Disposal (DSTD) involves mixing the PGM tailings with seawater and depositing them by pipe onto the ocean floor (Das and Choudhury, 2013). The PGM tailings are not contained in anyway and in some cases currents have moved the PGM tailings several kilometres from the deposition site. The PGM tailings smother the natural ocean bottom and the ability of marine life to return is uncertain.

2.8.4.3 Dry land disposal

The most common method for disposing of waste rock is dry land disposal where the waste is piled in a designated area and eventually covered with soil and rehabilitated in a responsible operation. Initial dry land disposal of PGM tailings is quite rare as it requires the almost complete separation of the liquid and solid parts of the tailings slurry, and because the dry tailings must be transported to the disposal area by truck or with a conveyor system, rather than less expensive option of using a pipeline and pumps or gravity (Mitchell and Balley, 2010). According to Das and Choudhury (2013), PGM dry land disposal requires the dewatering of tailings using vacuums and filters which save the water and reduces the impact on the environment.

2.8.4.4 Co-disposal of waste rock and tailings

Co-disposal is a relatively new approach to mine waste disposal that takes advantage of the characteristics of waste rock and of tailings. If disposed of together, PGM waste rock can provide the structure and strength that PGM tailings lack, while the tailings can fill in the voids between the larger pieces of waste rock. Filling the voids reduces the amount of air and water that can come in contact with the waste rock, reducing the potential for acid drainage and leaching of metals. Combining the PGM tailings and waste rock also reduces the footprint required for disposal and eliminates the risks associated with a tailings impoundment failure. Though economic savings are gained by not requiring a tailings dam, there may be additional costs in handling the wastes. This is a relatively new approach and still in the experimental stage. As with dry stacking, an impermeable cover may be required to further reduce the risks of acid and metal leaching (Mitchell and Balley, 2010).

2.8.5. Rehabilitation

Mine site rehabilitation is important for environmental sustainability. Rehabilitation involves returning the land to its natural state after mining through strict, well researched strategies of revegetation and the regeneration of natural ecosystems (Griffin Coal, 2017). When mining operations are complete, the change in topography and stripping of vegetation can lead to significant soil erosion, not only washing precious nutrients away and clogging up waterways with run-off, but also creating unsightly and unusable heaps of dirt. This is why rehabilitation of mining sites is so important because it establishes new growth as quickly as possible and allows any land destroyed by mining to be put to better use for forestry or grazing purposes (Mining technology, 2017).

Rehabilitation involves a comprehensive process of classifying overburden material, land recontouring, seeding and regeneration. Overburden material is classified according to its potential to cause geochemical impacts (acid rock drainage) on the environment. Dumping of waste material is undertaken so that the best materials end up near the surface of waste landforms and the other material is encapsulated in the middle. When the landforms are no longer needed for mining or dumping purposes the slopes are recontoured to around 10 degrees to control surface runoff and to ensure a stable slope. Topsoil is then spread to a depth of 150 mm before the area is contour ripped, fertilised and seeded with local native species (Mining technology, 2017). Rehabilitation areas are seeded at the break of the winter rainy season, and initially are susceptible to erosion damage until germination and root development has occurred.

Legislation now stipulates that all mining operations within South Africa are required to make provision for environmental rehabilitation during the life of the mine and at closure (Guardrisk, 2017). Environmental rehabilitation in South Africa is based on the principle of “polluter pays” and is a costly, complex and lengthy process (Tomorrow magazine, 2015). The obligations with respect to the rehabilitation of mine sites are largely contained in the Mineral and Petroleum Development Act (MPRDA) and accompanying regulations, though mining-related activities will invariably trigger a range of environmental provisions contained in legislation. The laws will also include the National Environmental Management Act (NEMA), the National Water Act (NWA) and the National Environmental Management Waste Act (NEMWA) (Krause and Synman, 2015). The MPRDA, the main source of rehabilitation obligations, requires rights holders to ‘as far as reasonably practicable’ rehabilitate the land affected by the operation ‘to its natural or predetermined state, or to a land use which conforms to the generally accepted principle of sustainable development’ (MPRDA, 2002). Processes such as backfilling, soil revegetation and regeneration as well as reuse and recycle are examples of rehabilitation of mines and are discussed below.

2.8.5.1 Backfilling

According to Mitchell and Balley (2010), mine wastes can be returned from where they once came, in a process known as backfilling. Backfilling is fairly common in underground mines as it can be used to fill mined-out voids, increasing the stability of the surrounding rock and decreasing the risk of collapses and surface subsidence. When backfilling underground mines, PGM tailings are usually mixed with cement to solidify the slurry and chemically stabilise the tailings. In open pit operations tailings and waste rock must be stored until excavations in all or a part of the pit is finished. Backfilling can be more expensive than other alternatives because of the extra storage and handling requirements. The advantages to backfilling are the eventual reduction of the physical footprint of the mine, rehabilitation of excavated pits and shafts, and eliminating the need for maintaining an impoundment. According to Das and Choudhury (2013), backfilling is also highly recommended for managing overburden.

2.8.5.2 Soil revegetation and regeneration

Mining of mineral resources results in extensive soil damage, altering microbial communities and affecting vegetation leading to destruction of vast amounts of land. Management of top soil is important for reclamation plan to reduce the losses and to increase soil nutrients and microbes. Revegetation and regeneration constitute the most widely accepted and useful way to reduce erosion and protect soils against degradation during reclamation (Marc, 2015).

Historically dumps were rehabilitated to pasture species. This approach was chosen to stabilise the dump outslope quickly to prevent erosion. More recently efforts have been directed to the re-establishment of native flora. Native species do not germinate and develop until the following spring, therefore the potential for massive erosion is present during the winter. A strategy has been developed whereby native bush species comprising grasses, groundcovers, shrubs and trees, are sown together with a “nurse” crop of cereal rye. The cereal rye germinates quickly and stabilises the surface through the winter and the native plants emerge the following spring. The seed mix includes Jarrah, Wandoo, Flooded Gum, numerous Acacias and understorey species. This process is called regeneration (Mining technology, 2017).

2.8.5.3 Reuse and recycling

Mining waste comes in many forms and varies from harmless to highly hazardous. Much of it has little or no economic value but the mining industry is making an effort to find new uses for waste to reduce environmental impacts (CMA Ecocycle, 2016). Mine wastes are generally considered worthless at the time of production, yet they can still contain mineral and energy resources that may become valuable. Changing circumstances may turn a particular waste into a valuable commodity, either because the economic extraction of metals, energy and minerals may now be possible using superior technology or a market that has been identified for the previously discarded waste (Geoscienceworld, 2011).

PGM Slags are the non-metallic components left over from metal smelting. They are largely environmentally safe and are increasingly being used in making concrete and in road construction. There are many other types of mining waste, from airborne dust and gasses to clays and sludge. Efforts to find better mine waste management solutions are seeing these materials made into a range of products including bricks, tiles and glass or used in agro-forestry, for soil improvement and in construction (CMA Ecocycle, 2016).

Disposal methods of solid wastes such as PGM tailing, overburden and waste rocks can also be considered as recycling methods since the wastes are repurposed and reused into something of economic and environmental importance. For example, when waste rocks and tailings are used for back filling, it reduces the amount of waste piles leaving fewer mine workings. The most promising reuses for coarse-grained mining wastes and especially barren waste rocks from coal and metal mining are as building and construction materials. These wastes are used as fill for subsided land or as aggregates in embankment, dam, road, pavement, foundation and building construction. They also find applications as feedstock for the production of cement and concrete (Geoscienceworld, 2011).

2.9 Impacts of mining on the environment

Mining is a major economic activity in many countries, both developed and developing. However, like all other industries and sectors, the mining sector is also bereft with its own problems and challenges. The “footprints” it usually leaves behind are tremendous especially when it is not managed well. Badly managed impacts of mining on the environment or the social fabrics of society can reflect negatively on economic parameters countrywide (World Bank and International Finance Corporation, 2002). They can allow many communities to become poorer with little access to resources especially when mining ventures fail (Kapelus, 2001). Impacts to be covered under this section include physical, social and economic.

2.9.1 Physical impacts

According to DEFRA (2011), physical impact is any change that a project or activity may cause on the environment, including any effect of any such change in: the quality of soil, water and air, biodiversity and the condition of habitats. This also includes change in the current use of lands and resources for traditional purposes and any structure, site or thing that is of historical, archaeological, paleontological or architectural significance. Physical impacts of mining can be either short term or long term. They include impacts such as pollution, degradation, loss of biodiversity and erosion or those impacts caused by the process of mining itself like waste generation and sinkholes

Mining is an activity that needs to be very properly planned with possible impacts anticipated, identified and evaluated. It has mitigation measures planned because it is a short-term activity with long-term effects on the environment (Abdus-Saleque, 2008). Mining involves a lot of stages which usually begin from deposit prospecting and exploration stage, mine development and preparation stage, mine exploitation stage and treatment of the mineral itself with each of these stages involving specific environmental impacts (Gualnam, 2008). It is also noted that the preparation of access routes, topographic and geological mapping, geophysical work, hydro-geological research, deforestation of the land and elimination of vegetation affecting the habitats of hundreds of endemic species (Abdus-Saleque, 2008; Yeboah, 2008). Deterioration of land from blasting and use of heavy machinery, consequent erosion and silting of the land, reduction of water-table, contamination of the air, water and the land by chemicals such as cyanides, concentrated acids and alkaline compounds are also huge concerns caused by mining activities. Air pollution caused by dust, gases and toxic vapour can have diverse effect on the environment, health and social life of the local communities (Abdus-Saleque, 2008; Yeboah, 2008).

Mining requires a large amount of land cover to be removed to dig the quarries. In so doing, large scale loss of vegetation cover occurs which result in loss of biodiversity, especially indigenous vegetation species. Excavation results in the removal of fertile top soil (land degradation) and generations of extensive amount of spoil or overburden generally in the form of gravel, coarse sand, fragmented rock pieces, which deteriorate the aesthetic beauty of the proximate landscape (Bloodworth, 2009).

Mining involves the production of large quantities of waste, in some cases contributing significantly to a nation's total waste output. For example, a large proportion of the material flow inputs and outputs in the United States can be attributed to fossil fuels, coal, and metal mining (Matthews *et al*., 2000). Disposing of such large quantities of waste poses tremendous challenges for the mining industry and may significantly impact the physical environment. The impacts are often more pronounced for open-pit mines than for underground mines, which tend to produce less waste. Degradation of aquatic ecosystems and receiving water bodies, often involving substantial reductions in water quality can be among the most severe potential impacts of metals extraction (Ashton *et al*., 2001).

2.9.1.1 Case studies on physical impacts of mining

Discussed below are case studies of physical impacts of mining on the environment, resulting from waste generation, pollution (air, water, and land), land and vegetation clearance at a global, continental to national level.

- Global

In China, an emerging economy, the need for coal to provide energy has created environmental problems. Currently, coal mining and its resultant waste have become the leading cause of pollution in China (Haibin and Zhenling, 2010). Waste problems noted by Haibin and Zhenling (2010) include coal bed methane, coal slime, coal gangue, fly-ash and coal mine drainage. Bian *et al*. (2010) argue that coal mining creates physical environmental problems through land subsidence, mining waste disposal, damage to aquatic systems and air pollution. In Mongolia, it is stated that deterioration in water quality resulting from water pollution, mercury pollution, waste rock piles and tailings repositories as well as air pollution has been a major characteristic of mining induced impacts in communities where mining operations are undertaken (World Bank, 2006).

For decades, Helena in Montana area (USA) had dozens of mines producing gold, silver, and lead. The mine tailings left behind turned the creek orange as it ran to the Boulder River. In 1998 when officials from U.S. Geological Survey tested the water, using live fish tests, all the fish died within 72 hours. Other tests conducted by the state of Montana found high levels of arsenic, lead and zinc in the creek. Mining operations in the area had resulted in severe water pollution which cost the Montana's Mine Waste Cleanup Bureau nearly $2 million in funding to clean up the water (Buck and Gerald, 2001).

Macedo *et al*. (2003) studied environmental management in the Brazilian non-metallic small-scale mining sector. They reported that in spite of a lower degree of damage, the physical environmental impacts and waste from non-metallic mining firms are broader than those of conventional metal mines and fuel mining processes. Independent studies of mining activities in the Banská Stiavnica (Hodruša metal ore district and the Handlová Cígel' brown coal district) revealed that waste generated by mining operations ended up contaminating the local aquatic environment through the discharge of highly toxic mineral waste stored in tailings dams and damps, which ended up in groundwater and surface water (Klukanová and Rapant, 1999).

Luis *et al.* (2011) examined the physical environmental effects of an abandoned mine, the Lousal mine in Portugal. They discovered that the waste disposed in the tailings formed acid mine drainage, which ended up being the primary pollutant of water sources in the Lousal area. Similarly, Loredo *et al.* (2006) also studied the effects of toxic metals and metalloids on the environment in an uninhabited mercury mining area in Spain. They discovered that the waste resulting from mining operations accumulates and forms acids, which pose physical environmental threat to surface and groundwater systems. Crispin (2003) reported that small scale gold mining in Papua New Guinea faced waste problems as reported in other small scale and artisanal gold mines overseas. The environmental and waste challenges posed by these small scale mines included Mercury use and its subsequent discharge and general physical environmental damage.

- Africa

According to Akabzaa and Darimani (2001), extensive areas of land and vegetation in Tarkwa (Ghana) have been cleared to make way for surface mining activities. Currently, open pit mining concessions have taken over 70% of the total land area of Tarkwa. This has momentous adverse impact on the land and vegetation, the main sources of livelihood of the people.

In Ghana and many other tropical areas of mining, it was noted that mining is a major cause of deforestation and forest degradation, generating a large number of environmental impacts. Surface mining alone is on record to represent a serious threat to the last vestiges of Ghana's forest resources and threatens the rich biodiversity of the country's tropical rainforest (World Rainforest Movement, 2004). Major physical environmental problems have resulted in most mining communities in Ghana and are largely brought about by the mining boom which requires massive vegetation clearance and land excavation, waste disposal, mineral processing and misuse of mining chemicals. The above has resulted in the decline of safe drinking water for humans, and in air quality, loss of ecological biodiversity, decreasing forest cover as well as decreasing space for human waste disposal (Awudi, 2002).

Communities in which mining is done in Ghana normally have high illiteracy rates, unemployment and poverty. This causes the people of such communities to engage in small scale mining activities which are legal in Ghana. However, their activities are not monitored by the relevant agencies leading to severe environmental degradation and pollution. Some also engage in illegal mining activities called "galamsey". Due to poverty, they are unable to purchase modern equipment to carry out their mining activities, hence they engage in acts which results in environmental pollution and sometimes loss of lives (Kaapena, 2004).

A study by Darimari *et al.* (2005), in Tarkwa area of Ghana found that airborne particulates of major concern include respiratory dust, sulphur dioxide, nitrogen dioxide, carbon monoxide and black smoke. These particulate matters are produced from site clearance and roads constructions, open-pit drilling and blasting, loading and hauling, movement of vehicles, ore and waste rock handling and heap leach crushing by companies during heap leach processing.

Physical environmental problems directly linked to historical mining operations in the Copperbelt in Zambia are largely related to geotechnical integrity of waste dumps. There are at least 21 waste rock dumps covering more than 388 hectares, 9 slag dumps covering 279 hectares and finally more than 45 tailing dams covering an area of around 9 125 hectares (Environmental Council of Zambia 2008). In total, more than 10 000 hectares in the Copperbelt is covered with mineral waste and thus represent a “loss of opportunity” for the local population in terms of other land use such as agriculture, forestry, housing, ranching etc. (SGAB *et al,.* 2005).

In Zambia, the mining industry mostly the copper smelters, contribute to over 98% of the country’s sulphur dioxide (SO_2) emissions. In the early 2000s, the total SO_2 emission was 346 700 ton/year (Environmental Council of Zambia, 2008). Recent investments in mining activities are expected to yield increased SO_2 emissions because of several new copper smelters. High SO_2 concentrations will directly affect the health of both humans and biota. Oxides of sulphur (SO) can irritate respiratory passages and aggravate asthma, emphysema and bronchitis. Due to normal weather conditions such as wind speed and direction, areas northwest and west of the large Nkana and Mufulira smelters are severely affected by poor air quality. Most residential areas in both the city of Mufulira and Kitwe lie directly within the affected vicinity of the smelters and the inhabitants there are exposed to concentrations exceeding maximum daily average guidelines for SO_2 (SGAB *et al*., 2005).

- South Africa

Although mining contributes significantly to the South African economy, the adverse environmental impacts of these activities are heavily felt. Air and water pollution as a result of mining, acid mine drainage, toxic waste and abandoned mines continue to pose serious risks to South Africa's communities and its environment. Mine waste is still the largest source of pollution in South Africa and the country is one of the world's largest emitters of carbon dioxide (CO_2) in terms of population size. Furthermore, the impact of old coal fields poses threats on scarce water supplies as a result of contamination due to heavy metals seeping into water resources (Benchmark Foundation, 2012).

Historical problems of mining in South Africa include the estimated 6 000 abandoned mines. The abandoned Transvaal and Delagoa Bay Colliery outside Witbank has been identified as representing the greatest possible risk of any mine in the directors and office mines database. This is a large colliery which has partially collapsed, leaving large sinkholes in an area adjacent to an informal settlement. The remaining coal in the underground workings is burning, compounding the physical hazard posed by the mine as well as polluting the air. The workings are flooded and have started to decant, producing highly saline acid drainage with unacceptable levels of heavy metals. This water drains into the Brugspruit, a tributary of the Olifants River. Poor water quality resulting from this and other abandoned and operational coal mines has been linked to the death of fish and crocodiles in the Loskop Dam Nature reserve downstream (Munnik *et al*., 2010).

Concentration mines have caused detrimental atmospheric pollution. Mark (2014) showed that the Mpumalanga province has been declared as an air quality priority area. This province has amongst the worst air quality in the world, largely due to coal mining activities, uncontrollable underground fires and power-stations burning coal (Clarke, 1991). In a study by the International Network for Acid Prevention (INAP) (2007), it was found that mine water at the navigation coal mine near Witbank in Mpumalanga was very acidic and high in sulphur dioxide, calcium and magnesium. The acid water was treated by adding lime stone and to improve the sulphate removal through the addition of lime. They continued to state that the most common treatment for acidic and metal-bearing waters is the addition of neutralizing materials such as lime to reduce the acidity.

Water pollution from gold mining in the Witwatersrand basin is contaminating a large proportion of underground water. Old gold tailings dumps are reprocessed releasing mercury (Hg) to the environment and high mercury concentrations found in post gold mining operations are important contributors to the pollution of streams, draining the mining site and they are seriously affecting the nearby game reserve and Cradle of Humankind (Cukrowska *et al.*, 2012).

A study by Naicker *et al*. (2003) revealed that the groundwater in the mining district of Johannesburg, South Africa, is heavily contaminated and acidified as a result of oxidation of pyrite contained in the mine tailings dumps, and has elevated concentrations of heavy metals. Where the groundwater table is close to the surface, the upper 20cm of soil profiles are severely contaminated by heavy metals due to capillary rise and evaporation of the groundwater. The polluted groundwater is discharging into streams in the area and contributes up to 20% of the stream flow, causing an increase in the acidity of the stream water. The effect of the contaminated water from the mines can persist for more than 10 km beyond the source (Naicker *et al*., 2003). Evidence of radionuclide pollution was found in the Wonderfonteinspruit Catchment (Wade *et al.*, 2002; National Nuclear Regulator, 2007).

2.9.2 Social impacts of mining

Knowledge Whaton High School (KWHS) (2015) defines social impacts as the effect an organisation's actions have on the well-being of the community. Johnson (2013) on the other hand, defines social impacts as the effect of an activity or project on the social fabric of the community and well-being of the individuals and families.The social impacts of mining activities and projects have received increasing attention in recent years. It has been argued that mining can be a vital economic propellant for most countries, especially the developing ones, because it can facilitate industrialization along with the promises of wealth and jobs. On the contrary, it can also be a source of social discontent, civil unrest and other high social cost (Gualnam, 2008).

Social impacts of mining occur throughout the life cycle of mines, from the planning until the closure and decommissioning stage. Mining can generally bring social benefits to communities. If done responsibly, mining can be a catalyst for social growth in developing countries. For example, it creates jobs and better living standards by improved services such as education, healthcare, sanitation and business opportunities. The opening of mines has led to a rapid growth of the population in many areas as a result of the migration of labourers working in these mines, along with their families, and this has lowered the ability and capacity of the town's social services such as housing, to cope with the rising number of migrants (Gualnam, 2008; Akabzaa, 2009).

The displacement of settled communities is a significant cause of resentment and conflict associated with large-scale mineral development (IIED, 2002). Entire communities may be uprooted and forced to shift elsewhere, often into purpose-built settlements not necessarily of their own choosing. Besides losing their homes, communities may also lose their land, and thus their livelihoods. According to Awudi (2002), the degradation of large tracks of land by the large-scale surface mines constitutes a major threat to agriculture in the communities and their economic survival. Akabzaa (2009) also noted this trend and stated that mining companies are annexing vast lands in their operational areas and depriving communities of their chief source of livelihood. Community institutions and power relations may also be disrupted. Displaced communities are often settled in areas without adequate resources or are left near the mine, where they may bear the brunt of pollution and contamination. Forced resettlement can be particularly disastrous for indigenous communities who have strong cultural and spiritual ties to the lands of their ancestors and who may find it difficult to survive when these are broken (IIED, 2002). At the extreme, mining has led to growing conflicts among most communities displaced by mining operations and has even increased the presence of social vices such as prostitution, drug and alcohol abuse, gambling, incest, inadequate housing, youth unemployment, family disorganisation and school dropout rates (Akabzaa and Darimani, 2001; World Rainforest Movement, 2004; Gualnam, 2008).

Health impacts occur during every phase of mining (Terblanche, 2002). Deep mines produce severe harms for employees in terms of their risks of high blood pressure, heat exhaustion, myocardial infarction and nervous system disorders (Stephens and Ahern, 2001). The exposure of large numbers of workers to hazardous working and living conditions are characterised by high dust levels, extreme heat, ergonomic risks, safety hazards and crowded single-sex hostels or squatter camps, result in a plethora of mining-related diseases (Murray *et al*., 2011). Respiratory impacts are the most studied and problematic of health impacts for mine workers. Long-term effects include cancers, mental health impacts and some proof of impacts on genetic integrity of workers.

The mining, metal extraction and beneficiation phases are accompanied by air and water pollution, the generation of solid waste deposited on tailings dams and waste rock stockpiles, the abstraction of vast quantities of water and the use of huge quantities of energy (Norgate and Haque, 2012; Glaister and Mudd, 2010), all with direct or indirect health consequences around surrounding communities.

2.9.2.1 Case studies on social impacts of mining

Discussed below are case studies of how mining activities have affected the social aspect starting from a global scale to a national scale.

- Global

Most of the Philippines' mineral resources are located within the ancestral domain of its indigenous people. By law, it is required that indigenous peoples give their Free Prior Informed Consent (FPIC) before any projects proceed within their territories (Indigenous Peoples Rights Act, 1997). There were several incidents where companies violated the legal guidelines and 'engineered' the required consent. Leaving local communities being violated of their social rights and causing conflicts. Furthermore, the fact-finding team witnessed at first hand the havoc mining is wreaking on the livelihoods, health and human rights of indigenous peoples and other local communities. They also saw the potential for massive environmental damage to critical water catchment areas, thousands of hectares of agricultural land and the valuable marine environment (Fact-finding trip, 2006).

Mining activities in the Rio Tinto (Spain) has resulted in water pollution along the eastern part of the Iberian Pyrite Belt (IPB), an area with a huge amount of massive sulphide deposits that has been mined for the last 4500 years. This river presents extreme conditions, with very high concentrations in solution of metals and metalloids and low pH values. Mining activities in the upper part of the watershed of the Río Tinto have been documented since historical times and a huge amount of widespread acid-producing mine residues exist in this area. People in the area relied on the water for domestic uses and their livelihood but can no longer use it as it is highly contaminated and if consumed, it can cause waterborne diseases (Olias and Nieto, 2015).

In Solomon Islands, mining activities have had some social impacts on the surrounding communities. According to Greenpeace (2016), many serious social impacts resulting from logging have been documented over the last decade. These include: destruction of water sources and desecration of sacred and burial sites, child sexual abuse and prostitution, increased disputes and conflict within a community, the breakdown of social structures and hardship resulting from the loss and damage to forest resources that local people rely on for their everyday living.

- Africa

Fluorite mining in Kenya (Rift and Kerio Valley) has resulted in community members being forced to relocate without an offer for fair compensation or the means to rebuild their livelihoods elsewhere. Some people's houses were demolished while others were forcefully evicted or engulfed by mining operations, leaving them no choice but to leave. People were also not allowed to rebuild or make significant renovations to their homesteads located within the lease area. Erecting a fence around the homestead or making improvements to the traditional mud thatches by introducing iron sheets could result in warning letters being issued. The mining company in the area continued to disturb people and disrupted their livelihoods and in the process community members have suffered dire social inconveniences and losses as well as mental anguish and trauma due to those haphazard mining plans (IANRA, 2016).

Rodang's mining activities in Angola affected the Tyihule community in a number of ways, the most important of which is closing transhumant paths and occupying some farming land used by the community. The restriction in the community's movement, a long-standing tradition of transhumant practices, occurred when mining operations began in 2008. In addition to the mine occupying land that the local community was using, it also destroyed two additional communal agricultural plots located outside the perimeter of the mine by dumping stones produced from mining activities. Fruit trees on some of the hills were destroyed when mining operations began, removing an important source of nutrition for an already food insecure population. The Tyihule community, which had never been displaced from land prior to the opening of the Rodang mine, received no compensation for the loss of their land. The community's access to water sources was restricted by the mining operation. The excavation of the area was drastically altering the local topography, eliminating the small hills around the communities which served a number of important purposes (IANRA, 2016).

Mimosa mining company in Zimbabwe has contributed to equipping Mhondongori Clinic, drilling a borehole to improve local water supply and building a clinic and housing for nearly all its employees. On the other hand, the mining has had some negative social imprints on the local community as well. Prevailing wind from mining activities generally blows dust from the slime dam towards several villages and villagers have reported that the air was pungent from mine operations. The dust has caused some trees to turn black or white, and to dry and die. Communities also complained of noise from heavy trucks and machinery from the mine. Littering by contractors and small-scale miners is another problem. The regulations to ensure refuse was properly disposed of at designated points are poorly enforced which leads to litter being widely scattered. As the mine area is not completely fenced off, livestock then feed on the litter which includes disused overalls, paper, bottles, aluminium cans and plastic. There was also tensions concerning some land-use boundaries between Mimosa and the local community. When Mimosa fenced off its mining area it cut off the community's traditional walking paths to shops and grazing areas (IANRA, 2016).

Mining activities in Katanga, Democratic Republic of Congo (DRC) have had social impacts on local community members. Local people have mentioned that their drinking water was no longer safe for consumption because toxic waste from the mine is poured into the company's retention ponds, which overflowed and ran into the Ruashi stream and on to the Luano River, which is a vital source of water for local villages. The water changed colour into a yellowish mud. Before mining began, two pumps supplied drinking water to the three districts. The mining company replaced two pumps, built a water tower, and drilled two wells but the latter had lower water capacity, thus reducing water availability. One of these pumps now supplied water that was untreated and muddy, clearly unfit for consumption. Of over 250 people interviewed near the mining area, 85% said their soil had been harmed by mining, notably by polluted water leaking into their vegetable gardens. Around 40% of people in the three districts earn their living by producing fruit and vegetables and selling these in and around the markets of Lubumbashi. Soil infertility is causing food production to decline and further impoverishing families (IANRA, 2016).

Several families in DRC were relocated by the mine when mining activities began. According to interviews with those affected, the company imposed the terms of compensation without negotiation, and many people were not given any compensation at all. Some people, however, did receive compensation but at very low rates. For example, some farmers working their land in the mine area simply received a lump sum of US$100, even though their future livelihood was being taken away. Compensation was awarded according to plot and house sizes, but for many people compensation was not provided for water wells and fruit trees on their land. People in Luano, Kawama, and Kalukuluku are also worried that Ruashi Mining releases toxic smoke into the air for two hours each morning and evening when the chimney from its processing plant is active. People complain of problems with their sight and respiratory systems, such as chronic coughs. Virtually all those interviewed said the quality of the air they are breathing is very poor. Further, air pollution is caused by the huge amount of dust coming from the open pits and landfills and from massive deforestation (IANRA, 2016).

Maeda-Machang'u *et al*. (1999), found that in Tanzania, uncontrolled digging and abandoning of pits has caused destruction of land beyond economic and technical reclamation. Mine pits not only make land unfavourable for agricultural activities following closure but also adversely impact livestock and wildlife resources, which, in turn, affects locals, who depend on energy from animal manure. Darimari *et al.* (2005) noted that the discharge of airborne particulate matter into the environment, principally minute dust particles of less than 10micronmeters posed a threat to the health of the Tarkwa area, Ghana. This is because of the high level of exposure to dust and silica content that cause respiratory diseases and other dust related disorders.

- South Africa

It was mining that gave South Africa its current shape through processes from the 1880s to 1910. Gold mining took center stage early, both because of its importance for the British and thus global monetary system and the profits to be made. Cheap black labour, achieved via the migrant labour system (in which mineworkers left their families behind and lived in all male, strictly controlled compounds), required political control. Early conflict between gold companies and Paul Kruger's Transvaal Republic about access to water, railroad transport and dynamite concessions, led to the Anglo Boer War and the consolidation of four independent provinces into a single South African state in 1910 (Munnik, 2010).

South African gold mines are among the deepest in the world, with a depth of up to 3.9 km (SPG Media Group, 2013). Underground working conditions are arduous if not brutal. Rock face temperatures are up to 55ºC, humidity levels are high and poor control of exposure to dust, coupled with poor health surveillance systems, give rise to a high incidence of dust related diseases (Cairncross *et al.,* 2013). The mining sector has been affected by the worldwide epidemic of HIV/AIDS, and this is apparent in the studies of South African mines.

According to Flynn (1998), approximately 69 000 miners died in accidents in South Africa in the first 93 years of this century and more than a million were seriously injured. In 1993, out of every 100 000 gold miners, 113 died in accidents, 2 000 suffered a reportable injury, 1 100 developed active tuberculosis and of these 25 died. In 1990 about 500 miners were identified as having silicosis. Several studies (Jochelson *et al.,* 1991; Campbell, 2000) have focused on the condition of the gold mines of South Africa. Migrant labour plays a vital role in the mining sector of South Africa, some of these HIV positive migrants were believed to have played an important role in the transmission of HIV/AIDS.

Rustenburg's history has been closely linked with platinum. Social problems associated with PGM mining in Rustenburg include demographic effects of the migrant labour system. According to Census (2011b), Rustenburg's population grew by 3.5% from about 387 000 inhabitants in 2010 to 550 000 in 2011 and the growth is directly affected by the mining activity. Other social problems in this area caused by platinum mining activities included high rate of HIV, high crime level and lack of access to formal education (Eunomix, 2014). Only 31% of Rustenburg's population aged 20 and over have completed high school and only 8.9% of that same age group has some form of higher education. Five point four percent (5.4%) of those aged 20 and older have received no form of schooling. On-the-ground research revealed overcrowded schools and a lack of basic schooling infrastructure (NWDE, 2013).

The labour strike in South Africa's platinum sector that started on 2012-2014 became the country's largest and most expensive in history. The dispute regarding wages and conditions of service between the Association of Mineworkers and Construction Union (AMCU) (Bohlman *et al.,* 2014). The Marikana incident which took place in Rustenburg is one of the most tragic mine strikes to take place in South Africa. On August 16 2012, 34 people, mostly employed by Lonmin platinum mines, were killed after police opened fire on striking miners. The strike, which had begun on August 9 over a wage dispute, was marred by intimidation and violence. Ten people, including two policemen and two security guards were killed (Tosli, 2012).

The displacement of settled communities can be a significant cause of resentment and conflict associated with large-scale mineral development. In South Africa the situation of resettlement of local communities near mining was observed in Limpopo province, Anglo platinum (Mogalakwena mine). In the 1990s several hundred families were resettled and two additional villages were also resettled the same year as the mine continued to expand (Farell *et al.*, 2012).

Although mining has had some negative social impacts, mining can also contribute significantly to the social upliftment of many communities in the world. Benchmark Foundation, 2012), stated that sometimes mining companies consult with local government in drafting of social and labour plans. For example the Royal Bafokeng Nation in South Africa is one of communities that used the royalties from the Impala Platinum mine of approximately R180 million a year of which R2 billion has been spent on infrastructure development over a period of 10 years. Fifty (50) public schools, 10 clinics, two bulk water treatment plants have been built. Among these are infrastructures such as roads, electricity, sewage systems and water provision (Mantshantsha, 2007).

2.9.3 Economic impacts of mining

Cambridge dictionary (2017) defines economic impact as a financial effect that something, especially something new, has on a situation or person. Economic impact is the effect that an event, policy change, or market trend will have on economic factors such as interest rates, consumer confidence, stock market activity, or unemployment.

Mining has the potential to shape and affect economies directly and indirectly. Mining brings employment, government revenues, and opportunities for economic growth and diversification (Miningfacts, 2015). The impact of mining goes beyond mineral extraction and processing. Mining is linked to many other industries and sectors in the economy including transportation, construction, equipment, manufacturing, environmental management, geological services, education and research, among others (OMA, 2012).

Mining plays a vital role in the economic development of many countries. Historically this has been the case in many parts of the developed world, while mineral development is an important factor for economic growth. The economic impact of mining needs to be assessed within the perspective of the industry's tendencies. For example, emerging economies are a major player in the production and availability of key commodities, such as copper (70%) and bauxite (40%) and with iron ore, precious metals, lead and others within this range. The continuous declining trend of real metals price during the past 35 years represents a difficult challenge for mining companies to reduce production costs through technical and financial management (Wasler, 2014).

Important economic impact of mining can be measured in terms of employment and income generation. Commercial-scale mining provides employment and skills transfer to more than 2 million workers with an employment multiplier effect by a factor from 2 to 5. While mostly a poverty-driven activity, small-scale mining provides income to about 13 million workers and their families worldwide, in countries such as Bolivia, Brazil, Colombia, Venezuela, Burkina Faso, Ghana, Madagascar, Mozambique, Tanzania and Indonesia, among many others (Walser, 2014).

Taking into consideration the present trends affecting the mining industry, it is increasingly important to assess the economic and social impacts of mining at the community level. Recently, the World Bank Mining Department has been carrying out an in depth study in Chile, Peru and Bolivia, as well as other studies of mines in Papua New Guinea and Mali, to assess such impacts. The studies demonstrate clearly that there are substantial economic benefits to local communities, but they do not come automatically and their sustainability is a key issue (Walser, 2014).

2.9.3.1 Case studies on economic impacts of mining

This section looks at how mining has affected the economy of different countries on at international, national and local level.

- Global

According to Ontario Mining Association (OMA) (2012), mining is a key contributor to the Ontario economy, as well as an engine for regional development and value-add generation. Though the number fluctuates with various commodity price changes, mining in Ontario Canada produces revenues of around $10 billion per year. Over 256 000 people are employed in Ontario's mineral cluster. The industry provides a major boost in the financial sector where the Toronto Stock Exchange (TSX) is the leading global mining exchange, listing more of the world's public mining companies and raising more mining equity capital than any other exchange.

U.S. mining directly and indirectly generated nearly $1.7 million full-time and part-time jobs in 2015, including employees and the self-employed (NMA, 2016). The coal sector of the U.S. mining accounted for a total of 535 372 jobs, $37.2 billion in total labor income and $65.6 billion in total contribution to GDP. Annual wages and salaries in coal mining operations excluding support activities and transportation, averaged approximately $83 600 in 2015. Overall, the total jobs attributed to coal mining were responsible for approximately 32% of U.S. mining's total employment contribution, 36% of total labor income and 30% of mining's total contribution to GDP (BLS, 2015).

According to the Canadian Mineral Yearbook (2009), mining remains an important source of employment in Canada. In 2010, one out of every 50 Canadian workers were directly employed in mining, resulting in 308 000 jobs. This sector accounted for 2.1% of Canada's total employment yet contributed 2.7% of Canada's total GDP. It also reported that 3 223 companies supply goods and services to mining companies such as accounting, environmental consulting, legal and technical advice, and finance as part of indirect employment.

Mined minerals represent a large share of exports in many countries. According to the Australian Bureau of Statistics (2014), the minerals industry is Australia's largest export earner with mineral exports accounting for 50% to 60% of the annual value of total exports of goods and services. They continued to state that the value of Australian mineral exports (excluding oil and gas) increased from $45.9 billion in 2002-03 to $145.6 billion in 2012-2013, dominated by iron ore, coal, gold, copper, alumina/aluminium, and nickel.

Mining is a growing force in Alaska's economy, providing jobs for thousands of Alaskans and millions of dollars of personal income throughout Alaska. Alaska's mines produce coal, gold, lead, silver, zinc, as well as construction materials, such as sand, gravel, and rock. In 2016, Alaska's mining industry provided: 4 350 direct 8 600 total direct and indirect jobs $675 million in total direct and indirect payroll and $111 million in payments to Alaska Native corporations (AMA, 2016).

- Africa

For more than a decade, Africa has enjoyed a mineral boom. This has fueled exports, government finances and hope for a sustainable growth trajectory. During 2001-2012 extractive industries (including oil) comprised three-quarters of exports with metals and minerals alone accounting for 60% (Africa's Pulse, 2013). Although there has been a recent slowdown in exploration due to the weakness in the global economy, natural resource extraction is expected to contribute significant shares of exports and public finance in all but five of the region's countries in the years ahead (Devarajan and Fengler, 2013).

The mining industry remains the backbone of many economies in the developing world. Its resurgence in Ghana since 1989 was driven by the global paradigm which emphasizes private sector-led development as the engine of economic growth in developing countries. The historical importance of mining in the economic development of Ghana is evident in the country's colonial name, Gold Coast (Akabzaa and Darimani, 2001). Ghana earned $2.5 billion from mineral exports in 2007. Twenty thousand (20 000) people are employed in large-scale mining whilst 500 000 are employed in the small-scale sector. Mining contributes about 7% of Ghana's total corporate tax earnings, 41% of total exports, 12% of revenue collected by the Internal Revenue Service and 5% of Gross Domestic Product (Ghana Chamber of Mines, 2008).

The mining sub-sector accounts for a significant share of the Gross Domestic Product (GDP) in most countries of Sub-Saharan Africa, including those of southern Africa. According to the SADC Mining Annual Report (1998), the share of the mining industry in GDP in SADC countries is about 10%. At individual country level, the contribution of mining to the GDP of countries such as Botswana, South Africa and Zambia is very substantial. In Botswana, it accounts for about 40% of the GDP and about 80% of foreign exchange earnings. In 1996, the mineral revenue to the Botswana government (royalties, dividends, lease rental and sundries) was 49% above the 1995 receipt. In Zambia, it accounted for 13% of GDP and 90% of the total export earnings in 1997 (SADC, 1998).

Gambos municipality (Angola) is rich in iron ore and granite and the main mining company in the area is Rodang Rochas Orcamentais LDA, an Angolan mining company reportedly established in 2008 with a $3.5 million investment. Rodang mines thousands of cubic metres of marron (black) granite in the area and exports to the United States, Europe and China. It has around 70 employees who are employed from the local communities (IANRA, 2016).

Research by the Zimbabwe Environmental Law Association found that the local community believes mining has contributed to some economic benefits in the area. The Mimosa mine has allocated some funds to support local community development and has contributed $10 million to the Zvishavane Community Share Ownership Trust which funds projects in the district and in the 12 villages near the mine. At Mukwidzi Secondary School in one village, for example, the company has built two classroom blocks and equipped them with furniture, helped construct a community block by providing roofing and furniture, drilled a borehole and renovated a windmill and tank to supply water to the school and teachers' houses. The Mimosa mine has also employed around 1 550 staff and contractors in 2014. Although it has created some jobs for local people, community leaders say these are disappointingly low, at only around 5% of the mine's workforce. The community is also concerned about an unclear quota system used to employ local people and what it perceives as the company's failure to deliver on its promises to employ more locals. Mimosa sub-contracts the hiring of employees to contractors who then take on construction workers. Most of these jobs are for casual labourers. Community members are concerned that labour laws are sometimes violated since there are cases of employees working for months without being paid (IANRA, 2016).

- South Africa

South Africa has been built on the back of mining. For nearly 150 years, mining has been the driving force behind its economy. The industry has shaped, and continues to shape, the country's socio-political and cultural development as well (KPMG, 2017). According to the Chamber of Mines, South Africa's total mineral reserves are estimated at $2.5 trillion, with the mining sector contributing 18% of GDP and over 50% in foreign exchange earnings. The sector brings in an annual income exceeding R330 billion and accounts for 20% of all investment in the country. Mining also contributes significantly to the State Treasury around R17 billion in corporate tax and R6 billion in royalties. Having helped found the Johannesburg Stock Exchange (JSE), today mining houses still provide around 30% of its market capitalisation (KPMG, 2017). The Mining Intelligence Database points out that, currently, the mining and related industries not only employs over one million people, spending R78 billion in wages and salaries, but is the largest contributor by value to Black Economic Empowerment (BEE) (KPMG, 2017). Importantly, mining provides job opportunities for unskilled and semi-skilled people. The mining industry also exerts a strong influence on the currency of the Republic. The South African Rand was introduced in 1961, prior to the country becoming a Republic and replaced the British Pound. To this day, the rand continues to be inextricably linked to mining. Minerals and metals contribute such a hefty portion of South Africa's export revenue and its foreign exchange value is highly sensitive to the price of minerals and production, fluctuating up and down as the price of gold and other commodities rises and drops or when labour unrest on the mines threatens production (KPMG, 2017).

Although mining activities have resulted in job creation for many it is not always the case in all mining areas. In 2011, unemployment in Rustenburg (platinum mining area) stood at 26.4% (amounting to roughly 70 000 people), while youth unemployment was at 35% (Census, 2011b). Furthermore, 30% of the economically active population earns no income and 24% of households live on less than R600 per month. The poverty level is at almost 62% of the population, which is higher than the national poverty rate (Eunomix, 2014).

2.10 Environmental compliance from mining operations

Environmental Compliance means conforming to environmental laws, regulations, standards and other requirements such as site permits to operate. In recent years, environmental concerns have led to a significant increase in the number and scope of compliance imperatives across all global regulatory environments. As they are closely related, environmental concerns and compliance activities are increasingly being aligned with corporate performance goals and being integrated to some extent in order to avoid conflicts, wasteful overlaps and gaps. In order to comply with the above requirements and obligations, certain conditions within them must be met. Typically, these will include: managing monitoring programmes or schedules, ensuring that the monitoring required in the permit has been done, at the correct locations, for the correct parameters, and at the correct frequency. It also includes pre-processing, performing calculations and validating the data for compliance with any alert or reporting levels as well as generating routine compliance reports for authorities (Wikipedia, 2017).

Existing guidance (DETR, 1997; Mitchell-Jones *et al.*, 1999) stresses the importance and relevance of adopting a hierarchical approach in planning mitigation and compensation measures. Priority should be given to the avoidance of impacts at source, whether through the re-design of a project or by regulating the timing or location of activity (UNEP, 2005). Mining companies need careful planning based on comprehensive and integrated approach to identifying, avoiding and minimising environmental impacts. The best practices are also controlled by the type of resources mined and the area. This then means that the best practices for one mine may not be the best for another mine. Today more companies are making it a priority to manage environmental impacts of mining using the best practices to avoid, minimize, mitigate and compensate for environmental impacts from mining (Epstein *et al.*, 2014). It is important for platinum mining companies to have the best practices, measures and standards to manage the environmental and social impacts in a continuing process from the exploration to the construction, operation and closure of the mine.

Mining has always been synonymous with waste production (Mineral Policy Institute, 2012). At a community and local level, mining operations constitute an environmental and ecological problem (Evangelinos and Oku, 2006; Garvin *et al*., 2009; Mutti *et al*., 2011). According to Nyirenda (2014), to curtail the waste management problems faced by these mining operations, there is a need for mining operations to adopt waste management practices into their corporate agenda. Currently, waste management practices by South African mining operations are borne out of the need to comply with regulations. Mining operations are now steadily adopting voluntary waste management practices but little evidence in the form of scientific study exists to show the extent of this voluntary adoption. Most mining studies that have been done in South Africa focuses more on environmental impacts and how they affect the surrounding communities while there hasn’t been much documented on compliance from the mining operations.

2.10.1 Mandatory legislation of mining activities in South Africa

South Africa has, and still is, relying heavily on mining activities to generate wealth that could be translated into economic development, infrastructure and employment. Formal mining in South Africa is more than 100 years old (Swart, 2003). Mining does, in general, have a substantial impact on the environment, and has left South Africa with an enormous economic, social and environmental legacy. According to Swart (2003), prior to the enactment of the Minerals Act, 1991 (Act 50 of 1991), mining companies used irresponsible mining methods with no regard for protecting the environment and often shirked their responsibility towards environmental rehabilitation by leaving an area unrehabiltated prior to them being liquidated or leaving the country.

There are currently many policies, legislative and strategic frameworks governing waste management in South Africa (Enviropaedia, 2012). According to Enviropaedia (2012), South Africa has numerous Acts that affect waste management and related issues. Some of these Acts include: the Hazardous Substances Act (5 of 1973), the Occupational Health and Safety Act (85 of 1993), the Constitution of the Republic of South Africa (1996), the Municipal Structures Act (117 of 1998), the National Environmental Management Act (107 of 1998), the National Water Act (36 of 1998), the Municipal Systems Act (Act 32 of 2000), the Mineral and Petroleum Resources Development Act (28 of 2002), the Health Act (63 of 2003), the National Environmental Management: Air Quality Act (NEMAQA) (39 of 2004) and the National Environmental Management: Waste Act, 2008 (59 of 2008). For the purpose of this study, the Constitution of the Republic of South Africa (1996), the National Environmental Management Act (NEMA) (107 of 1998) and the Mineral and Petroleum Resources Development Act (28 of 2002) were the main focus as they are the underlying legislations for mining in South Africa.

2.10.1.1 The Constitution of the Republic of South Africa (1996)

Mines have to comply with South African constitutional law by conducting their operational and closure activities with due diligence and care for the rights of others (Swart, 2003). Section 24(a) of the Constitution states that everyone has the right to an environment that is not harmful to his or her health and well-being. This supersedes all other legislations. Section 24(b) states that the government must also use reasonable legislative and other measures to protect the environment. This section further covers matters such as prevention of pollution and ecological degradation as well as ensures sustainable development and use of natural resources while promoting economic and social development (Constitution of the Republic of South Africa, 1996). According to Swart (2003), this is the reason why a person suffering harm as a result of mining activities may still claim damages from a mine and or its directors and even the shareholders in terms of company law, once the mine has closed. A claim could be based on any of the following causes of action: nuisance (infringement of the right of a neighbouring owner’s use and enjoyment of property), property rights (subsidence), aquilian action (damage to person or property) and administrative law (review of an administration decision or act by an official or organ of State).

2.10.1.2 The National Environmental Management Act (NEMA) (107 of 1998)

The National Environmental Management Act (NEMA) provides the framework and principles for sustainable development and sets national norms and standards for integrated environmental management. Section 24 states that all spheres of Government and all organs of State must cooperate, consult and support one another. Section 28 of the act also imposes a duty of care and remediation of environmental damage on any person who causes, has caused or may cause significant pollution or degradation of the environment. Furthermore, sections 32 and 33 of the act provide for legal standing to enforce environmental laws and private prosecution respectively (NEMA, 1998). The National Environmental Management Act (NEMA) (Act 107 of 1998) is enforced by the Department of Environmental Affairs and Tourism (DEAT), and requires Environmental Impact Assessments (EIAs) and Environmental Management Programmes (EMPs) for activities that affect the environment (Munnik *et al*., 2010).

NEMA (107 of 1998) acts as an umbrella for other environmental acts such as the National Environmental Management: Air Quality Act (NEMAQA) (39 of 2004) and the National Environmental Management: Waste Act (NEMWA) (59 of 2008). The objective of NEMAQA (39 of 2004) is to ensure that the environment is protected by providing rational measures for the deterrence of air pollution and environmental degradation, the protection and enhancement of air quality in South Africa and fortifying environmentally sustainable development while fostering economic and social development (NEMAQA, 2004). The NEMWA (59 of 2008) is primarily responsible for governing the management of waste and other waste related aspects. In quoting from the Act, its objectives include to protect health, well-being and the environment by providing reasonable measures for minimizing the consumption of natural resources. The law also helps by avoiding and minimizing the generation of waste; reducing, reusing, recycling and recovering waste; treating and safely disposing of waste as a last resort. This Act aims in preventing pollution and ecological degradation; securing ecologically sustainable development while promoting justifiable economic and social development. Furthermore, the law helps in promoting and ensuring the effective delivery of waste services remediating where contamination presents, or may present, a significant risk of harm to health or the environment. The Act helps in achieving integrated waste management reporting, planning as well as ensure that people are aware of the impact of waste on their health, well-being and the environment.

2.10.1.3 The Mineral and Petroleum Resources Development Act (MPRDA) (28 of 2002)

The Mineral and Petroleum Resources Development Act is a milestone in the transformation of the mining industry in all aspects, it provides a holistic cradle-to-grave approach to prospecting and mining by fully considering economic, social and environmental costs to achieve sustainable development of South African mineral resources (Swart, 2003). This Act seeks to ensure that the nation's mineral and petroleum resources are developed in a sustainable manner while promoting justifiable social and economic development and ensuring that holders of mining and production rights contribute to the socio-economic development of the areas in which they operate (MPRDA, 2002). In this Act, the State affirms its obligation to: protect the environment for the benefit of present and future generations, ensure ecologically sustainable development of mineral and petroleum resources and to promote economic and social development. Section 37 of the MPRDA (49 of 2008), confirms the adoption of the principles for sustainable development as set out in section 2 of NEMA (107 of 1998) as well as other generally accepted principles of sustainable development, by integrating social, economic and environmental factors into the planning, implementation, closure and post-closure management of prospecting and mining operations. Section 38 provides for the application of integrated environmental management and the responsibility to remedy. Section 38(2) makes provision to keep directors of companies or members of closed corporations liable for any damage, degradation or pollution caused by the company or closed corporation which they represent or represented (MPRDA, 2008).

Section 39 of the MPRDA provides for an Environmental Impact Assessment (EIA) and Environmental Management Programme/Plan (EMP) to be undertaken by the applicant to identify, mitigate and manage the environmental impacts emanating from prospecting or mining activities. Section 41 makes financial provision for the remediation of environmental damage while section 42 makes provision for the management of residue stockpiles and deposits. Regulations in this regard also adopt the principles of waste management in the Integrated Pollution Control and Waste Management Policy as well as the precautionary approach followed in terms of the National Water Act (1998). The regulations also prescribe waste management throughout the life-cycle of a mine including decommissioning, closure and post-closure management of deposits. Section 43 provides for the issuing of a closure certificate by the Minister of Minerals and Energy and the transfer of environmental liabilities to a competent person (MPRDA, 2002).

Furthermore, the laws help in the sustainable development of natural resources while protecting the environmental and social regimes. The laws also help in ensuring that mine operators acquire license for waste management in their operation. Therefore, for a mine to be considered as compliant in the South African context, it must cover all the basics mentioned in the above laws as the cover for the prerequisite practices expected from mining operations.

2.10.2 Environmental compliance provisions emanating from South African laws and legislation.

Although mining operations can choose which voluntary waste management practices they want to use in their corporate agenda, these should be implemented in a way that they do not contradict the mandatory practices as per the South African government. Discussed below are environmental compliance provisions for waste management at mines as per the mandatory regulations in South Africa.

2.10.2.1 Environmental Impact Assessment (EIA)

Simply defined, the EIA process helps identify the possible environmental effects of a proposed activity and how those impacts can be mitigated (Doberstein, 2004).The EIA process is an interdisciplinary and multi-step procedure to ensure that environmental considerations are included in decisions regarding projects that may impact the environment (Glasson *et al.*, 2005). The purpose of the EIA process is to inform decision-makers and the public of the environmental consequences of implementing a proposed project. The EIA document itself is a technical tool that identifies, predicts, and analyzes impacts on the physical environment, as well as social, cultural, and health impacts (Demidova and Cherp, 2005).

According to Environpaedia (2007), EIAs are a key tool in effective environmental management. Section 24 of the Constitution of the Republic of South Africa 1996, calls on the State to secure everyone the right to an environment that is not harmful to health or well-being. An important component of ensuring a healthy environment is an understanding of the impact of human activities on the environment and the health and well-being of those who live in and depend on that environment. EIAs are a system of analysing and reporting on the impact of certain types of activities to enable decision makers to decide what sort of activities should and shouldn't take place and to determine what measures should be taken to mitigate and manage the impacts of the activity. Chapter 5 of NEMA (1998) provides for integrated environmental management and promotes the application of appropriate environmental management tools in order to ensure the integrated environmental management of activities. EIAs are conducted to analyse and predict the nature and extent of the consequences of a particular activity or development on the receiving environment.

As a tool, EIAs are intended to facilitate informed and environmentally sound decision making. To be an effective tool in decision-making and environmental management, EIAs must predict and evaluate the impact on not only the environment, but also socio-economic conditions and cultural heritage (Environpaedia, 2007). The EIA must fully assess alternatives and possible mitigation measures. Glazewski (2012) argues that the ultimate success of an environmental assessment depends on three fundamental mechanisms being satisfactorily carried out: public participation, inter-sectoral coordination and the consideration of alternatives to specific development proposals.

2.10.2.2 Environmental Management Plan (EMP)

The Environmental Management Plan is a significant component of the EIA, showing the specific plan highlighting the environmental objectives and targets, explaining the means and time frame of meeting the objectives and targets of the environmental. It shows how mitigatory measures are to be taken. It therefore helps the organisation maximize compliance and reduce environmental harm. Once the EMP has been completed, it is easily incorporated into the organisation's Environmental Management System (EMS) (Chapuka, 2011).

In Zimbabwe, the EMP is prepared in terms of section 96 of the Environmental Management Act, Chapter 20, subsection 2 and contains the following: a description of the functions exercised by the specified authority in respect of the environment and a description of the environmental standards set or applied. An EMP should include a description of the policies, plans and programs that are designed to give effect to the plan as well as the degree of compliance required of other persons. It should also contain arrangements for cooperation with other persons on environmental management. EMPs should give a description of the manner in which the specified authority will ensure that its functions are exercised in a way that will facilitate compliance with this act and other relevant enactments and environmental standards so as to achieve the optimum management and protection of the environment (Chapuka, 2011).

In South Africa, the EMP needs to be in accordance with the MPRDA's environmental management principles in that any mining operation needs to be conducted within the principles of sustainable development and all environmental impacts need to be managed in accordance with the approved plan. An EIA must be conducted and this forms part of the approved plan. The EMP must establish baseline information concerning the affected environment to determine protection, remedial measures and EM objectives. It should investigate, assess and evaluate the impact of the mining operation on the environment as well as the socio-economic conditions of any person or community who may be directly affected by the operation. Lastly, it should develop an environmental awareness plan which outlines the manner in which the applicant will inform employees of any environmental risks which may result from their work and the manner in which the risks must be dealt with in order to prevent degradation of the environment and describe the manner in which to control any process which may cause environmental degradation. As an environmental measure, the EMP aims to ensure the minimal impact on the environment and the socio-economic well-being of the community in which the mining operation takes place (Morris and Baartjes, 2010).

2.10.2.3 Environmental Management System (EMS)

Barrow (1999) described an EMS as a component of the overall management system that includes organisational procedures and environmental responsibilities. It is a process that helps an industry to comply with environmental regulations, identify benefits and ensure that environmental policies are adopted and followed. Tinsley and Pillai (2006) described an EMS as a useful tool that ensures that environmental improvement is met. Others referred to it as a problem identification and problem solving tool, based on the concept of continual improvement that can be implemented in an organisation in many different ways, depending on the sector of activity and the needs perceived by management (UNEP, 2005).

EMS auditing aids the monitoring of the effectiveness of the systems to ensure continual improvement, which is an underlying principle in EMS implementation (Varnas *et al.*, 2009). Verifying whether objectives and targets are being met is done through audits. As argued by Bronson and Noble (2006), a well-crafted EMS or one that meets ISO 14001 specifications (i.e. one with well specified environmental programs and enough documentation on objectives and targets) does not necessarily guarantee environmental performance. It is important to frequently monitor whether the specifications are being met. According to Wilkie (2005), there are various benefits of implementing an EMS including: showing an organisation's commitment to quality and the environment, reducing costs, helping in meeting legislative requirements, meeting customer needs and enhances customer satisfaction. It also improves environmental performance, reduces mistakes, defects and accidents, raises awareness of environmental issues; improves team work and staff morale, enhances employee involvement and provides a competitive advantage.

An EMS can be used as an environmental aspect and identification tool and for turning environmental impacts identified in the EIA into practice (Varnas *et al.*, 2009). When applied to the mining industry it can mean that environmental impacts that would have been identified during the preliminary stages (EIA) can be managed. Recent studies have been done to link EIAs and EMSs in project implementation (Hacking and Sanchez, 2002; Varnas *et al.*, 2009). Varnas *et al*. (2009) suggested that in order to ensure fulfilment of commitments made in the EIA, an EMS can be used as a follow up system. One other advantage of EMS implementation is that what could have been overlooked in the EIA can then be further scrutinized. The EIA looks at potential impacts whereas the EMS can consider both the potential and the actual impacts. An EMS can therefore enhance compliance with legislation and regulations. One important factor noted by Bronson and Noble (2006) is that an EMS prioritizes environmental concerns so that the managers can target those with the most significant environmental impacts.

2.10.2.4 Integrated Waste Management Plan (IWMP)

Integrated Waste Management Plan is a basic requirement of all waste management activities (industrial, retail, health) in terms of the NEMWA (59 of 2008) for South African government. The Waste Act requires that the development of an IWMP must follow a public participation and consultation process. These guidelines have been written to follow the waste handling process in accordance with the waste management hierarchy. This implies that waste management officials should include all aspects of the waste management hierarchy in their planning efforts. These guidelines provide a background for the compilation of Integrated Waste Management Plan (IWMP). It includes a short historical overview of IWMPs to date and a basic description of the legal framework pertaining to IWMP (DEA, 2012b).

The development of an IWMP involves a situation analysis which includes a description of the population and development profiles of an area to which the plan relates, an assessment of the quantities and types of waste that are generated in that area. It provides a description of the services that are provided or that are available for the collection, minimisation, re-use, recycling, and recovery, treatment and disposal of waste. It must also include the number of persons in the area who are not receiving waste collection services (DEAT, 2000). Furthermore the situation analysis must also be completed in terms of institutional, financial, political, legal and physical conditions which must also be translated into the desired end state (DEAT, 2006).

The Constitution places an emphasis on the need to have the environment protected for the benefit of present and future generations through reasonable legislative and other measures i.e. IWMPs. It is within this provision that IWMPs must strive or come up with measures to uphold the rights of all citizens within the jurisdiction of the municipality and should enhance and promote environmental protection from any form of degradation as enshrined by the South African Constitution (DEA, 2012a).

2.10.3 Case studies on environmental compliance with waste management practices from mining activities

According to Eggert (1994), for centuries denuded landscapes, fouled streams and dirty air were accepted by the society as part of the price that had to be paid for mineral production. Even environmental legislations devised by industrialized countries in the 1960’s and 1970’s were largely designed without mining in mind. With the advent of sustainability in the 1990s, times have changed and current policies are under rigorous review and mineral rich developing countries are designing environmental policies where none existed before. This shows that for a long time mining has been causing environmental degradation, water and air pollution. According to Chapuka (2011), these problems are the same problems that we are facing today and most of the effects that have not been addressed for centuries are now being felt, for example global warming resulting in global climatic changes.

Mining causes serious environmental and social problems on many different fronts if it is unchecked (Sinding, 1999; Piha and Shoko, 2000; Hilson, 2002). However, with the incorporation of various measures of environmental laws and management, these problems can be dealt with before they become widespread and uncontrollable. Environmental legislation is the influencing factor for companies to achieve environmental change. In the mining industry, environmental management has not been practiced, but legislation brought significant changes in the developed world and later on in the developing world (Kolk, 2000). It has also been noted that most modern legislations require organisations to identify risk at work places, assess risks, take measures to eliminate and control harmful exposures, communicate hazards and ensure that control measures are implemented (NOSA, 2009). Hilson and Murck (2000) noted that with good management practices in place, EM can be enhanced. Overall environmental performance of an organisation is measured by a reduction in environmentally related problems, as indicated by the laws, regulations and environmental standards in place. Many organisations have adopted EMS as a tool in EM to facilitate compliance to laws and regulations (Tinsley and Pillai, 2006).

Upon realization of the need for environmental protection, environmental legislation and regulations were established. Developed countries (the European community and the United States of America) were pioneers in the successful development and implementation of this approach. South Africa, along with other African countries, has joined in signing international environmental conventions and formal agreements committing them to address environmental issues of common interest. With the development of an environmental conscience, government at all levels were prompted to control the depletion of natural resources and environmental damage (Sengupta, 2000).

A common problem is that the majority of developing countries have only recently implemented national environmental legislation and of the laws pertinent to mining related activity, most are far from stringent, and fail to effectively regulate all aspects of the industry accordingly (Hilson, 2002).

Kolk (2000) believed that legislation is the main influencing force for organisations to facilitate environmental change. Legislation is used as an instrument in EM but it cannot be said for the whole world. Sengupta (2000) stated that legislation has resulted in a number of significant changes in the traditional approach to both mining and resource development. Examples include EIAs and public enquiries, conditions for permit approval, resources management and land use planning, land reclamation and rehabilitation and an Environmental Program (EP) that meet all existing regulations and standards for air, water and land quality (Sengupta, 2000).

- Global

In Brazil, EIA is a prerequisite for environmental licensing of any activity exploiting mineral resources. Its criteria and implementation guidelines were promulgated in 1986 and amended in 1990 by the national environmental agency. The Environmental Impact Report (RIMA) for mining operations is required to include a Plan for Recovery of Degraded Areas (PRAD) with a description of site mitigation measures to be approved by the competent state environmental agency (Hagler, 1998)

In the United States of America (USA), prior to the major regulatory efforts of the mid-20th century, the common law doctrines of tort and nuisance were the chief means of controlling damage caused by mining (Strong *et al*., 2011)). Starting in the mid-20th century, however, common law rules began to be supplemented by an array of federal environmental statutes that held polluters and others associated with mining activities accountable for damage. The Clean Water Act, the Clean Air Act, the National Environmental Policy Act, the Endangered Species Act, and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) all apply to mining and mineral development (National Research Council (NRC), 1999). The Clean Water Act prohibits any polluting discharges from “point sources” into navigable waters of the United States. The term “point source” includes any discernible, confined, and discrete conveyance, including such structures as pipes, ditches, and channels (Buck and Gerald, 2001). The CERCLA (the Superfund law) is the most significant environmental cleanup legislation of all. Under CERCLA, the Environmental Protection Agency (EPA) classifies polluted sites by their level of dangerousness, and puts the most dangerous on the national priority list. This makes these sites eligible for cleanup funds from Superfund (Buck and Gerald, 2001).

Greenland Minerals and Energy Ltd, based in Australia, had planned to open a mine in Greenland in 2013. However, the tailings disposal plan involved storing tailings in the Taseq lake, which could cause pollution of not only the lake but the rivers leading from it and the ocean beyond. Fluorine, heavy metals, and radioactive decay products would all be introduced into the lake by these tailings. Due to the lack of environmental regulations from Denmark, the country overseeing the project plans for the mine continue to move forward, despite the harmful effects it would have on the environment and the surrounding community. This shows the importance of legislation in the mining industry, non-environmentally friendly waste practices are put in place ultimately having negative impacts on the environment (Schuler *et al.*, 2011).

Danelski (2009), noted that lack of compliance through poor waste practices from a mining company in Molycorp resulted in a problem with its waste disposal system at Mountain Pass. Due to the waste, a pipeline leading out to evaporation ponds in the desert busted, spilling radioactive and toxic waste onto the desert floor. The resulting uncovering of past spills, coupled with economic factors, caused the shutdown of Mountain Pass and a complete reworking of their environmental practices. However, the damage was done and the area and surrounding water sources were affected.

The Indian cabinet approved a new mining policy in March 2008 which aimed at opening this resource-rich country to increased private investment in mineral exploration and production. However, this mining initiative still requires the consent of the Indian Parliament. The new mining policy plans to introduce new measures to update obsolete Indian mining laws (some of which date back to 1950s) which have deterred foreign investment over concerns related to security of tenure and the high level of discretion the Government has maintained over the granting and revocation of licenses. The current mining regulations in India do not provide for automatic conversion of a reconnaissance permit to a prospecting license to a mining lease. The new policy would allow this automatic conversion and would also distance the Government as a regulator, from the Government as a miner (Brown, 2008).

- Africa

For about four decades, up to the 1980's no new mine was opened in Ghana due to a number of problems faced by the mining sector. The government of Ghana then decided to bring in different laws and measures to regulate the mining activities (Morrice and Colagiuri, 2012). The two main institutions with direct supervisory and oversight responsibilities over the mining sector in Ghana are the Ministry of Lands and Natural Resources and the Mineral Commission. The Ministry of Lands and Natural Resources is responsible for all aspects of mineral resource exploration in Ghana. It formulates policies and grants licenses for mining and mineral exploration. The Mineral Commission, established under Article 269 of the 1992 Constitution of Ghana and the Minerals Commission Act of 1986, is the principal institution for providing regulatory framework for mining in the country. It administers the Mining Act, making mineral policy recommendations, promoting mineral developments in the country and advising government on mineral related issues. It also ensures compliance with the mining and mineral law and regulation. It operates under the purview of the Ministry of Mines (Harwood *et al.*, 1998)

A study by Armah *et al.* (2011) on the assessment of legal framework for corporate environmental behaviour and perceptions of residents in mining communities in Ghana found a number of weaknesses in the mineral and mining environmental policies. These included, but are not limited to the following: no best practice management systems for applying Corporate Social Responsibilities (CSR), no nationally recognized CSR standards against which a company can benchmark its efforts; weak institutions; lack of transparency in the legal and regulatory framework in terms of valuation and payment of compensation and royalties; non-involvement of the communities in the valuation of the crops on their farms; unsound environmental management systems; no standards for blasting in host communities in the mining industry regulatory framework.

Maponga (1995) noted that Zimbabwe does not suffer from lack of environmental regulations, but rather from lack of effective implementation power. Some of the noted problems included shortage of manpower, while expertise and lack of transport were the major constraints which hindered monitoring environmental compliance in the country. However, environmental legislation in Zimbabwe has a history of being too fragmented and contradictory (Maponga, 1995; Maponga and Ruzive, 2002; SAIEA, 2003). This was mainly because the term “environment” was not clearly defined by legislation as it was divided into land, water and air. Many parts of legislation were in place to address these different facets of the environment with the principal agency responsible for EM being the Ministry of Natural Resources and Tourism acting through the Natural Resources Board. The shortcomings and gaps of environmental legislation in Zimbabwe led to the upgrade of the laws in the early 1990’s by the Ministry of Environment and Tourism through the then Department of Natural Resources. Currently, the Environmental Management Act (EMA) (Chapter 20) is the main piece of legislation governing environmental issues in Zimbabwe; its advent has seen the repealing of some Acts such as the Atmospheric Act (Chapuka, 2011). A study conducted by Chapuka (2011) in Zimbabwe, Zimasco mining area, showed that large scale mines were the ones that complied to environmental laws on waste practices more, while small scale mines still had a lot of gaps in terms of compliance. Both mining scales had valid EIA reports and EMPs. However, the small scale mines did not have rehabilitation plans, mine closure plans and valid effluent discharge permit.

- South Africa

In terms of compliance, all mining industries in South Africa are expected to have an EMP report on their mining operation annually. The annual report should cover matters on the types of wastes the mine generates, waste minimization practices and strategies as well as mitigation measures taken to reduce environmental impacts of mine operation. A study by Nyirenda (2014) on selected mining firms in South Africa revealed that according to the annual reports from these firms, they complied with both mandatory and voluntary legislation. The mines had written their annual report with waste management practices as expected by the Constitution of the Republic of South Africa, MEMA and MPRDA.

2.11 Self-regulatory/voluntary practices from mining industries

Dictionary.com (2017) defines self-regulatory practices as control by oneself or itself, as in an economy, business organisation, etc., especially such control as exercised independently of governmental supervision, laws, or the like. According to Your dictionary (2017), self-regulatory practices is when a person or group governs or polices itself without outside assistance or influence. Regulation by organisation is from own behaviour without external control or monitoring. Self-regulatory systems, organisations, or activities are controlled by the people involved in them, rather than by outside organisations or rules (Collins dictionary, 2017).

Apart from the external influence brought about by the legislation, organisations today have internal systems which it controls exclusively in principle. Such systems enable organisations to comply with regulations effectively and consistently (Stapleton *et al.,* 2001). As such, many organisations do comply with certain environmental standards that have been set internationally to facilitate the protection of the environment, such as the Strength, Weakness, Opportunity and Threat (SWOT) analysis, benchmarking, the National Occupational Safety Association (NOSA) and the International Organisation for Standardization (ISO) environmental standards.

2.11.1 Strength, Weakness, Opportunity and Threat (SWOT) analysis

Strategic planning is one of the topics that despite its relative antiquity is still of great importance in the field of scientific and administrative fields. One of the reasons for turning to strategic planning is the transformation and evolution that occurred in today's environments of organisations (Chapuka, 2011). One of the most appropriate techniques, under the topic of strategic planning, among others, is the technical analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT). Nowadays, this approach is used as a new tool of performance analysis for designers and evaluators of strategy (Ritah *et al.*, 2001). An example of SWOT analysis of a PGM mine is shown in table 2.2.

Table 2.2 SWOT analysis approach in mining

Strengths	Weaknesses
1. PGM production in SA is number one in the world 2. PGM in high demand	1. Political influence at local level 2. Capacity gaps and shortfalls
Opportunities	**Threats**
1. Job creation for locals 2. Infrastructure development in neighbouring community	1. Conflicts with neighbouring communities 2. Protests from workers 3. Environmental pollution

From the SWOT analysis it would be advisable for the mining companies to use benchmarking as to compare their operation to similar mining operations in order to be able to minimize threats and weaknesses while maximizing strengths and opportunities.

2.11.2 Environmental benchmarking

Environmental benchmarks can simply be referred to as the environmental expectations of the organisation. According to Chapuka (2011), environmental benchmarking is a structured approach to rigorously examining and comparing, from an environmental perspective, the processes supporting different activities. The objective of environmental benchmarking is to identify and assess the abilities and attitudes that help to step up in operational and environmental performance simultaneously. It is considered to foster healthy competition among communities and lead to improvements (Zotos *et al.*, 2009).

According to Ellis and Rickman (2003) benchmarks can also be used for audits. Benchmarks include corporate standards, regulatory requirements and best practices for an organisation. In mining, benchmarking can help improve the overall waste management system operation by implementing best practices used by other mining companies that are favourable to both environmental and economic conditions for a specific mining company. Figure 2.6 shows an example of a schematic diagram of the process of environmental benchmarking implementation

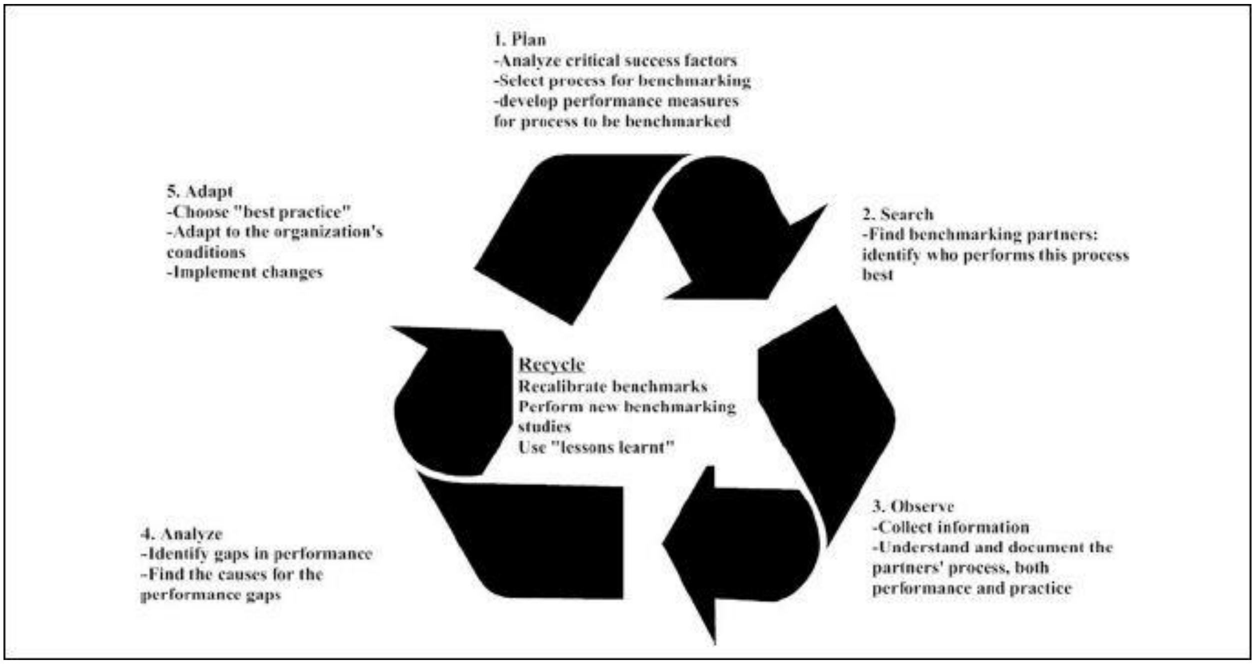


Figure 2.6 The process of benchmarking (Chapuka, 2011).

2.11.3 The National Occupational Safety Association (NOSA) integrated five star system

The National Occupational Safety Association integrated five star system is one example of an Integrated Management System (IMS). The NOSA integrated five star system is a risk based management system, whose main idea is to optimize profits and minimize loss, including loss relating to people, assets, process material and the environment. It is made up of 5 sections and 72 elements. The five sections are: premises and housekeeping (11 elements); mechanical, electrical and personal safeguarding (17 elements); management of fire and other emergency risks (8 elements); incident recording and investigation (5 elements) and organisational management (31 elements) (NOSA, 2011). Environmental elements are mentioned in Section 1 (Premises and housekeeping) and Section 5 (Organisational management), including, among others: factory and yard, resource conservation, waste management, pollution risk control and environmental monitoring. These elements are then used to devise environmental management standards based on the approach of the system (Chapuka, 2011).

According to Ellis and Rickman (2003), many organisations have a single department handling Safety, Health and Environmental (SHE) issues, reflecting the trend towards integration, also known as NOSA integrated five star system. A well planned IMS is believed to be efficient, the sharing of systems procedures and practices rather than duplicating them can guarantee efficiencies in audits. It is based on the Plan-Do-Check-Act routine where managers are expected to continuously check their system, giving them the opportunity and mechanism to review their health, safety and environmental performances. The checking is based on certain benchmarks such as corporate standards, regulatory requirements or organisation's best practices.

As a SHE service provider, NOSA integrated five star system has its own approach in conducting business which could aid the understanding of the NOSA integrated five star systems implementation by organisations. Part of their mission is to offer risk management services, consulting, auditing and certification, as illustrated in figure 2.7, which illustrates the safety, health and environmental management standards offered by the NOSA integrated five star system.

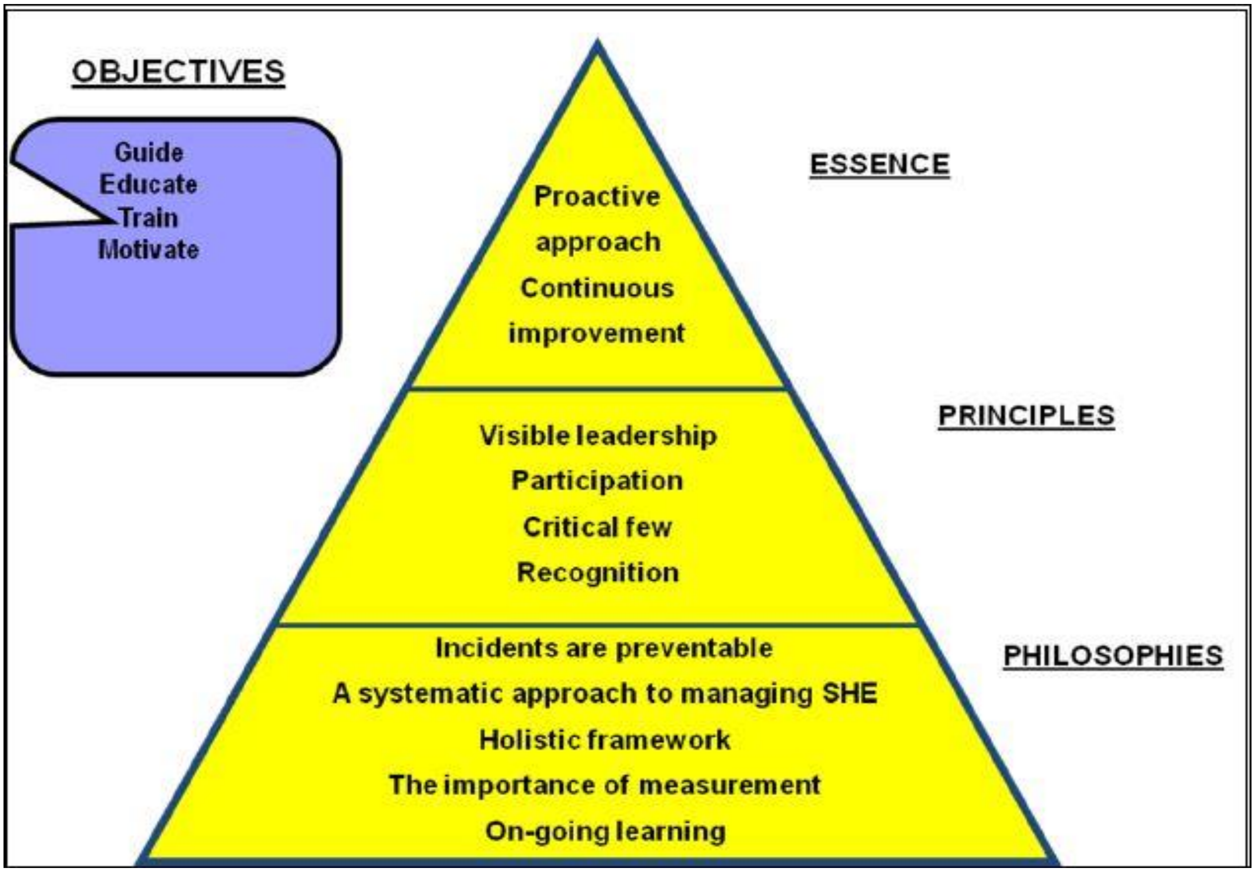


Figure 2.7 The NOSA approach (NOSA, 2009).

The NOSA integrated five star system takes cognizance of other management systems to form one system catering for SHE. The three related systems are ISO 9000 (QMS), ISO 14000 (EMS) and OHSAS 1800 (Chapuka, 2011).

2.11.4 International Organisation for Standardization (ISO) Standards

The International Organisation for Standardization is an internationally recognized environmental organisation which has been created to initiate world standards. Initially, the ISO 9000 series of quality management systems was introduced, followed by the ISO 14000 series of environmental management systems. According to Stapleton *et al*. (2001), the two models share common elements since ISO 9001 was used as a source document to draft ISO 14001, with the main difference in the technical requirements of each standard (Chapuka, 2011).

ISO 9000 sets quality management principles, such as the system approach, which involves the identifying, understanding and managing of a system of interrelated processes, contributing to the effectiveness and efficiency of the organisation (Chapuka, 2011). The ISO 14000 series of environmental management systems is widely used and sets standards and guidelines for environmental management principles based on environmental policy, planning, checking, corrective action and management review. The commonly used EMS standard is ISO 14001, which may or may not require certification (Chapuka, 2011). According to Hagler (1998), ISO 14001 is not intended to serve as a substitute for or supplement to national environmental laws and regulations. It purposely refrains from establishing specific performance levels and rates of improvement. Instead, the standard provides a framework (implementation of voluntary waste practices) that allows individual companies the flexibility to establish their own policies and performance objectives which may go beyond the current regulatory requirements. Some mining companies may find that the benefits of adopting ISO 14001 outweigh the costs, while others will find that the opposite is true. Even if ISO 14001 certification proves unfeasible, the company may decide to put an EMS in place for its own management reasons, e.g., reductions in waste disposal costs, liability, or to improve worker and community relations.

2.11.5 Case studies on self-regulatory practices from mining industries

- Global

International mining enterprises have realized the advantage of having long-term internationally acceptable environmental rules. They understand that their self-interest is served when they undertake environmental improvements. Local branches are required to adhere to guidelines issued by company headquarters. Competition between multinationals and local mining companies can accelerate considerably the process of environmental reorientation of the mining industry in places such as South America (Hagler, 1998).

Environmental quality standards are still being developed in many South American countries. Where such standards exist, they are usually general sets of values adopted from international guidelines or foreign legislation that have not been adapted to local conditions due to the lack of relevant background information. For example, Chilean air and water quality standards are modeled after U.S. EPA regulations. The Chilean mining industry has been a leader in EMS implementation, an example of which is, the publiclyowned Codelco mining company aspired to qualify for ISO 14000 certification in 1998 (Hagler, 1998).

- Africa

A study conducted by Ogola *et al*. (2015) on environmental impacts of mining in Ghana showed how SWOT analysis could be beneficial in a mining environment. Some of the strengths identified in the mines from the study included contribution to economic growth, job creation and infrastructure development. The weaknesses identified were vegetation clearance, soil erosion and land disturbance which were mainly caused by surface mining method. The opportunities from the study were increased small scale mining activities, curtail illegal mining in the area, community participation and increased environmental awareness to mining entrepreneurs. The threats were water pollution in nearby rivers, displacement of local community members and shifting of primary use of land from agriculture to mining.

A study conducted by Chapuka (2011) in the Zimasco area (Zimbabwe) showed that Zimasco implemented the NOSA integrated five star system as their SHE management system which recognizes the ISO 14000 environmental standards, ISO 9000 quality standards and the OSHAS 18000 for occupational health and safety. However with the structure of the organization there are some operations that are under the full implementation of the NOSA integrated five star system whereas others have environmental measures which are derived from the EMS but are not audited externally by the NOSA Company.

Zimasco mining organisations also incorporated benchmarking to improve their overall environmental management practices. Mining organisations adopted EIAs, environmental plans and policies as well as waste minimization practices applicable to them used by other mining organisations (Chapuka, 2011). A SWOT analysis was conducted in the Zimasco area and the strengths identified included safety and health decisions being made at corporate level, up to date legislative database, legal compliance audit were carried out, amendments and new clauses were effectively and efficiently identified. Weaknesses included the fact that SHE system was not implemented in full in all the operations and as such not all operations were audited externally and no environmental representatives at sites and environmental management issues do not have specific responsible personnel. An opportunity identified was extension of the NOSA system to the tributors was a great advantage for total environmental improvement on chrome mines. Lastly, threats identified included too many small scale operators who needed training on environmental management issues to ensure total environmental commitment, poor economic conditions which forced both Zimasco and its tributors to be more concerned of making money rather than improving environmental performances and trained tributor personnel on environmental issues who were faced by challenges of high labor turnover such that training needs became more demanding and frequent (Chapuka, 2011).

- South Africa

All mining operations in South Africa are required to have NOSA offices (environmental offices) which are responsible for managing environmental matters of the mine. The offices are responsible for compiling Environmental Management Performance Reports (EMPARs) which entails specifics on mandatory and voluntary waste practices in the mine. A study by Nyirenda (2014) on selected mining firms in South Africa revealed that according to the annual reports from these firms, they complied with the legislation. Eighty nine percent (89%) of the companies mentioned ISO 14001 in their waste management practices while the remaining 11% did not.

2.12 Summary of chapter

The mining industry has shaped and continues to shape the economy of many countries globally. It has been practiced for centuries to benefit human beings wants and needs and has improved the living standard situation for many, especially in communities surrounding the mines. South Africa still remains the biggest producer of PGM and the sector employs thousands of people. Although PGM mining has employed and improved social situations of many, its operation is associated with many negative environmental and social problems. Most PGM operations use underground mining method which has more severe impacts as compared to surface mining and generates large amount of waste, as such it is important for PGM mining operations to implement best waste management practices to minimise impacts as much as possible.

Environmental laws such as the NEMA and MPRDA can help improve the overall management system of an operation. Implementation of self-regulatory practices can also help a mining operation as they can adopt best practices that suit their operation. This chapter covered a review of literature on mining, its operation, wastes generated from mining, waste management practices that can be employed, mining impacts, environmental compliance practices and theoretical framework of the study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the methods and techniques that were used in the collection and analysis of data. The first part of this chapter looked broadly at the area in which the study was undertaken. It covers the background and profile of Marula Platinum Mine (MPM) and its surrounding villages as well as the population and types of people found in those villages. The second part looked at the procedures (methods) that were used to accomplish the aim of the study, this includes research design, sampling and data collection methods (primary and secondary). The last part deals with data analysis and presentation of the results.

3.2 Study area

Limpopo province is one of the poorest provinces in South Africa and mining operations are seen as a way of job creation and alleviation of poverty (Benchmark Foundation, 2012). Limpopo is one of the provinces with the largest number of mining productivity in South Africa after North West province (Stats SA, 2016). Limpopo's rich mineral deposits include the Platinum Group Metals (PGMs), iron ore, chromium, high- and middle-grade coking coal, diamonds, antimony, phosphate, and copper, as well as mineral reserves like gold, emeralds, scheelite, magnetite, vermiculite, silicon, and mica. Commodities such as black granite, corundum, and feldspar are also found. Mining contributes to over a fifth of the provincial economy (Wikipedia, 2017). The biggest mining area in Limpopo is the Bushveld Igneous Complex (BIC) located in Greater Sekhukhune District Municipality (GSDM). The Bushveld Igneous Complex (BIC) is a large layered igneous intrusion within the earth's crust which has been tilted and eroded and now outcrops around what appears to be the edge of a great geological basin, the Transvaal Basin. The BIC contains some of the richest ore deposits on Earth. The complex contains the world's largest reserves of PGMs which include platinum, palladium, osmium, iridium, rhodium, and ruthenium, along with vast quantities of iron, tin, chromium, titanium and vanadium (Wikipedia, 2017).

The Greater Sekhukhune District Municipality (GSDM) is the smallest district in the province, making up 11% of its geographical area (13 528 km²). GSDM consist of 5 local municipalities, which are Elias Motsoaledi Local Municipality (formerly the Groblersdal Local Municipality), Fetakgomo Local Municipality, Greater Marble Hall Local Municipality, Greater Tubatse Local Municipality (GTLM) and Makhuduthamaga Local Municipality (MSA, 2012). Modern mining has been practiced in GSDM for well over a century and typically involved the extraction of andalusite, asbestos, chromite and platinum deposits from the Merensky Reef, which forms part of the mineral rich BIC. In fact, the District features the world's largest deposit of PGMs. Currently, 17 operational mines are found within the District, with the majority of activity situated along the Dilokong Corridor (R37 and R555). The Dilokong corridor stretches across the Fetakgomo and Greater Tubatse Local Municipalities respectively. Major mining companies operating in the GSDM as of 2006 include Anglo Platinum, Xstrata, BHP Billiton, Implants, ASA Metals and Marula Platinum, which falls under the jurisdiction of GTLM. In 2012, it was estimated that from 2013 to 2016, 11 new platinum and chrome mines would open possibly creating 17 000 direct jobs and a R2 billion smelter plant was being considered for construction in Tubatse, possibly creating 1 200 jobs (MSA, 2012).

Greater Tubatse Local Municipality (GTLM), under which MPM is located, is located north of the N4 highway (Middelburg, Belfast and Mbombela) and east of the N1 highway (Groblersdal and Polokwane). The area of jurisdiction is known as the Middelveld as it is located between the Highveld and Lowveld regions. It comprises 29 wards represented by one councillor per ward and is administered by a local municipality that has its main offices in Burgersfort. The vast majority of the area is made up of villages that are scattered throughout, particularly, the northern part of the municipality. There is one main municipal office and there are three satellite municipal offices. GTLM has an area of 4 601.96 km², population of 335 676 (72.94 per km²) and 83 199 households (18.08 per km²) (Census, 2011b).

The mine's geographical coordinates are $24^{0}29'51''$S and $30^{0}40'42''$E (Figure 3.1) (Implats, 2010). The villages closest to the mine are Diphale, Magabaneng and Seuwe. Diphale has a population of 3 709 and 890 households (Census, 2011a), Magabaneng has a population of 906 and 250 households (Census, 2011c) and Seuwe has a population of 1 690 and 345 households (Census, 2011e). The vast majority of people there are Black Africans with a population group of 329 810 (98.3%), followed by Whites at 4 409 (1.3%), Coloured at 643 (0.2%), Indian or Asian at 538 (0.2%) and other nationalities at 277 (0.1%). The area is dominated by Sepedi speaking people accounting for 29 3644 (88.1%) of the population (Census, 2011b).

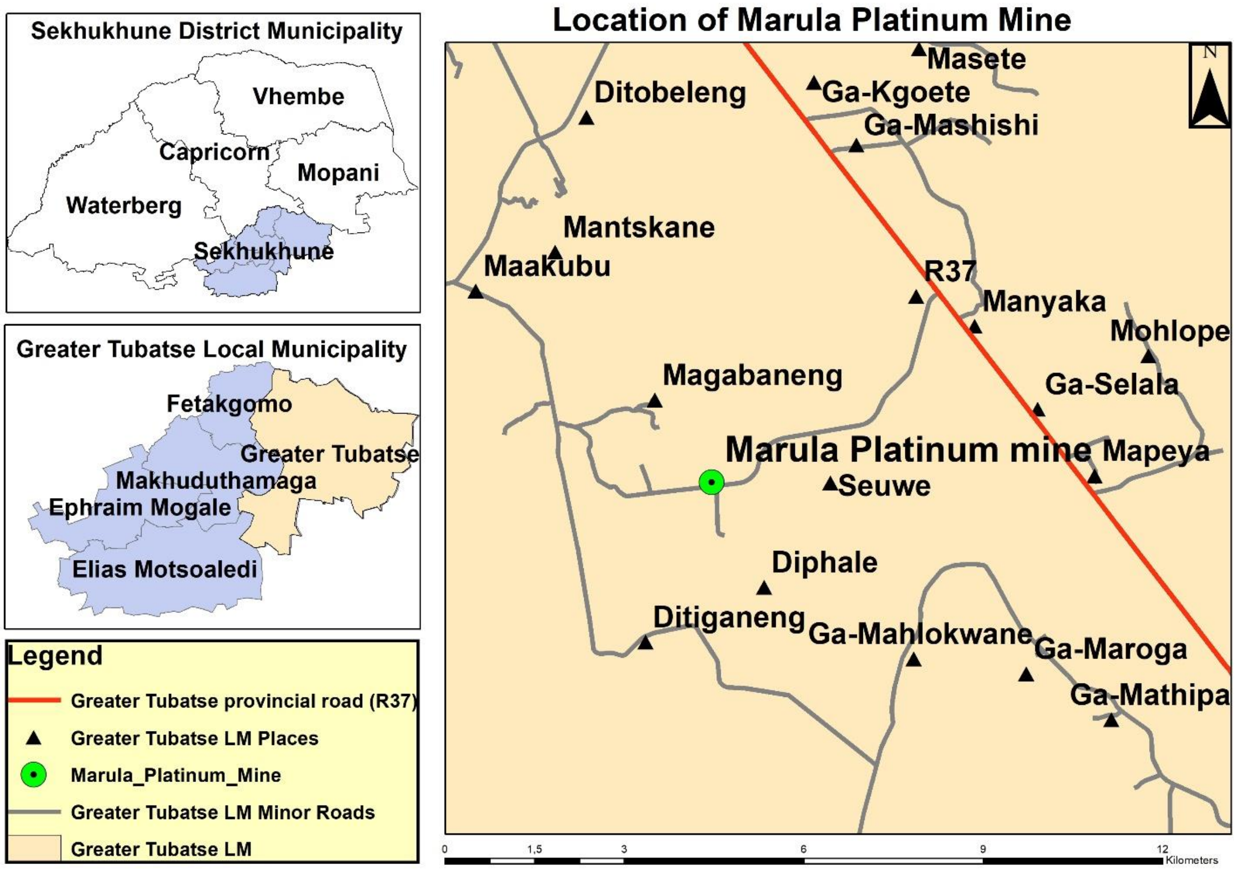


Figure 3.1: Location of Marula Platinum Mine

3.2.1 Physical features of MPM

In geography, physical features are the natural characteristics of the Earth's surface, especially in its current aspects, including land formation, climate, currents, and distribution of flora and fauna (Dictionary.com, 2015a).

Figure 3.2: Physical features of MPM (https://www.google.co.za/maps, 2017)

Figure 3.2 depicts physical features of MPM. This figure shows vegetation and geological cover of the study area. The arrow in the center and other dark green shades in the area represent the vegetation cover and the arrow on the far right shows the location of Moopetsi River. The arrow on the top center of the figure depicts where the environmental office and the first plant at MPM are, while the top arrow on the far left depicts where the second plant is located as well as the salvage yard.

Figure 3.3: Moopetsi River (https://www.google.co.za/maps, 2017)

Figure 3.3 shows Moopetsi River (seasonal river) which is indicated by the arrow on the right side on the figure just roughly about 1km away from MPM facility. The river appears to be drying up with little signs of flowing water. The arrow on the left side of the image shows a small plantation site and there appear to be planted vegetables by one of the local farmers in the area.

Marula Platinum Mine is located within the summer rainfall region of South Africa, receiving more than 80% of its rainfall between November and March (DWAF, 2005). In terms of temperature, the summer tend to be extremely hot and humid with temperatures often exceeding 35^0C between the months of October and March, while the winters tend to be warm during the day and cool to cold at night and in the early mornings (IDP, 2018).

3.2.2 History and ownership of MPM

Marula Platinum Mine (MPM) is 73% owned by Impala Platinum Holding (Implats) Limited and is one of the first operations to have been developed on the relatively under-exploited eastern limb of the Bushveld Complex in South Africa (Implats Integrated Annual Report, 2014). The remaining 27% is being held through equal proportions of 9% by the following

Black Economic Empowerment (BEE) partners: Marula Community Trust, Mmakau Mining and Tubatse Mining. MPM has been in operation since early 2001 when it initiated full scale mining at two shafts on the farms of Driekop and Clapham. The original Environmental Management Plan (EMP) was approved in December 2001. Trojan Platinum (Pty) Limited was granted consent in favour of Impala Platinum Limited to apply for mining authorisation in terms of Section 9 of the Mineral Act 50 of 1991 over Winnaarshoek, Clapham, a portion of Forest Hill and Driekop which is currently owned by Trojan Platinum (Pty) Limited under prospective permit no 51/2000 and Section 8 permission no 6/2001 (EMPARMPM, 2017).

MPM amended its EMP according to the Mineral Petroleum Development Act (MPRDA) in July 2007 to approve additional activities which was approved by the Department of Mineral Resources (DMR) in 2008. The EMP amendment represented a consolidation of the existing and proposed activities at MPM and upon approval replaced the mine's original EMP (EMPARMPM, 2017).

Table 3.1 Land ownership of MPM (EMPARMPM, 2017).

Property description	**Tribal authority and Kgosi**	**Registered owners**	**Title deed**	**Extent (ha)**
Driekop 253KT	Babina-Nare Ba Mohlala-Mohlala W (Kgosi) Banareng Ba Mohlala-Mohlala MB (Kgosi) Jack Mahlokwane	Republic of South Africa	T16453/1951	3 382
Winnaarshoek 250KT	Banareng Ba Mohlala-Mohlala MB (Kgosi)	Republic of South Africa	T759/1936	1 687
Portion 1 of Winnaarshoek 250KT	Lutheran Church (Magabaneng settlement)-Bishop Molefe	Evangelical Lutheran Church of Southern Africa (Northern Diocese)	T25571/1987	78
Clapham 118KT	Babina-Phuthi Ba Manyaka-Manyaka MS (Kgosi) and Manyaka ML (Kgosikgadi)	Republic of South Africa	T8670/1948	2 151

	Roka Mashishi Tribe			
Forest Hill 117KT	Banareng Ba Kgoete-Kgoete S (Kgosikgadi) Roka Mashishi-Mashishi MS (Kgosi) Nareng Thokwane	Republic of South Africa	T8670/1948	3 202

The current mining operations extend across the farms of Driekop, Winnaarshoek, Clapham and Forest Hill. The ownership of the farms are presented in table 3.1. The Driekop shaft was planned to be closed in 2009 but an extension for another 15 years has been granted by the DMR.

3.3 Research design

A case study design was used as it involves looking at waste management practices employed at a mining facility as well as the socio-economic and environmental impacts of mining activities in a specific place. For research approach, a mixed method (qualitative and quantitative) was adopted. The choice of this approach was informed by the fact that the unit of analysis in the case study are the communities.

3.4 Sampling

3.4.1 Sampling frame

The sampling frame of the study consisted of a total number of households from the three villages of Diphale (890), Magabaneng (250) and Seuwe (345), since they are the three neighbouring villages that are closest to the mine.

3.4.2 Sample size

Sample size was calculated using an online sample size calculator, with a confidence level of 95%, level distribution of 50% with 10% margin error (Barnett, 2002; System survey, 2017). After entering the sampling frame data on the online calculator, the sample size was 87 for Diphale, 70 for Magabaneng and 75 for Seuwe.

3.4.3 Sampling method

Systematic random sampling was used to select the required households from these three villages. The k^{th} value (skip) is the sampling interval. The following formula was used to determine k^{th} value: $K=\frac{N}{n}$, where n is sample size and N is population size. The

k^{th} value in Diphale was 10, Magabaneng it was 4 and Seuwe it was 5. The first household was randomly selected and thereafter the skip value was used for each village.

3.5 Data collection methods

3.5.1 Secondary data

Secondary data on environmental compliance and effects of mining were obtained from the MPRDA, NEMA, journals, reports, pamphlets, internet and books.

3.5.2 Primary data

Primary data was collected through questionnaires, field observations, key informant interviews and a checklist. A pilot study was used to validate research instruments.

3.5.2.1 Questionnaires

A total of 232 structured questionnaires were administered in the study area. The questionnaire consisted of both open-ended and close-ended questions. The questionnaire addressed objective (iii), which was to evaluate effects of waste management practices on the communities surrounding MPM. Data on cases of improper mine waste disposal in the neighbouring communities (pollution and environmental degradation etc.), social and economic impacts (infrastructure development, job creation etc.) was also collected. To validate the research data collection instrument, nine questionnaires (three in each village), were administered in Diphale, Magabaneng and Seuwe. The questionnaire was then adjusted so it could be answered by participants while still meeting the requirements of the study. The questionnaires used for the pilot survey were not included in data analysis.

3.5.2.2 Field observation

Field observations were conducted in the three villages (Diphale, Magabaneng and Seuwe) neighbouring the mine. Photographs on how the mine had impacted communities physically, socially and economically were taken.

3.5.2.3 Key informants interview

Interviews were used to address objectives (i) and (ii) which are: to examine the level of environmental compliance of solid waste management practices at MPM and to assess challenges that hinder environmental compliance of solid waste management practices in MPM, respectively. A formal unstructured interview was conducted with Limpopo Department of Economic Development Environment and Tourism (LEDET) officials (Table 3.2).

Table 3.2 Data from key informant interviews

Type of interview	Key aspect
Formal unstructured (LEDET)	✓ Responsibilities of the license holder (licensing conditions) in terms of solid waste management before, during and after mining operations; ✓ Solid waste management practices, such as classification, separation, storage, collection, transportation, treatment and disposal, expected from mining activities; ✓ Expectations from mining activities in terms of rehabilitation and closure plans.

3.5.2.4 Checklist

The investigation of this research was conducted by the use of a checklist which was used to address objective (i). Data on the checklist included responsibilities of the license holder (have a detailed waste management plan etc.), waste management practices (separation, collection, storage etc.) and rehabilitation processes and monitoring plans. The checklist scale rate of 1 to 4 was applied where: 1-very poor (not available), 2-poor (non-compliant), 3-moderate (partially compliant), 4-good (compliant). A colour coding system was used for the compliance assessment (Table 3.3). A similar approach was used by Patmal and Maya (2014) for mining impact assessment and is the appropriate method to be used in order for the researcher to address the research problem that motivated this study. The researcher also noted that the mine itself for assessment reports did not only use a similar approach, but other mining companies in South Africa also used it. A legend for the colour coding system is given below:

- Compliant -C
- Partially compliant -PC
- Non-compliant -NC
- Not available -NA

Table 3.3: Assessment level using colour-coding system

Level of compliance	Description
Compliant (4)	All wastes management practices per NEMA and MPRDA are followed.
Partially compliant (3)	Not all waste management practices per NEMA and MPRDA are followed.
Non-compliant (2)	Waste management practices per NEMA and MPRDA are not followed
Not available (1)	Data on waste management practices was not available

3.6 Data analysis and presentations

Data collected from questionnaires (close-ended part) on impacts of mining on surrounding communities (objective iii) was coded and analysed using a Statistical Package for Social Sciences (SPSS) version 25. Tables, graphs and charts were used to present the data. Data collected from interviews and open-ended part of the questionnaires was manually coded and summarized in order to support trends and findings and addressed objective (i), (ii) and (iii) and presented in a descriptive manner. Data collected using a checklist to address objective (i) was summarized and presented in the form of a table and analysed in a descriptive manner. Statistical techniques such as Pearson Chi-Square test for independence was used to analyse objective (iii). According to Moore and McCabe (2003), "The Pearson Chi-Square statistics is a measure of how much the observed cell counts in a two-way table diverge from the expected cell counts". Therefore, the Pearson Chi-Square Tests the following hypothesis:

H_o: Row and column variables are independent – there is no relationship

H_a: Row and column variables are not independent – there is a relationship

To get the value of Pearson Chi-Square, the formula below was used:

$$x^2 = \sum \frac{(O-E)^2}{E} \quad \text{(Equation 1)}$$

Where: x^2 = Chi-Square value

$\sum$ = the sum of

o = observed value

E = expected value

Pearson Chi-Square Test was ran to check if there is a relationship between level of education (literacy level) and age group of respondents, level of education and perception of impacts of mining on the environment as well as change on environment and number of years respondent had been residing in the village.

3.7 Summary of the chapter

This chapter covers sections on what methods were used in order to meet the aim and objectives of this study. Sections covered under this chapter include the study area, research design, sampling, data collection methods and lastly data analysis.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents findings from both secondary and primary data. The findings are presented on themes starting with the main objectives of the study which were to: examine the level of environmental compliance of solid waste management practices at Marula Platinum Mine (MPM), assess challenges that hinder environmental compliance of solid waste management practices in MPM and evaluate effects of waste management practices on the communities surrounding MPM. The section ends with a summary of the chapter. Objectives (i) and (iii) were addressed using both secondary and primary data, while objective (ii) was addressed by using secondary data.

4.2 Examination of the level of environmental compliance with solid waste management practices at Marula Platinum Mine.

Environmental Compliance means conforming to environmental laws, regulations, standards and other requirements such as site permits to operate (Wikipedia, 2018b). According to Dole (2007), environmental compliance relates to public health, conservation of natural resources, pollution control and land use control. Legislation plays a huge role in environmental compliance not only for MPM, but for all mining activities in South Africa. Legislation forms a key response because it provides a means by which policies are enforced by defining responsibilities and methods of ensuring that environmental compliance take place (Walmsley and Walmsley, 2002).

South Africa's legal framework on waste management is one of the most progressive in the continent (DEA, 2012b). There is a clear division of roles, responsibilities, and obligations of different spheres of government. This alignment of the law governing waste demonstrates the country's ambition towards a clean environment and healthy society (DEA, 2012b). According to Section 24(a) of the Constitution of South Africa, all South African people have the right to an environment that is not harmful to health or well-being. This fundamental right underpins all environmental policies and legislations, in particular the framework on environmental legislation established by the National Environmental Management Act (NEMA) (107 of 1998) (DEA, 2012a).

NEMA provides instruments for integrated waste management. It also places a duty of care on any juristic person who may cause significant pollution or degradation of the environment, requiring them to institute measures to either prevent pollution from occurring, or to minimise and rectify the pollution or degradation where it cannot reasonably be avoided (DEA, 2012a). Based on the NEMA framework, the most innovative feature is the National Environmental Management Waste Act (NEMWA) (59 of 2008) is the preference for the regionalisation of solid waste management services. The Act also places considerable emphasis on the development of an integrated waste planning system through the development of interlocking integrated waste management plans by all spheres of government and industry waste management plans for specified waste generators (DEA, 2012a).

Mineral and Petroleum Resources Development Act (MPRDA) (28 of 2002) provide for the regulation of associated minerals, partitioning of rights and enhancing of provisions relating to beneficiation of minerals. The MPRDA sets out the process a mining company must follow to get a license or permit to mine and is administered by the DMR (CER, 2014). In terms of section 29 of the MPRDA (28 of 2002), holders of mining rights granted in terms of section 23 of this Act are hereby directed to report their level of compliance with Broad Based Socio Economic Empowerment Charter (BBSEC) for the South African Mining Industry as contemplated in section 28 (2) (c) (MPRDA, 2002). If a mining company is not complying with environmental legislation and policies in the South African context, the DMR, Department of Environmental Affairs (DEA) and Department Water Affairs (DWA) have the power to investigate and stop the company from continuing or starting with mining (CER, 2014).

In order to address this objective, secondary data obtained from the Department of Mineral Resources (DMR), internet, company documents and Environmental Management Performance Assessment Report (EMPAR) from MPM were used. Level of environmental compliance with solid waste management practices was based on what the EMPAR and company document waste strategies said in contrast to laws and legislations from the South African government. Aspects looked at under this objective included environmental authorisation, mining method used at MPM, types of wastes generated at MPM, the management of wastes generated and compliance assessment.

4.2.1 Mandatory practices

4.2.1.1 Environmental authorisations

Environment is the surroundings within which humans exist that are made up of the land, water and atmosphere of the earth as well as micro-organisms, plant and animal life (NEMA, 1998). Authorisation is a process used in verifying that the individual or organization who has requested or initiated an action has the right to do so. Environmental authorisation can simply be defined as a process in which individuals or organisations have obtained rights to conduct any form of activity on the environment.

Often when a mining company proposes to start mining or prospecting, this process involves other activities that affect the environment. These include building roads, clearing vegetation, erecting buildings, installing petroleum tanks and other activities. Many of these activities require an environmental authorisation. These authorisations in South Africa are governed by NEMA and the Environmental Impact Assessment (EIA) Regulations. The mining company must submit an application for an environmental authorisation to the appropriate authority. The mining company will usually be required to submit its application to the provincial Department of Environmental Affairs (DEA) (CER, 2014). In the case of MPM, environmental authorisation was obtained from Limpopo Province's Department of Economic Development, Environment and Tourism (LEDET).

A mining company is required to appoint an Environmental Assessment Practitioner (EAP) who will prepare its EIA and who will consult with interested and affected parties. The mining company's EAP must do an EIA which means they must assess the environment before mining starts and their assessment must describe what impact the mining will have on the environment and on the communities that live and work in that environment. Depending on the extent of activity, the mine may be required either to prepare a basic assessment or a full EIA (including a scoping report) (CER, 2014).

A basic assessment is usually prepared for small scale mining activities which will only have limited impacts. The basic assessment report must describe the proposed mining or prospecting and its impacts. It must say what will be done to protect the environment. It must include a report describing the consultation with interested and affected parties. A full EIA is generally used for large scale mining activities with more serious impacts and consists of all the stages of the EIA process, from scoping to monitoring and after care plans. The scoping report has to properly describe the activity and alternatives. Importantly, the scoping report must describe what the impacts might be and how these impacts will be studied in the environmental impact report. Mining companies have to prepare a scoping report and an environmental impact report as part of the process of compiling an environmental management program (CER, 2014). MPM hired an EAP who conducted the EIA before operations started and submitted documents to LEDET for approval of environmental authorisation.

In South Africa, a waste management license under the NEMWA (59 of 2008) is required for the creation of a residue stockpile. Applicants for waste management must undertake EIA in accordance with NEMA. Only a basic EIA is required if the waste in question is generated from prospecting or activities requiring a mining permit. A full EIA is required for the waste generated by activities requiring mining, exploration or production rights. This means that the mining activity will have to pay for more detailed and stringent EIA processes involving considerably more public participation than was previously the case under the MPRDA. Registered engineers must design stockpile under the MPRDA regulations and the stockpile has to be designated to competent persons. The mining regulation requires that this be done by a civil or mining engineer registered under the Engineering Profession of South African Act 114 of 1990. Stockpiles must comply with landfill requirements and with the norms and standards for the assessment of wastes for landfill disposal 2013 and disposal of waste to landfill. Section 39(1) of the MPRDA (28 of 2002) states *that every person who has applied for a mining right in terms of section 22 must conduct an environmental impact assessment and submit an environmental management program within 180 days of the date on which he or she is notified by the Regional Manager to do so* (MPRDA, 2002). MPM did comply with this requirement as it still has mining engineers for ongoing stockpile management.

Many countries have become more environmentally conscious in their mining practices and do this through the Environmental Management Plan (EMP). According to the MPRDA (2002) an EMP is defined as a plan to manage and rehabilitate the environmental impact as a result of prospecting, reconnaissance, exploration or mining operations conducted under the authority of a reconnaissance permission, prospecting right, reconnaissance permit, exploration right or mining permit. MPM has an EMP that explains the strategies, methods and good practices to minimize environmental impacts during their operation. However the EMP is made from combined documents to which the company must comply and commit in order to ensure good environmental practices standards. The amendment to the EMPAR for MPM used for the purpose of this study was conducted by an environmental consulting company called SRK Consulting which generated the consulting report number 474738. The EMPAR (474738) used was conducted at the end of November 2016 (for 2015 and 2016) and submitted to DMR of Limpopo in March 2017 (EMPARMPM, 2017). The EMPAR contained information on background of the project, air quality management, water quality management, waste management, compliance assessment and financial provisions for closure and rehabilitation plans.

The EMPAR was done per the requirement of Section 55 MPRDA (28 of 2002) regulations which states that "as part of the general terms and conditions for prospecting rights, mining rights or mining permits and in order to ensure compliance with EMP and to assess the continued appropriateness and adequacy of EMP, a holder of such permit or rights must:

- Conduct monitoring on continuous basis;
- Conduct performance assessments of EMPs as required; and
- Compile and submit an EMPAR to the minister in which compliance is demonstrated.

The mine is currently in the operational phase following the completion of the construction phase. Decommissioning and closure as well as post closure plans have not yet commenced. Compliance for this report was only evaluated up to operational phase as the other stages have not been implemented yet. According to regulation 55 of the

MPRDA, frequency of EMPAR shall be in accordance with the period specified in the approved EMP which in MPM's case is once every two years. MPM currently operates with two shaft complexes (Driekop and Clapham), UG2 mineral processing unit, a tailing dam, a waste rock dump and water management facilities. The Driekop shaft consists of box cut and shaft/decline, storm water dam, workshop, settling dam, offices and ventilation shaft. The Clapham shaft consists of waste rock dump, Tailing Storage Facility (TSF), storm water dam, settling dam, Enrichsen dam, workshop, box cut, salvage yard, offices, plant, waste water treatment work and explosive yard. The above facilities form part of the compliance requirement in terms of facilities by mining operations (EMPARMPM, 2017). The facilities are compliance requirements for better environmental management and safety measures within the mine facility.

The EMP amendment (approved in January 2008) includes the third shaft complex and the following associated infrastructure, none of which have been constructed:

- A second concentrator plant;
- A chrome recovery plant;
- Facilities for tailing and waste rock disposal;
- Facilities for water management; and
- Upgrading of existing service and infrastructure.

4.2.1.2 Mining methods used at MPM

Marula Platinum Mine is an underground operation mine which can be in some sense less destructive than surface mining. However, underground mining can still cause some widespread damage to the environment (Chapuka, 2011).

Bureau of Geology and Mineral Resources (BGRM) (2001) highlighted the factors determining the choice of method to be used which includes location, geometry, morphology, depth, environment and sometimes mining tradition. Underground mining can be done in two different ways, namely adits and inclined shafts. Underground adits follow the seams for short distances and these are generally small and usually unventilated cuts. A series of regularly spaced horizontal and near horizontal drives are up to 250m long. They are constructed parallel to the strike of the seam where it outcrops along steep hill sides. Mining is usually done by hand drilling and blasting a narrow hanging wall cut. Platinum ore is then lifted by hand, transported down the adits to the surface either by rail and cocopan or by wheelbarrow. These have a very short mine life of about less than five years and are generally operated by small scale tributors, though some larger scale tributors can resort to adits during periods of economic slowdown and in wet seasons (Chapuka, 2011).

Recently, due to economic problems, some tributors have resorted to adits rather than inclined shafts. Ventilation and underground sanitation are essential in these operations in order to maintain good environmental health. Environmental problems can also arise as a result of poor management of waste. Inclined shafts also known as reuse mining can go to depths of more than 700m, with a deep pilot shaft having regularly spaced seam drives. It involves the stopping of seam drives on levels spaced at fixed intervals down an inclined pilot shaft, sunk parallel to the chromite seam. Drilling and blasting are followed by lifting of the ore by hand and tramming it to the pilot shaft. From there it is hauled to the ground mechanically. The above operations are usually done by tributors who can afford the equipment. These generally create large dumps which must be maintained and strategically positioned to avoid erosion and dump instability. Improper siting of the dumps occurs on steep slopes and along streams or river channels (Chapuka, 2011).

Differences have been noted in BGRM (2001) between underground methods and surface methods. These include the quantity of waste produced per unit of ore as lower in underground mines when compared to surface mines, the ground area affected by underground mines is smaller than surface operations and mechanical risks are greater for underground than surface operations. Figure 4.1 depicts an example of machinery used during underground mining and its process.

Figure 4.1: Underground mining machinery (https://www.google.co.za/url)

4.2.1.3 Types of waste generated at MPM

The wastes generated by the mining industry are mainly produced during the process of extraction, beneficiation and processing of minerals (Das and Choudhury, 2013). MPM generates both general and hazardous waste. General waste is mainly generated from the office and kitchen (domestic), these includes papers, boxes of equipment packaging, broken equipment (fax machines, computers, tables, and chairs) and food wrappings. Hazardous waste is generated in the plant facility and all three states of matter are generated, that is, gaseous (dust), liquid (oil) and solid (waste rock, tailing and overburden) wastes. Gaseous waste is generated during the operation and processing stage. Vibrations caused by explosions and movement of heavy machinery causes the generation of dust particles which pollutes the air. Machinery and vehicles need oil to function properly which has resulted in oil spillage on land in the facility which can contaminate surface (runoff) and underground (seepage) water. Solid waste in the facility is mainly caused by vegetation clearance and extraction of minerals which resulted in waste rock and overburden generation (EMPARMPM, 2017)

4.2.1.4 Management practices of wastes generated at MPM

The evolution of environmental policy and legislation generally follows a continual iterative process in which present laws reflect what society believes should be done to solve a historical situation that has become unacceptable. Current environmental policy and legislation should, therefore, embody environmental management practices intended to attain the desired present and future state of the environment. Both past and present policies and legislations are powerful driving forces in shaping the state of the environment (Walmsley and Walmsley, 2002).

A good management system of all wastes, whether general or hazardous, should therefore embody environmental policy and legislation as it reduces the impacts that a mining operation can have on the environment and its surrounding villages. Hence it is important to incorporate these measures from the beginning of mining life cycle until the end.

Section 2 of NEMA (107 of 1998) outlines certain principles which are relevant to sustainable development and environmental management. These principles relate broadly to sustainable development, integration, participation, empowerment and transparency, environmental justice and equity maintenance of ecological integrity and international responsibilities. Section 37 of the MPRDA (28 of 2002) confirms the adoption of the principles for sustainable development as set out in Section 2 of NEMA (107 of 1998) as well as other generally accepted principles of sustainable development. The above is achieved by integrating social, economic and environmental factors into the planning, implementation, closure and post-closure management of prospecting and mining operations. World Commission on Environment and Development (WCED) defines sustainable development as development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. It aims for equity within and between generations while adopting an approach where the economic, social and environmental aspects of development are considered in a holistic fashion. Sustainable development deals with principles such as duty of care, polluter pays, proximity analysis, product stewardship, among others. Duty of care principle also known as environmental responsibility principle, imposes the duty of acting with due care so that damage to others and the environment can be avoided. Duty of care principle goes hand in hand with the cradle to grave principle which states that any entity that generates waste has the final responsibility for ensuring that such waste is safely treated or/and disposed (NEMA, 1998).

Sustainable development is dependent on good governance at the provincial and local levels, as well as the integration of social and economic considerations in environmental management. There are several facets to governance that include: roles and responsibilities, planning, implementation and information management. Policy, legislation and planning are all responses that set the scene for specific actions necessary for effective implementation. Without implementation of policies, plans and programmes there can be no effective environmental management or reversal of negative environmental trends (Walmsley and Walmsley, 2002). The above implies that mining operation should take effective measures in ensuring that their operation does not have harmful impacts on the environment. Furthermore, mining operations are also responsible in implementing waste management practices that do not cause harm on the environment or its inhabitants. The section below covers waste management strategies that are used at MPM mine as guided by environmental policies and legislations in South Africa.

Training of staff members is the first and most vital step of a good waste management system. Employees at the mine need to know what type of waste they will be working with and how to handle that waste. The Human Resources Development Programmes (HRDP) in MPM include basic tool handling, basic hygiene and safety, basic environmental and pollution control, safe handling of material and tools as well as safe lifting and transportation of equipment. According to Implats (2004), their HRDP include appropriate training and skills development programmes as required by the workforce in support of the group’s workplace skills plan, operation-specific business plans (both mining and non-mining related) and other legislations. As such, emphasis is placed on the development of mining, engineering and plant related competencies and skills.

- Gaseous waste management

Reference.com (2018) defines gaseous waste as a waste product in gas form resulting from various human activities, such as manufacturing, processing, material consumption or biological processes. Potential sources of air pollution from mining industries identified by Walmsley and Walsmsley (2002) include particulate matter, asbestos fibers, heavy metals (e.g. vanadium, chrome) and odours. The Tailing Storage Facility (TSF) contractors maintain the dust suppression system (sprinkler system) as well as the alien invasive vegetation removal program on TSF, both of which are operational and effectively maintained. Inspite of the effort by TSF, there are levels of gaseous pollution effect at MPM from chemical emissions, dust generated from mine hydrocarbons, emissions from smelting plants, storage and handling of materials. Gaseous pollution is also contributed by mine processing, blasting, construction activities, roadways associated with mining activities, leach pads, tailing piles and waste rock piles emission such as dust. Marula Platinum Mine (MPM) has implemented measures to monitor fugitive dust. Fugitive dust is an environmental air quality term that refers to very small particles suspended in the air, the source of which is primarily the Earth's soil. It does not include particulate matter from other common sources, such as vehicle exhaust or smokestacks (Wikipedia, 2019). A truck with water is used to spray water on the site to lower the fugitive dust (EMPARMPM, 2017).

Dust deposition measurements are usually performed over monthly average sampling periods in accordance with American Society for Testing and Materials (ASTM) standards indicated in the dust control regulation. American Society for Testing and Materials International is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. Some 12.575 ASTM voluntary consensus standards operate globally (Wikipedia, 2018a). The National Dust Control Regulation (R. 827, GG No. 36974) also stipulates dust deposit rates that are permitted for residential and non-residential regions. There were a total of 11 non-residential exceedances around the mining site since December 2012. The new exceedances were predominately around the tailing dam in the northern area of the mine. Between December 2013 and December 2014, MPM had 4 exceedances at its main TSF areas whereas only one monitoring point recorded 2 exceedances within a 12 months period. Over the past 2 years, the dust fall has improved most notably around the tailing north monitoring point. The exceedances over the entire operation have dropped from 7 to 4. The average daily dust fall measured over the 12 months period has dropped from 326mg/m^2/day to 236mg/m^2/day. Monthly freeboard monitoring on top of the TSF is continuing, well maintained and complied with. MPM has conducted annual Ecological Function Analysis (EFA) since 2014 to monitor the entire TSF system's ecological function and assess its sustainability in maintaining itself, with closure in mind. In general, the function of the landscape meets the threshold values associated with a system nearing a state of self-sustainability (EMPARMPM, 2017).

To avoid the reduction in air quality due to excessive dust, Lafarge plant in Lichtenburg has implemented dust control measures. In the old quarry, dust is produced from the radial conveyor and it is wetted with wetting agents such as dust sprays to reduce the limestone dust produced. A truck with water is used to spray water and Dustex in the site to lower the dust. In order to reduce the releases of oxides of nitrogen the flame cooling and low-nitrogen oxide (NOx) burner was used. Lafarge plant also has Air Emission Licenses which help by ensuring that air quality is maintained. Just like the findings on this study, dust fall-out measurements in Lafarge are also done monthly to ensure compliance to the Dust Control Regulations. Surveys on noise and airborne pollutants are also done by the occupational hygienist and reports are submitted to the DMR, as required by the Occupational Health and Safety Act (OHSA). According to the company's EMPAR, in 2015 there was monitoring done on site and the air quality quarterly report indicated that particulate matter, NOx and sulphur dioxide (SO_2) are monitored. In order to reduce the releases of oxides of sulphur they use high grade coal in the kiln processes. In order to minimize the release of smoke and other gases, all vehicles and machinery are regularly maintained (EMPARL, 2015).

- Liquid waste management

Mining and prospecting often involve the use of water and may have an impact on a community's water supply and on rivers, wetlands, streams and groundwater. Activities that use water for mining include spraying for dust, pumping water from one location to another, storing dirty or clean water and others. All of these activities require a Water Use License (WUL) from the Department of Water Affairs (DWA) (CER, 2014). According to MPMs EMPAR, the mine applied for a WUL and it was approved and granted by the DWA before mining operation commenced. Summary of conclusion was done based on the Integrated Water Waste Management Plan (IWWMP) by SRK consulting in 2015. SRK Consulting is responsible for water monitoring within the plant.

Regulation 7(a) of the Government Notices (GN) 704 requires that water containing waste or any substance that is likely to cause pollution of water resources must be prevented from entering any water sources either by natural flow or by seepage and must retain or collect such substances or for use, re-use, evaporation or for purification and disposal. Although MPM has a WUL, the water quality of Moopetsi River (near the mining area) is deteriorating from upstream to downstream of the operation indicating the pollution effect that MPM has on this surface water resource. This is attributed largely to increased nitrate levels, although sulfate and chloride levels also increased downstream. Regulation 7(b) of the GN 704 further requires that all water systems, including residue deposits, in any area must be designed, modified, located, constructed and maintained so as to prevent the pollution of any water resources through the operation or use thereof. The deterioration appears to be due to contribution to the Tailing Storage Facility (TSF) as well as an additional source, possibly surface flow from the Driekop and Clapham shaft area from the Tshwenyane River detected at monitoring plants. The above implies that MPM is not compliant with Regulation 7(b) as the TSF is also one of the causes of deterioration of water bodies. However, the Total Dissolved Solids (TDS) data downstream of the TSF at certain monitoring points indicate a downward long-term trend. This can be attributed to the improved tailing water management. The most significant improvement since lining of the dam in 2011 is for sulfate. The most likely source of contamination has been identified as the unlined emergency dam. The dam has been emptied a couple of times since August 2013, but receives water on occasions when the pumps fail or maintenance is done. MPM plans to keep this dam empty until it is lined and licensed. Only lined dams will be in operation in the Claphams operation shaft. Runoff water flowing from the Clapham waste rock dump is contained in paddrocks for evaporation which reduces the pollution risk to the Moopetsi River via discharge into Tshwenyane River. MPM is facing challenges with fully complying to GN 704 Regulations, however, additional measures to fully comply with Regulation 704 to address the water containing waste risk to water resources are planned or in progress. The medium-term objectives will remain focused on nitrate as it is the most significant concern of contamination at MPM (EMPARMPM, 2017).

Baseline groundwater quality is based on early time data obtained between 1999 and 2004 from studies undertaken in 1998 (EMA, 1993), monitoring data in EMPAR 2001 (Rinson, 2001) and monitoring data from 2003 and 2004 from boreholes located outside or up-gradient of operational areas and/or potential sources. The Ground Water Quality Limits (GWQL) in the WUL, whilst similar to those of the preliminary Groundwater Reserve for Olifants B71E, are much lower than the natural or background groundwater quality for most of the boreholes with an exception of pH. Comparison of the background groundwater quality to the WUL specified GWQL, indicated that over 80% of the boreholes in and around the mine lease area would be considered as impacted including areas where the mine has never operated. Median ambient groundwater quality exceeds the limit of conductivity, calcium, sodium, magnesium, sulfate and nitrate with maximum concentration exceeding the limits for chloride and fluoride. This implied that the natural groundwater generally exceeds the WUL limits provided prior to the commissioning of the mine. The nitrate limits are considered unrealistic for a mining environment as elevated nitrates in upstream water are evident due to natural ecology of the area and surrounding community activities. The World Health Organisation (WHO) drinking water quality guidelines (2011) set the nitrate level at 11 mg/l as N, which aligns with the SANA241:2051 for lifetime consumption. Based on the above, it was recommended by SRK Consulting that the WUL at MPM be revised to a level that takes the ambient levels and human health risk factors into consideration (EMPARMPM, 2017).

Unlike MPM, Lafarge Lichtenburg was still in the process of acquiring the WUL as they have applied for it but had not received it (EMPARL, 2015). A water and waste management plan was submitted first on the 26th of May 2011 and it was still undergoing assessment by the Department of Water and Sanitation (DWS). At the moment they utilise water use certificates in place of the WUL which are temporary and give the total amount of water used in a year and ensuring that it is not exceeded. The water that is thermally polluted after use in the cooling process in the plant is recycled to be used again. There is water that can be contaminated from wash-off from handling of building materials, equipment materials, especially groundwater. These are materials such as raw materials (limestone additives), fuels (paraffin) and interim process materials (ground raw mix). To avoid such, storage facilities have impermeable floors or have under covers and have appropriate runoff containment measures. All the materials with the potential of polluting water are not being stock piled on bare ground (EMPARL, 2015).

- Solid waste management

Solid Waste Management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economics, aesthetic, engineering and other environmental considerations (LeBlanc, 2017).

As mentioned earlier, although underground mining is less of an environmental threat than surface mining, it can still have negative impacts on the environment. Underground mining generates large quantities of waste, such as waste rock, tailings, overburden, and sulphidic waste that often become toxic when it come into contact with air and water. Soil profile can get destroyed in the process upsetting the micro-organisms which inhabit it and pertubing natural nutrients cycling. It is important that solid waste generated from mining be properly handled so as to prevent negative environmental problems, especially for surrounding communities of mining areas (Greenpeace, 2016).

Section 24 of the Constitution of the Republic of South Africa (1996) states that, everyone has a right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that: prevent pollution and ecological degradation, promote conservation and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The polluter-pays-principle states that all costs associated with waste management should, where possible, be borne by the waste generator (NEMA, 1998). Mining companies in South Africa not only hire consulting companies to help improve environmental management in their facility, but they also hire waste management companies to outsource and treat wastes generated within the mine facility. MPM uses a waste company called Waste Legends for the management of its waste. The mine facility offers classes and training to staff on how to implement proper waste management of waste (EMPARMPM, 2017). Waste management practices that are employed at MPM facility noted in the company's EMPAR are discussed below.

- Characterisation

Characterisation of wastes is done both in the plant facility and offices at MPM. In the plant, characterisation is done based on the chemical and physical characteristics of type of waste by shaft workers that are well trained. In the offices characterisation is practiced by the mine workers as they are the ones that have to store different types of waste into their classified containers (EMPARMPM, 2017).

- Separation

All waste that is generated within the mine facility is separated at point of generation. General and hazardous wastes are separated and stored differently. In the offices, they have drums for plastic and paper in which the type of waste are stored in while at the plant, skips are used to separate the wastes. Skips are used to store steel, wood, old pipes, damaged machines, chemical containers and other types of hazardous waste (EMPARMPM, 2017).

- Container

A colour coding system is used to store the different types of waste that is generated in the offices at the mine facility. Both the containers in the offices and skips in the shaft have hazardous signs on them and have name tags showing which type of wastes should be thrown in the containers. The containers in the offices have refuse bags in them and a lid to prevent waste spillage and scattering. However, there were tanks in the aschem area that were not labeled properly (EMPARMPM, 2017).

- Storage

Both general and hazardous wastes generated at the mines offices and shaft are temporarily stored at point of generation in their designated storage containers.

Thereafter, the waste is then collected and taken to the salvage yard and aschem area where it will get collected for treatment and disposal by a hired waste contractor. Salvage yard is poorly maintained, the ground is bare, there is poor runoff control, poor sorting of waste, broken bundwall and a decrease in recycling volume. The mine facility has new aschem area that is used to store all petrol, diesel and oil drums. The aschem area is properly fenced with visible appropriate signage (EMPARMPM, 2017).

- Collection

Trained staff members in the plant and cleaners in offices collect generated wastes from the plant and offices on a daily basis to the salvage yard where they are stored until the day of collection by a waste collection company called Waste Legends. However, the staff members from the mine mix the wastes instead of properly putting the waste into proper stations in the salvage yard. Waste Legends collect the waste stored at the salvage yard on a weekly basis (EMPARMPM, 2017).

- Transportation

In the offices, waste refuse bags are collected by cleaners by hand and placed into a waste handling truck and transported to the salvage yard until the day of collection. In the plant, the skips are collected by trucks to the salvage yard until day of collection by Waste Legends (EMPARMPM, 2017). Figure 4.2 shows a truck owned by waste contactor Waste Legends which is used for the onsite collection of waste for treatment and disposal.

Figure 4.2: Waste collection truck from Waste Legends (Thovhakale, 2015)

All vehicles used for waste transportation in the mine are serviced in the workshop and cleaned at the washbays. These areas have drainage system that feeds to oil traps. However, there were minor cracks evident in the workshop floor (EMPARMPM, 2017). The negative environmental impact of cracks in the workshop is that this could result in seepage which ultimately affects underground water.

- Treatment

  The mine facility has hired a company called Waste Legends for the treatment and disposal of waste. Waste Legends collects both general and hazardous waste on a weekly basis (EMPARMPM, 2017).

- Disposal

  The mine facility does not practice disposal of waste on site and has hired a company called Waste Legends to outsource its waste for disposal (EMPARMPM, 2017).

- Rehabilitation

  Section 41(1) of the MPRDA (28 of 2002) states that an applicant for a prospecting right, mining right or mining permit must, before the Minister approves the EMP or environmental management program in terms of section 39(4), make the prescribed financial provision for the rehabilitation or management of negative environmental impacts. Section 42(2) of the same law states that, if the holder of a prospecting right, mining right or mining permit fails to rehabilitate or manage, or is unable to undertake such rehabilitation or to manage any negative impact on the environment, the minister may, upon written notice to such holder, use all or part of the financial provision contemplated in subsection (1) to rehabilitate or manage the negative environmental impact in question (MPRDA, 2002). The mine facility has not implemented rehabilitation plans as it is still in the operational phase. However, rehabilitation plans were outlined in the original approved EMP submitted to the DMR for license permit (EMPARMPM, 2017).

- Monitoring

  The mine facility has ongoing biomonitoring as per the mines biomonitoring programs in the WUL. The biomonitoring plans are conducted by SRK Consulting. Other monitoring plans on rehabilitation and post closure are not yet in place as the mine is still on its operational phase but they are outlined on the original approved EMP submitted to the DMR for license permit (EMPARMPM, 2017).

Similar waste management practices were noted in other EMPARs of mining companies in South Africa. At Lafarge Lichtenburg, they used the same consulting company as MPM (SRK Consulting) but they had a different waste contractor called EnviroServ Waste Management. Just like findings from this study, all wastes generated from the mine facility were characterised, classified and separated at point of generation. The bins have a label tag for the type of waste that should be stored in the bin and the company also uses a colour coding system just like in the findings of this study. According to the company's EMPAR, once full, these bins were collected from the areas and transported to Holfontein for disposal of the waste. All other wastes were conveyed from within the facility to the salvage yard area by EnviroServ and/or Lafarge staff or contractors. All waste conveyed to the salvage yard area are sorted by EnviroServ staff and all recyclable materials extracted from the waste are placed into the appropriate bulk bags/receptacles for baling and then removed/collected from site by EnviroServ truck. The remaining waste, non-recyclables and hazardous are placed in the correct bins at the salvage yard to ensure the most economical transportation and treatment method. Waste is treated or disposed of at a permitted facility at Holfontein. The onsite staff record the collections thereof. The recyclables collection slips, and the general and waste manifest documents are also included (EMPARL, 2018).

De Beers Venetia Mine has a consultant company called Green Gain Consulting (GGC) that is responsible for EMPAR. Same as MPM and Lafarge, De Beers Venetia Mine also characterised, classified and separated its waste at point of generation. The wastes are stored into appropriate containers that are found around the mine's facility and transported to the salvage yard when full. However, GGC noted that the salvage yard was not in good condition. The salvage yard had bare soil which did not have provision for containment of runoff water from the wastes and furthermore the wastes were not properly separated while temporarily stored. Vehicles at De Beers Venetia Mine were in good condition as they were serviced in accordance with a planned maintenance schedule. De Beers Venetia Mine had hired waste contractors called Basil Read and Barlow World who are responsible for the maintenance of heavy duty equipments. Basil Read and Barlow World ensure that heavy equipments are in good condition, that there are no oil spills in the facility which prevents contamination of soil from hazardous spills and leakage. They are also responsible for timeous spill management and clean up, mechanical maintenance on all critical equipments to prevent abnormalities and risk of failure and lastly they are also responsible for containment measures associated with pollution point sources (EMPARDBVM, 2015).

Modikwa Platinum Mine has a consulting company called GCS water and Environmental Consultants that is responsible for EMPAR. Just like the other mining companies above, Modikwa Platinum Mine characterized, classified and separated the wastes into appropriate containers at point of generation. Both hazardous and non-hazardous wastes are transported from various collection points around the site to designated collection points by trained staff members. Once full, all the hazardous and non-hazardous wastes are transported around site by specialised containers (bulk tankers) to prevent spillage. Fuel storage tanks are bunded and fitted with sumps to control spillage of fuels. However, according to the mines EMPAR, GCS noticed fuel spills on the floor at refueling bays in the facility. Medical wastes generated in the mine facility are stored in sealed containers provided by the supplier. The supplier is the one responsible for collection and removal of the medical wastes from site on a regular basis and is responsible for offsite treatment and disposal of such wastes. Rehabilitation and monitoring plans are to be implemented once mining is completed. This process will be in consultation with the regional manager in terms of Section 44 of the MPRDA 2002 (EMPARMPM, 2013).

4.2.2 Environmental compliance assessment as per NEMA (107 of 1998) and MPRDA (28 of 2002)

Environmental Compliance means conforming to environmental laws, regulations, standards and other requirements such as site permits to operate (Enviropaedia, 2015). To be able to derive the checklist for a compliance assessment, both secondary and primary methods were applied. Secondary data was obtained from environmental legislation, namely, NEMA (107 of 1998) and MPRDA (28 of 2002). Waste management practices and responsibility of the license holder expected from the mining industry was then obtained from the DMR in Limpopo at the end of 2017.

Key informant interviews were scheduled and conducted with staff members from LEDET who are involved in hazardous waste, including mine waste and related issues. Most of the information that was gathered from the interview matched that which was found from the legislation. The key informant interview was useful in validating the information used for the construction of the checklist. Additional waste documents such as the Anti-waste were obtained from LEDET. The Anti-waste document is licensed in terms of section 49(a) of NEMWA (59 of 2008) which is used for solid waste management practices.

After both secondary and primary data was collected, a checklist was constructed based on principles and waste management practices from NEMA and MPRDA as well as additional information gathered from the interview. The waste management practices of the mine were then compared to those stipulated by the legislation so as to check compliance level. Patmal and Maya (2014) used a similar approach for mining impact assessment and it is an appropriate method to be used in order for the researcher to address the research problem that motivated this study. Another reason for using this method was that MPM also used more or less a similar approach to assess environmental compliance in its operation as well as other major mining companies in South Africa. Table 4.1 gives an overview of compliance level of the mine. A legend is also provided in order to simplify findings.

Legend

• Compliant	-C
• Partially compliant	-PC
• Non-compliant	-NC
• Not available	-NA

Table 4.1 Compliance assessment checklist of MPM

	Marula Platinum Mine		**Assessment**
	Review criterion	**Observation**	
Responsibility of license holder	**Before:** MPRDA section 27(5) states that, the license holder should provide an EMP stating how it will avoid pollution and prevent ecological degradation. This must include environmental management principles set out in section 2 of NEMA (107 of 1998). Details of rehabilitation of residue should be included in the EMP.	MPM has an EMP that explains the strategies, methods and good practices to minimize environmental impacts during their operation. EMP was performed as per NEMA (107 of 1998) and MPRDA (28 of 2002).	C
	During: According to NEMWA (59 of 2008), the license holder in terms of MPRDA (28 of 2002) must ensure that a residue stockpile and deposit are constructed and operated in accordance with the EMP approved. As part of the monitoring system, the mining facility must keep record of	Approved EMP by DMR in place however there are still some technicalities that need improvement. Unauthorised access of residue policy is in place, fencing has signs but there are parts of the fence that are worn out and not in good condition.	PC

	measurements of all residue transported from the site. License holder should also ensure that appropriate security measures are implemented to limit unauthorised access to residue.		
	After: According to NEMWA (59 of 2008), the decommissioning, closure and post closure management of a residue stockpile and residue deposit must be done in accordance with the relevant provisions in the environmental management program and any other applicable legislation.	Decommissioning, closure and post closure plans not yet implemented but are outlined in the mine's company EMP.	N/A
Solid waste management practices	**Characterisation:** According to NEMWA (59 of 2008) section 4(2), residue stockpile and residue deposit must be characterised in terms of its physical and chemical properties/characteristics.	Characterisation of waste measures are put in place where wastes are characterised based on their chemical and physical characteristics at point of generation.	C
	Physical characteristics include the permeability, weight, size and strength of the material. Chemical characteristics include the toxicity, pH level, stability and reactivity of the material. NEMWA (59 of 2008) section 5(1) states that, a competent person must classify residue stockpile and deposit.	Classification of waste is done by mine workers who are trained on how to classify different types of waste.	C
	Separation: Wastes should be separated at point of generation, general wastes should not be mixed with hazardous waste.	All wastes that are generated at the mine (plant and offices) are separated at point of generation.	C
	Containers: According to NEMWA (59 of 2008) section 21, waste containers must be intact, not corroded or rendered unfit. Measures must be taken to prevent leakage or spillage. Containers for hazardous waste should have a biohazard sign.	The mine facility uses a colour coding system for the containers of waste which have a biohazard sign, name tag and lids. However, there were some oil tanks in the aschem area with no tags, there were oil spills in the aschem and there were signs of littering.	PC
	Storage: Temporary storage area should be secured and not cause nuisance such as	There is a designated salvage yard for temporal storage of waste within the	PC

	odour and visual impact.	mine facility. Unfortunately the storage area is not in good condition (bare ground, poor runoff control, lack of separation of waste, broken bundwall etc.)	
	Collection: Section 24 NEMWA (59 of 2008) states that, no person may collect waste for removal from premises unless such person is a municipality or municipal service provider or authorised by law to collect that waste.	Authorized waste contractor called Waste Legends collects wastes generated in the mine on weekly basis.	C
	Transportation: Section 25 (2) of NENWA (59 of 2008) states that any person engaged in the transportation of waste must take all reasonable steps to prevent any spillage of waste or littering from a vehicle used to transport waste.	The mine has hired a waste contractor called Waste Legends for the transportation of offsite treatment of waste. The vehicle used for transportation of waste is subjected to the requirements of NEMWA (59 of 2008) section 25(2).	C
	Treatment: The mine facility should have contractors for the treatment of both general and hazardous wastes.	The mine facility has hired a waste contractor called Waste Legends for treatment of wastes.	C
	Disposal: Section 26(1)(b) of NEMWA (59 of 2008) states that no person may dispose of waste in a manner that is likely to cause pollution of the environment or harm health and well-being of humans.	The mine has hired a contractor called Waste Legends that is responsible for waste disposal.	C
Rehabilitation	Section 42(1) of the MPRDA (28 of 2002) states that an applicant for a prospecting right, mining right or mining permit must, before the Minister approves the EMP in terms of section 39 (4), make the prescribed financial provision for the rehabilitation or management of negative environmental impacts.	Rehabilitation measures are not yet implemented as the mine is still in the operational phase but the measures are stipulated in EMP.	N/A
Monitoring	The mine must have after care programs to evaluate the effectiveness of rehabilitation measures.	The mine facility has on going biomonitoring as per the mines biomonitoring programs as it is in the WUL. Rehabilitation and post closure monitoring plans are not yet in place but outlined in EMP.	C

Based on the compliance assessment table, MPM was compliant with 65% and 21% partially compliant with waste management practices as stated by MPRDA and NEMA legislation. There were no practices that MPM was non-compliant of, and only 14% information on post closure waste practices could not be accessed by the researcher because the mine is still operational. Overall, MPM complies with waste management practices but needs some improvement on those practices they are still partially compliant on.

4.2.3 Self-regulatory/voluntary practices

4.2.3.1 The National Occupational Safety Association (NOSA) integrated five star systems at Marula Platinum Mine.

The National Occupational Safety Association integrated five star system is one of the voluntary practices. It is a South African initiative setting global standards in occupational risk management solutions that enhance client's business performance. Services and products are tailor made according to clients' needs and risk profiles and include areas such as occupational health, safety, hygiene, working at heights, environmental management, mine safety, quality management, behavior based safety, Human Immune Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) in the workplace, social responsibility and sustainability (NOSA, 2012). The NOSA integrated five star system is a risk based management system, whose main idea is to optimize profits and minimize loss, including loss relating to people, assets, process material and the environment. The NOSA integrated five star system components, also known as loss exposure areas (safety, health and environment) are protected against any loss using the risk based approach. Risk management involves first identifying and assessing risks, with the aim of ensuring that effective control measures are in place to combat any possible risk. The NOSA integrated five star system adopted the risk based approach to ensure effective loss control. In terms of environmental management it therefore implies that the system can control site specific environmental problems as they are identified at source point (Chapuka, 2011).

Marula Platinum Mine (MPM) has an environmental office for all health, safety and environmental issues within the mine facility. The environmental office is responsible for ensuring that waste management practices as per the South African laws (mandatory and voluntary) are put into place and followed, this includes NEMA and MPRDA practices. The environmental office is also responsible for ordering supplies such as waste containers for the entire mine, in the plant and offices. This office also deals with supply of uniform for staff members, mine injury of staff members or unfortunate cases of loss of life of staff member and organising training for staff members (EMPARMPM, 2017).

Similar to MPM, other mining companies in South Africa such as Modikwa Platinum Mine, De Beers Venetia Mine and Lafarge Cement Mine had NOSA offices. The offices are responsible for environmental and safety issues within the mine facility (EMPARMPM, 2013; EMPARDBVM, 2015: EMPARL, 2018). At the environmental offices, there are environmental officers/practitioners that are responsible for ensuring that mandatory and voluntary practices are implemented and followed. The officers are also responsible for supplying required information for the assessment of EMPAR by consulting companies hired by the mine.

4.2.3.2 Strength, Weakness, Opportunity and Threat (SWOT) analysis

The SWOT analysis was based on findings from both secondary (EMPAR) and primary (questionnaire survey) data that was used to answer the aim and objectives of the study. The SWOT analysis was based on all three objectives of the study from compliance, challenges with solid waste management practices and impacts of the mine on surrounding communities (economic, environmental and social).

Table 4.2 SWOT analysis for Marula Platinum Mine (MPM) operation

Strength	**Weaknesses**
1. Approved EMP in place. 2. Compliance to EMP regulations as stated to MPRDA and NEMA practices. 3. Job creation for local community members (permanent and contract). 4. Offers bursaries to local students who want to go for higher education.	1. Ineffective structure and a non-complying waste facility in salvage yard. 2. Accumulated and poor sorting of waste. 3. Poor handling of waste from staff. 4. Broken bund-wall of hazardous storage area. 5. A decrease in recycling of waste.

5. Social infrastructure development (tarred road, pre-school facilities). 6. Stimulation of micro businesses for local community members (accommodation, vendors, and taxi businesses).	
Opportunities	**Threats**
1. Twenty seven percent (27%) of the mine shares have been equally distributed among the following three BEE partners: Marula community trust, Mmakau mining and Tubatse mining. 2. Mine facility offers refuse bins for domestic waste to local community members. 3. Funding for local community projects (brick making yard and establishment of a crèche.	1. Conflicts with neighbouring communities which resulted in strikes in 2017, twice within a period of 5 months 2. False accusation of disposal of domestic waste (dippers) in surrounding communities of the mine. 3. Death of a staff member on duty in 2017.

Table 4.2 shows that although the mine has had its fair imprints of negative impacts environmentally and socially, it also has its positive impacts. The mine has not only created direct and indirect employment but it also offers bursaries to local students to further their studies. In terms of the weaknesses and threats, the mine could improve its management of solid waste by fixing the salvage yard and bund wall and educating the staff members more on the importance of sorting and handling waste properly.

4.3 Assessment of challenges that hinder environmental compliance of solid waste management practices in Marula Platinum Mine.

Solid waste management issues can arise from different stakeholders in the overall management of waste. Management could sometimes understock waste equipments, staff members might not follow correct practices and off-site treatment agency may not follow day allocation for collection of waste. The solid waste management challenges noted from MPM's EMPAR were not from NEMA and MPDRA practices but from the Anti-waste document obtained at Limpopo Department of Economic Development, Environment and Tourism (LEDET).

According to the Anti-waste document (which is in line with NEMWA 59 of 2008) under the section of site security and accessibility control, it is the responsibility of the license holder to ensure effective access control by having the site fenced by a minimum height of 1.8m with gates of the same height to all entrances. By so doing, this helps in preventing unauthorised access entry and curtails the spreading of wind-blown waste. Furthermore, the license holder must have all entry points manned during operation hours and locked after working hours. The fencing of the barriers should also have warning signs at appropriate intervals. These warning signs must be in picture format and/or written in English, Afrikaans and Sepedi.

One of the challenges noted in the EMPAR from MPM was that some part of both the Driekop and Clapham fencing area of the mine was broken meaning that livestock and pets from the surrounding area can have access within the mine. Another disadvantage of the broken fence is that solid waste generated from the mine can be easily blown by wind to the surrounding villages. The barriers have signs which are visible and internationally accepted, however, placing of these signs can be improved (EMPARMPM, 2017).

Mining operations at MPM can cause detrimental impacts on land because during operational phase due to the movement of mine cars, trucks and mine machinery there is release of oils onto the land. Over time, the soils profile of the areas will be considered dead because micro-organisms will die and the soil will no longer be productive. One of the challenges from MPM was oil spillage within the mine facility and how the spillage has affected soil quality (figure 4.3). The arrows on the figure are pointing at the dark patches that were caused by oil spills at MPM facility.

Figure 4.3: Oil spillage in MPM facility (Thovhakale, 2015)

Additionally, some of the challenges faced during the management of solid waste practices noted from the EMPAR in the salvage yard included ineffective structure and a non-complying waste facility, littering, accumulated and poor sorting of waste, poor handling of waste from staff, broken bund wall of hazardous storage area and lastly, a decrease in recycling of waste (EMPARMPM, 2017).

Other mine companies had some similar challenges as those noted in MPMs EMPAR. According to the EMPAR from Modikwa Platinum Mine, there was a central workshop in which the pollution dam was full and there were spills on the environment, the oil skimmer was leaking, bins were leaking oil and grease and the housekeeping at the workshop was in poor condition. There were also signs of fuel spills on the floor at refueling bays in the facility (EMPARMPM, 2013).

Just like the salvage yard at MPM, De Beers also had more or less the same problems in terms of its management. The salvage yard at De Beers Venetia Mine had bare soil which did not have provision for containment of runoff water from the wastes and furthermore the wastes were not properly separated while temporarily stored (EMPARDBVM, 2015).

Mining has several unavoidable detrimental effects on the environment, some are from poor waste practices implemented at the mine facilities while others appear to be exacerbated by poor legislation and/or weak law enforcement. According to a statement in November 2017 by the Department of Water and Sanitation (DWS), at least 36 mines in South Africa were operating without WUL (FSD, 2018). This suggest that there are some mining companies in South Africa that are operating without environmental authourisation as WUL is one of the basic permits to be obtained by license holders before commencing of a mine operation.

According to a study produced for the Gauteng city region in 2015, the province contains 374 mine residue areas, which include tailings dams as well as other sites of localised mine waste. Along with 6 152 ownerless and derelict mines they continue to pollute the soil, air, and water. Rehabilitation costs have been estimated by the auditor general at R30 billion or more. Partly as a result of poor regulation or the absence thereof (FSD, 2018).

One of the major challenges that hinder environmental compliance of mining operations in South Africa is improper law enforcement. According to a report by the Department of Planning, Monitoring, and Evaluation the DMR does not adequately police mine rehabilitation funds. Nearly half of all South African mines did not set aside enough money to clean up their mess and the DMR lacked the necessary capacity, staff, and legal expertise to do its job. AgriSA said that state governance of mining is poor. Among other problems, the application of legislation affecting mining and the environment was taking place in a haphazard manner (FSD, 2018).

High unemployment and weak law enforcement have resulted in the growth of a large industry of illegal mining. Much of this takes place in derelict mines, although some of the illegal miners work clandestinely in operating mines. According to some estimates, as many as 30 000 people work in illegal mining and a large number of these are believed to be illegal immigrants. Many of them are also one-time employees of mining companies. These operate without complying with mining legislation. The Chamber has estimated that the annual commercial value of illegal mining and illicit dealings in precious metals and diamonds is more than R7 billion. Some of the output such as gold is sold via international syndicates. Other minerals extracted, such as coal, are sold to local communities (FSD, 2018).

4.4 Evaluation of effects of waste management practices on the communities surrounding Marula Platinum Mine.

Section 24(a) of the Constitution states that *everyone in South Africa has the right to a healthy environment that does not harm their health or well-being. The environment must be protected for current and future generations. If a mining company wants to mine, it must do so in a way that is sustainable and ensures that future generations can also benefit from South Africa's resources* (Constitution of the Republic of SA, 1996). Mining must be operated in a way that there is no harm to the environment which will ultimately affect the living conditions of its inhabitants. Section 37 of the MPRDA (28 of 2002) states that *any prospecting or mining operation must be conducted in accordance with generally accepted principles of sustainable development by integrating social, economic and environmental factors into the planning and implementation of prospecting and mining projects in order to ensure that exploitation of mineral resources serves present and future generations.*

Mineral development can create new communities and bring wealth to those already in existence but it can also cause considerable disruption. New projects can bring jobs, business activities, roads, schools, and health clinics to remote and previously impoverished areas, but the benefits may be unevenly shared, and for some there may be poor recompense for the loss of existing livelihoods and the damage to their environment and culture. If communities feel they are being unfairly treated or inadequately compensated, mining can lead to social tension and sometimes to violent conflict. If improperly managed (lack of environmental compliance), mining operations can also have negative impacts on the environment (physical, social and economic) they operate in. It is important that mining operations adhere to environmental laws in order to prevent or minimise environmental impacts that mining can have on surrounding communities. This objective looks at how mining activities in MPM have affected communities of the three nearest villages, namely, Diphale, Magabaneng and Seuwe from an environmental, social and economic perspective.

To address this objective, a questionnaire survey was conducted in the above villages surrounding the mine. A total number of 232 questionnaires were completed during the survey. Secondary data on benefits from the mine to the surrounding communities was obtained from EMPAR and mine company documents were also used to support socio-economic developments initiated by MPM. Sections covered include demographic information of respondents, environmental, socio-cultural and economic impacts caused by MPM activities.

4.4.1 Demographic information

This section looks at the demographic composition of the respondents used for the purpose of the study. Demographic information covered included gender, age, marital status, level of education, occupation, level of income, household composition and lastly, number of years that the respondent had been residing in the village.

4.4.1.1 Gender of respondents

Gender refers to the socially constructed characteristics of women and men such as norms, roles and relationships of and between groups of women and men. It varies from society to society and can be changed (WHO, 2018).

Figure 4.4 shows gender composition of respondents used in the study. In Diphale village, 52% of the respondents were female and 48% were male. In Magabaneng village, 63% of the respondents were female and 37% were male. In Seuwe village, 52% of the respondents were female and 48% were male. From the above information, it can be seen that females constituted a larger proportion in all of the three villages than male respondents amounting to 56% of the entire sample size while males accounted for 44%.

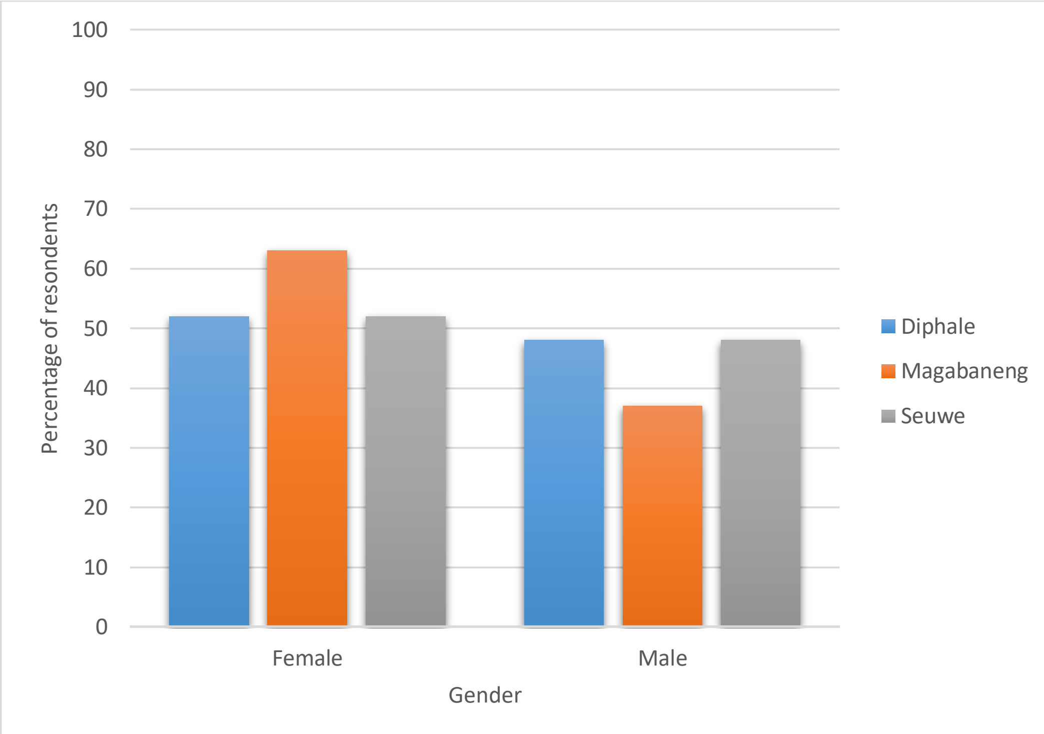


Figure 4.4: Gender composition of respondents

A study conducted by Jones (2010) in Kenyasi, Ghana did not reveal same gender composition as found in this study. Forty percent (40%) of the respondents were female and 60% were male. This shows that the study was dominated by male respondents. This was influenced by the fact that households in the community were male dominated. Cultural practices also played a key role in who took part in the study as males are given respect and as such they were the ones who took part in answering the questionnaire more than females.

4.4.1.2 Age of respondents

Age refers to the length of time that a person has lived or a thing has existed (Houghton, 2002). Respondents in the study age group ranged from 18 years and above in all of the three villages. The minimum age group for all the three villages was between 18 and 27 years while the maximum age group was 58 years and older (table 4.3).

In Diphale village, 21% of the respondents were aged between 18 and 27 years, 22% were aged between 28 and 37 years, 21% were aged between 38 and 47 years, 14% were aged between 48 and 57 years and 22% were aged 58 years and older. The median age range was between 38 and 47 years and there were multiple age range mode 28 and 37 years and 58 years and older. The second age range mode was 18 and 27 years as well as 38 and 47 years. The standard deviation for the age range in this village was 1.45.

Table 4.3 Age of respondents (years)

Name of village	**18-27 (%)**	**28-37 (%)**	**38-47 (%)**	**48-57 (%)**	**58 above (%)**	**Median in age group (years)**	**Mode in age group (years)**	**Standard deviation**
Diphale	21	22	21	14	22	38-47	28-37 and 58 and older	1.45
Magabaneng	33	19	20	13	15	28-37	18-27	1.46
Seuwe	33	23	21	15	8	28-37	18-28	1.31

In Magabaneng village, 33% of the respondents were aged between 18 and 27 years, 19% were aged between 28 and 37 years, 20% were aged between 38 and 47 years, 13% were aged between 48 and 57 years and 15% were 58 years and older. The median age range was between 28 and 37 years and the age range mode was between 18 and 27 years. The standard deviation for the age range was 1.46.

In Seuwe village, 33% of the respondents were aged between 18 and 27 years, 23% were aged between 28 and 37 years, 21% were aged between 38 and 47 years, 15% were aged between 47 and 48 years and 8% were aged 58 years and older. The median age range was between 28 and 37 years and the mode age range was between the ages of 18 and 27 years. The standard deviation for the age range was Seuwe 1.31.

Magabaneng and Seuwe villages seem to have similar age characteristics in terms of the median (28 and 37 years) and age range mode (18 and 27 years) while Diphale’s median age range was between 38 and 47 years and had multiple age range mode from 28 and 37 years and 58 years and older. Magabaneng and Seuwe villages had a larger number of respondents aged between 18 and 27 years while Diphale village had a larger number of respondents from two age groups, those of 28 and 37 years and 48 and 57 years. The above indicated that Magabaneng and Seuwe villages had a larger number of younger respondents than Diphale village which had both a middle age and aging number of respondents.

When all of the three villages are combined, the highest number of respondents is in the youngest age group (18 and 27 years) while the age group with the least respondents was aged between 48 and 57 years. The reason for a higher number of younger people in the area could be based on the fact that there is a high level of unemployment for youth in South Africa, hence they decide to stay at home until they find job opportunities.

4.4.1.3 Marital status of respondents

Marital status, is any of several distinct options that describes a person's relationship with a significant other. Married, single, divorced, and widowed are examples of marital status (Wikipedia, 2018e). In Diphale village, 51% of the respondents were single, 40% were married, 8% were widowed and 1% were divorced. In Magabaneng village, 61% of the respondents were single, 26% were married, 10% were widowed and 3% were divorced. In Seuwe village, 52% of the respondents were single, 41% were married, 7% were widowed and there was no respondent that was divorced (figure 4.5).

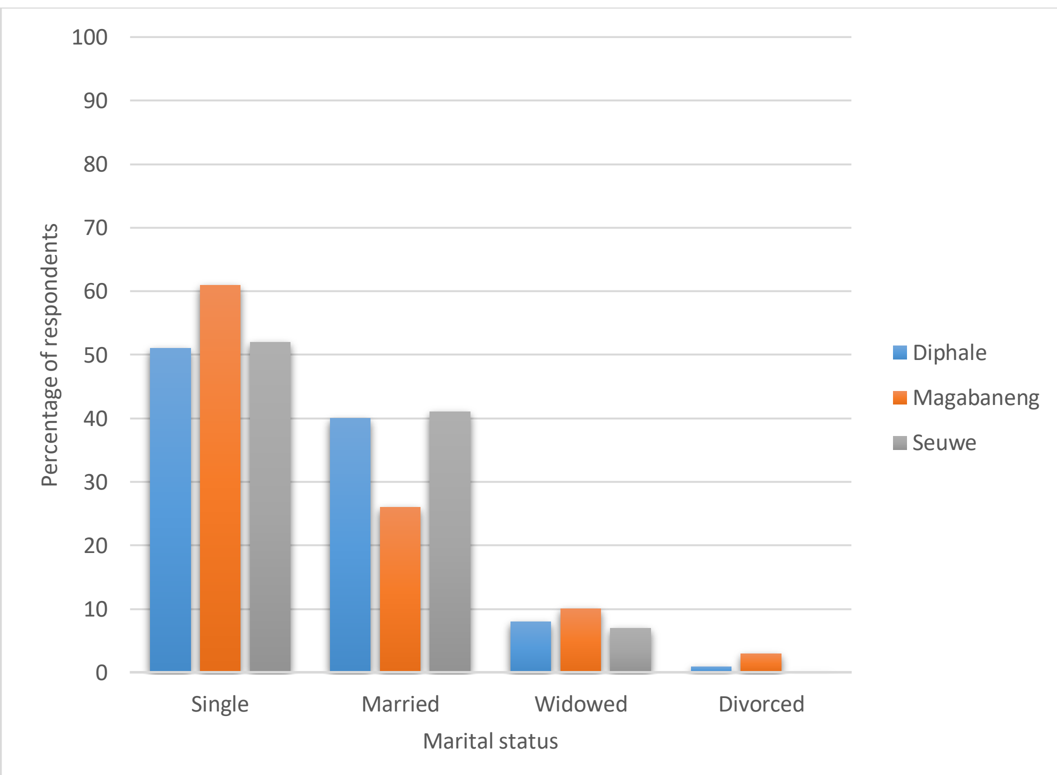


Figure 4.5: Marital status

From the above, one can conclude that there was a number of respondents who were single that participated in the study amounting to 55% of the entire sample size. The reason behind this could have been based on the fact that majority of the respondents were not only female but also because the age range with a large population was between 18 and 27 years. In this century, younger people prefer getting jobs and being stable before committing into marriage and starting a family as compared to before. Another reason for high level of single people could also be that there is a larger ratio of females to males worldwide and in South Africa while it is not legally allowed for a man to marry two or more women. Census (2011b) revealed that there were 160 398 males and 175 278 females in Tubatse Local Community. The above implies that there were 14 880 more females than males. Although polygamy is still practiced in certain parts of South Africa (especially in rural areas), there were no respondents that mentioned practicing polygamy in this study.

4.4.1.4 Level of education of respondents

Level of education refers to the act or process of acquiring knowledge, especially systematically during childhood and adolescence (RD, 2017c). It can be grouped in many stages, that is, no formal level of education, primary, secondary, tertiary and Adult Basic Education and Training (ABET) depending on a country one originates from. Level of education can be a key determinant of knowledge and perception of respondents on environmental (physical, social and economic) impacts caused by mining activity. It is believed that the more a person is educated, the more they are well informed about mining and it impacts both in a negative and positive way. People that are educated were likely to be exposed to the evolution (mining methods and technology) and advancement (law and safety measure) of mining over the past decades. Their ability to read, write and listen also exposes them to more information from different media sources hence making them more open-minded or not, to the idea of mining in their environment.

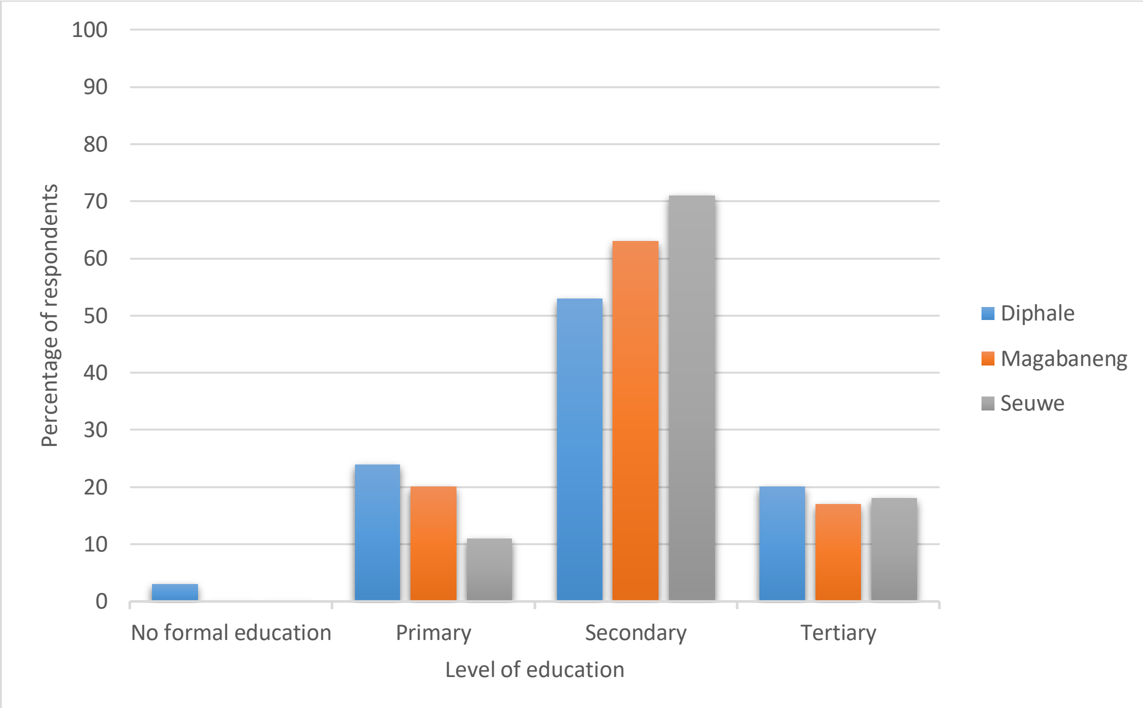


Figure 4.6: Level of education

In Diphale village, 3% of the respondents had no formal education, 24% had primary, 53% had secondary and 20% had tertiary level of education. In Magabaneng village, there were no respondents with no formal level of education, 20% had primary, 63% had secondary and 17% had tertiary level of education. In Seuwe village, there were no respondents with no formal level of education, 11% had primary, 71% had secondary and 18% had tertiary level of education (figure 4.6).

Table 4.4 Comparison of literacy level across age groups in villages

Level of education	**18-27 (%)**	**28-37 (%)**	**38-47 (%)**	**48-57 (%)**	**58 above (%)**
No formal	0	0	0	0	2
Primary	1	2	4	3	8
Secondary	19	16	14	9	3
Tertiary	8	3	3	2	3

Most of the respondents in the villages surrounding MPM were literate. This is evidenced by the fact that only 2% of the entire sample size had no formal schooling while the rest had some formal level of education and others even had qualifications (teaching, nursing, administration). The majority of the respondents (61%) had up to secondary level of education. When asked why they did not further their education they stated that they were from poor backgrounds and could not afford to pay tuition for higher level of education (table 4.4).

Table 4.5 Pearson Chi-Square Test results on comparison across level of education and age groups

	Value	Degree of freedom (df)	Significance (P)
Pearson Chi-Square (X^2)	59.878	12	0.001
Likelihood ratio	55.810	12	0.001
No of valid cases	232		

Significance level of 0.05

Table 4.5 shows comparison of literacy level across age groups using Pearson Chi-Square Test. All of the younger respondents were well educated (X^2= 59.878, df=12 (26.2) and P=0.001). Since X^2 is greater than df and P value of 0.001 is less than 0.05, it means that there is a relationship between literacy and age, younger respondents had some level of education as compared to the elderly group. This is evidenced by the fact that none of the respondents aged between 18 and 27 years reported having no formal level of education at all while those aged 58 years and above were the only respondents without any formal level of education. Again, age group between 18 and 27 years had a higher number of respondents of the secondary and tertiary level of education in all the three villages.

A study by Euromix (2014), revealed different results than those in this study. Only 31% of Rustenburg's population aged 20 years and over had completed high school and only 9% of that same age group had some form of higher education. Five percent (5%) of those aged 20 years and older had received no form of schooling. On-the-ground research revealed overcrowded schools and a lack of basic schooling infrastructure. In addition, the recent platinum strikes had contributed to a professional skills drain with many teachers leaving Rustenburg to find jobs elsewhere.

4.4.1.5 Employment status of respondents

Employment is a relationship between two parties, usually based on a contract where work is paid for. One party, which may be a corporation, for profit, not-for-profit organization, co-operative or other entity is the employer and the other is the employee. One major determinant of the social status and economic power of people is their employment and occupation (Jones, 2010). In order to understand the economic livelihood of the people *vis-à-vis* their poverty levels and a high expectation of job creation and opportunities with the onset of mining by MPM, the occupational background of the respondents were sought. Although it is believed that mining increases level of employment in villages neighbouring the mine, there were high levels of unemployment that were observed in the three villages (figure 4.7).

In Diphale village, 1% of the respondents were students, 46% were unemployed, 30% were employed, 11% were self-employed and 12% were pensioners. In Magabaneng village, 2% of the respondents were still students, 66% were unemployed, 16% were employed, 9% were self-employed and 7% were pensioners. In Seuwe village, 7% of the respondents were students, 53% were unemployed, 19% were employed, 14% were self-employed and 7% were pensioners.

Although Magabaneng and Seuwe villages are a kilometer closer to MPM than Diphale village, the two villages had a larger number of respondents that consisted of unemployed people than the other. Based on the data above that Magabaneng and Seuwe village had a larger number of respondents aged between 18 and 27 years while Diphale village had a larger number aged between 28 and 37 years and 48 and 57 years, this could be a factor in high levels of unemployment in the two villages as there are currently high levels of unemployed people in South Africa, especially for the youth. According to Stats SA (2018), the unemployment rate in South Africa in the first quarter of 2018 was at 26.6% and the South African youth are vulnerable in the labour market.

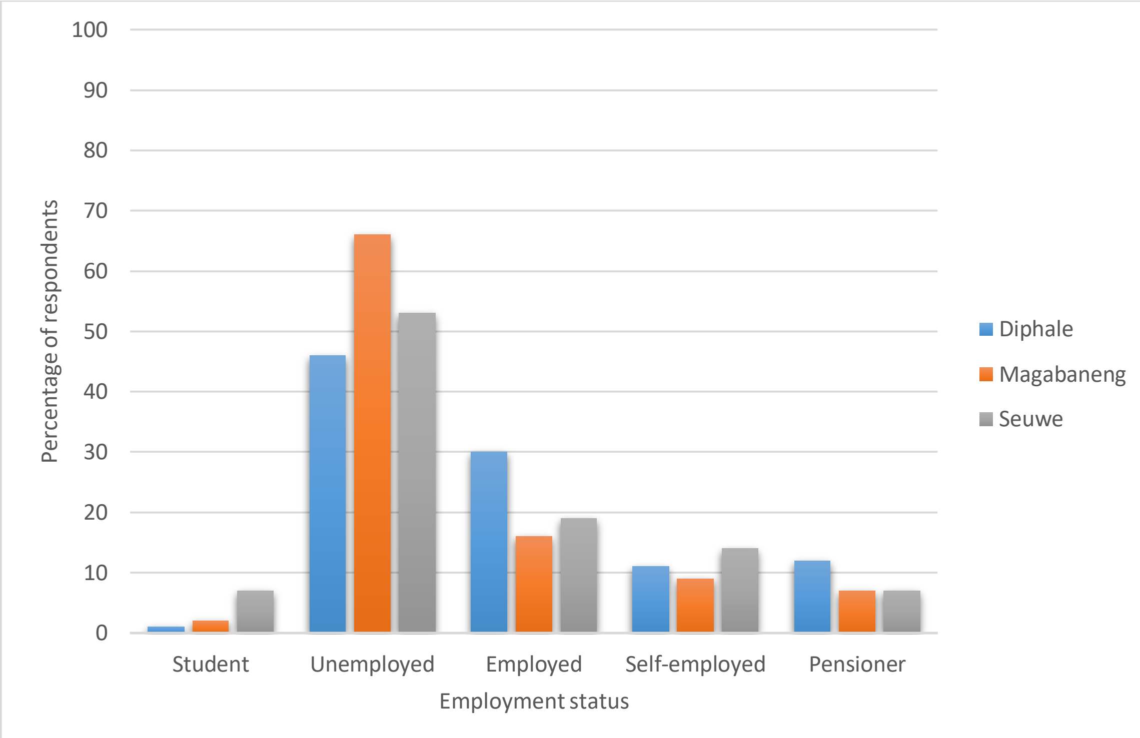


Figure 4.7: Occupation status

Youth unemployment, however, is not unique to South Africa, it is a global phenomenon. There were about 71 million unemployed youth, aged 15 and 24 years, globally in 2017, with many of them facing long-term unemployment (ILO, 2017). In South Africa those aged 15 to 34 years are considered as youth. South Africa's unemployment rate is high for both youth and adults, however, the unemployment rate among young people aged 15 to 34 years was 38.2%, implying that more than one in every three young people in the labour force did not have a job in the first quarter of 2018 (Stats SA, 2018). The findings from this research support those that were found in Stats SA as there was a level of high unemployment of respondents aged between 18 and 27 years and 28 and 37 years. Types of occupations mentioned by respondents included teaching, nursing, cashier, domestic worker and mine workers (engineer, environmental practitioner, shaft worker). Self-employed respondents mentioned mechanic, construction, plumbing and dress making businesses.

In a study by Jones (2010), in Kenyasi, Ghana, similar characteristics of high levels of unemployment were noted. From the responses given, the majority of the people were mainly involved in agricultural farming and continue to farm even with the start of mining in the community. Only a few people were engaged in other forms of petty commercial businesses such as selling phone cards and credit transfers, building materials, liquor, roasted plantains, sachet water and bicycle repairing. Even those engaged in petty business at one point or the other go to the farm and only use the petty commercial business as support or back up to their main economic livelihood which is farming. Only 10% of the respondents said that they had jobs while the remaining 90% were unemployed.

4.4.1.6 Income of respondents

Income is the sum of all the wages, salaries, profits, interest payments, rents, and other forms of earnings received in a given period of time (Wikipedia, 2018d). Reverso Dictionary (2017b) defines income as the amount of monetary or other returns, either earned or unearned, accruing over a given period of time. Due to high levels of unemployment in the area, this resulted in low levels of income in the three villages. Majority of the respondents depended on salaries from a family member, grants from the government while others had no source of income at all (figure 4.8).

In Diphale village, 61% of the respondents had an income of R2000 or less, 14% had an income between R2001-R4000, 9% had an income between R4001-R6000, 3% had an income between R6001-R8000, 9% had an income between R8001-R10000 and only 4% earned above R10000 per month.

In Magabaneng village, 77% of the respondents had an income of R2000 or less, 7% had an income between R2001-R4000, 3% had an income between R4001-R6000, no one had an income between R6001-R8000, 4% had an income between R8001-R10000 and only 9% earned above R10000 on monthly basis.

In Seuwe village, 65% of the respondents had an income of R2000 or less, 13% had an income between R2001-R4000, 5% had an income between R4001-R6000, no one had an income between R6001-R8000, 9% had an income between R8001-R10000 and only 8% earned above R10000 per month.

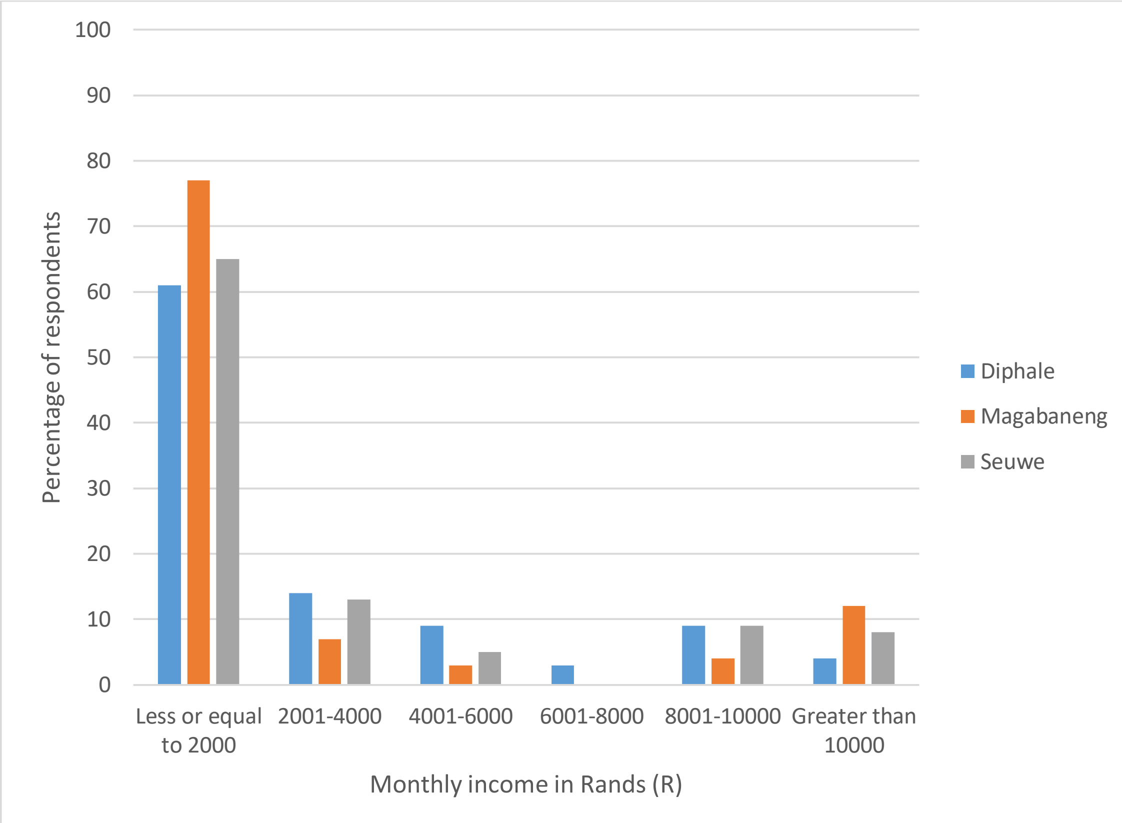


Figure 4.8: Income level per month

All three of the villages had similar characteristics in that the majority of the respondents (68% of the entire sample size) had an earning of R2000 or less per month. Of the 68% respondents, some were unemployed, others depended on grant money from the government (child grant or old age pension) while others depended on family members that had jobs. Those that had jobs but still earned R2000 or less on monthly basis, were domestic workers or sold at the vendor market next to the mine facility. Respondents that had earnings of between R2001-8000 per month were either self-employed, worked as taxi drivers, cashiers or builders. Some of the respondents stated that their earnings sometimes depended on busy seasons hence their income was not stable. Respondents that had monthly earnings of R8001 and above worked at the mine (engineer, shaft worker, digger, environmental officer), government and private sector.

Although North West is a province that accounts for highest mining revenue in South Africa, there were still high levels of unemployment as those noted in this study. Census measurement in 2011 of unemployment in Rustenburg stood at 26.4% (amounting to roughly 70,000 people), while youth unemployment was at 35%. Furthermore, 30% of the economically active population earn no income and 24% of households live on less than R600 per month. The poverty level is at almost 62% of the population, which is higher than the national poverty rate. Additionally, income inequality was substantial and along racial lines with poverty highly concentrated among Black Africans. The annual earnings of the top 5% of earners represent the annual earnings of 70% of the general population, while the middle class consists of less than 3% of the total population. Black Africans account for 90% of the less than R2 400 income group. The strong asymmetry between White families and Black families is compounded by the fact that segregation is not only economic, but also geographic (Euromix, 2014).

4.4.1.7 Household size of respondents

A household refers to the people living together in one house collectively (RD, 2017a). It consists of one or more people who live in the same dwelling and also share meals or living accommodation, and may consist of a single family or some other grouping of people (Wikipedia, 2018c). In Diphale village, 5% of the respondents were from a household of 2 or less people, 68% were from a household of 3 to 6 people, 26% were from a household of 7 to 10 people and 1% were from a household of more than 10 people. In Magabaneng village, 3% of the respondents were from a household of 2 or less people, 52% were from a household of 3 to 6 people, 29% were from a household of 7 to10 people and 16% were from a household of more than 10 people. In Seuwe village, 5% of the respondents were from a household of 2 or less people, 53% were from a household of 3 to 6 people, 25% were from a household of 7 to10 people and 17% were from a household of more than 10 people.

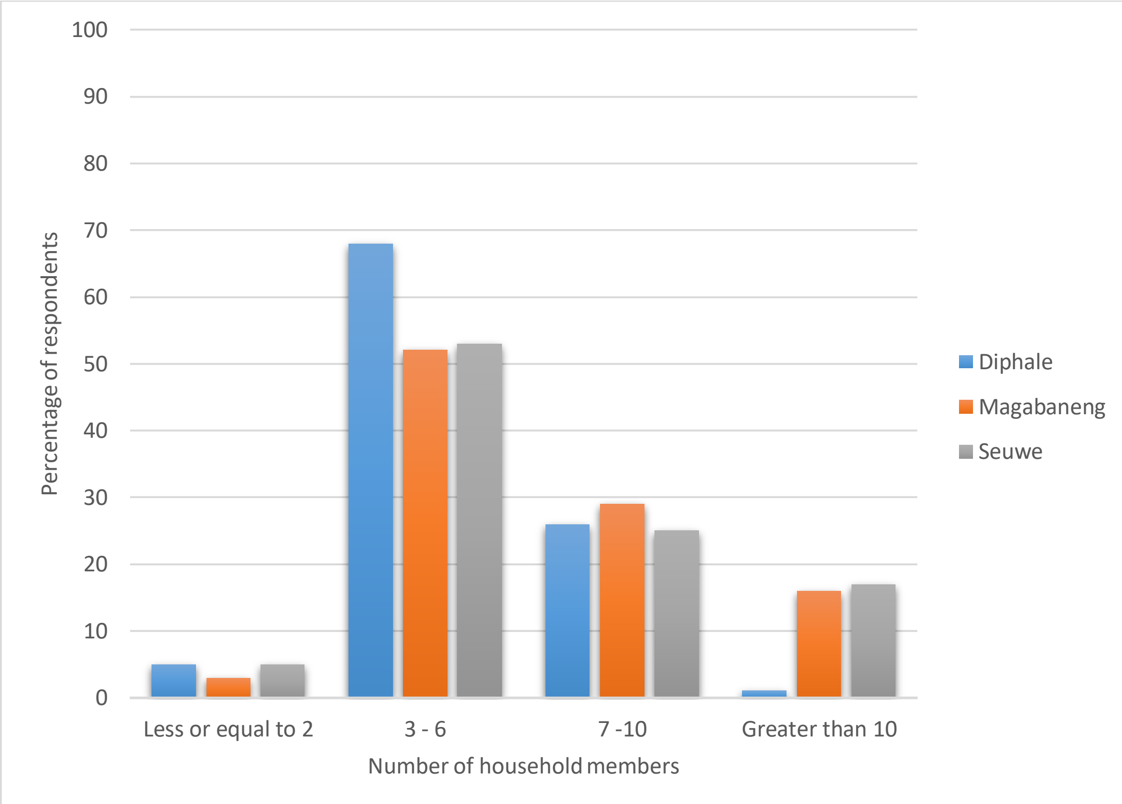


Figure 4.9: Household size

Figure 4.9 shows that all three villages had a larger percentage of people residing in a household of 3 to 6 people followed by 7 to 10 people. Diphale village did however have the highest percentage of respondents that were staying in a household of 3 to 6 people and the lowest percentage of respondents with more than 10 people. Magabaneng village had the lowest percentage of respondents that were staying in a household of 2 or less people and had the highest percentage of respondents with 7 to 10 people per household as compared to the other two villages. Seuwe village had the same percentage of households made of 2 or less people as Diphale. The median for all the three villages was 3 to 6 people per household.

4.4.1.8 Number of years of respondents residing in the village

Reside means to live permanently or for a considerable time in a place (RD, 2017d). Respondents were asked about the number of years that they had been residing in the three villages where the survey was conducted. This question was particularly useful and worth asking as it helped to determine the level of familiarity and knowledge of environmental and social issues in the community before and after the start of mining operations by MPM. Respondents were therefore able to give a comparative account of the situation in an objective manner.

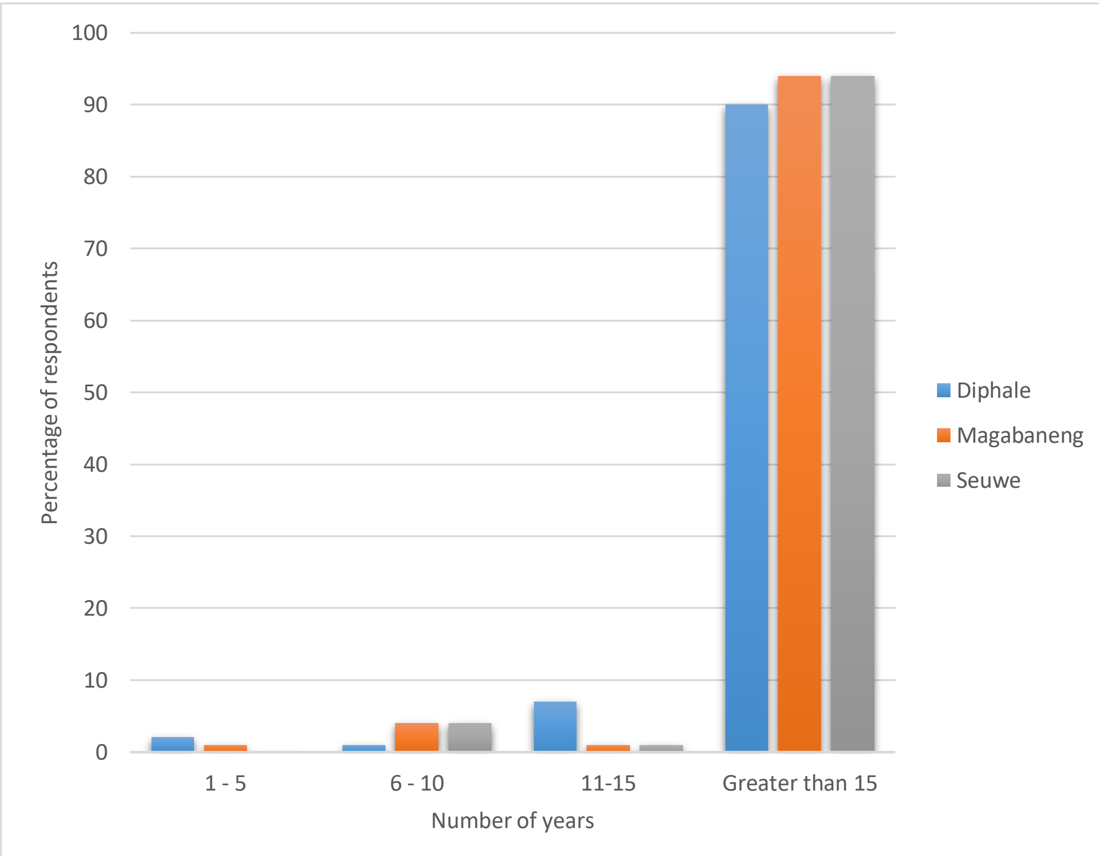


Figure 4.10: number of years residing in village

Figure 4.10 shows the number of years in which respondents had been residing in the village. In Diphale village, 2% of the respondents had been residing in the area for 1 to 5 years, 1% for 6 to 10 years, 7% for 11 to 15 years and 90% for more than 15 years. In Magabaneng village, 1% of the respondents had been residing in the area for 1 to 5 years, 4% for 6-10 years, 1% for 11 to 15 years and 94% for more than 15 years. In Seuwe village, none of the respondents had been residing in the area for 1 to 5 years, 4% had been living for 6 to 10 years, 1% for 11 to 15 years and 95% for more than 15 years.

Majority of the respondents (93%) from all the three villages had been residing in the villages for more than 15 years. When asked what the reason was for them residing in the villages for such a long period, most of the respondents stated that they were born in these villages.

In a study by Jones (2010) in Kenyasi Ghana, similar characteristics as those in this study were noted in terms of number of years respondents had been residing in the village. Majority (95%) of the respondents indicated that they were indigenes of the community implying that they were born and bred in the community and have grown as residents of the community. Some even indicated that since their birth they have never travelled out of the community since all their relatives are indigenes of Kenyasi. As a result, they were very knowledgeable when it comes to the matters relating to the community in various ways. In fact, only a few respondents (5%) interviewed were migrant settlers but had stayed in the community for 7 years or more.

4.4.2 Environmental impacts of MPM mining activity

Environment is the surroundings made up of land, water and atmosphere within which humans, animals, micro-organisms and plants exist. Environment is any interrelationships among and between them and the physical, chemical, aesthetic and cultural properties and conditions that influence human health and well-being (NEMA, 1998). Environmental impacts can be defined as the direct or indirect results of pressures exerted on the environment caused by human activities and can be in the form of primary impacts (change in water quality) or secondary impacts (water treatment costs) (Walmsley and Walmsley, 2002).

Section 2(4)(a)(v) of NEMA (107 of 1998) states that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource. Section 2(4)(a)(vi) of NEMA (107 of 1998) states that the development, use and exploitation of renewable resources and the ecosystems of which they form part do not exceed the level beyond which their integrity is jeopardized. This means that mining industries should always try to minimise their impacts on the environment in order to prevent negative environmental impacts. This section reports on environmental impacts since mining activity at MPM started. They include awareness of the presence of mines in the area, distance from village, direct and indirect impact, perception of impacts, waste disposal in communities and change in environment.

4.4.2.1 Awareness of presence of mines in the villages

All of the respondents (100%) from Diphale, Magabaneng and Seuwe villages, seemed to be aware of the mining operations around the area. Mining establishments identified by respondents, excluding MPM, were Atok, Black chrome, Bokoni, Modikwa and Twickenham. The distance from the villages surrounding MPM to the other mines was close, with a distance of 20km or less. According to the respondents, mining has in fact been one of the driving forces in the surrounding area over the past couple of years, supported with other mining activities in the Steelpoort region. Mining has also stimulated other activities such as the establishment of the Tubatse Mall and Thaba Moshate hotel.

Mining has extended beyond diamonds to gold, coal, platinum, and other minerals. It opened up the interior of South Africa. Longer and longer railways had to be built. Eskom, Iscor, and Sasol were established. Factories were built to supply the needs of the mining industry and of the new towns to which it gave rise as more and more people moved off the land. A vast array of service industries had also to be set up to service the mines, the people who worked in them, and everyone else in the towns (Kane-Berman, 2017).

From the research results, there were similarities noted between what was happening in MPM and in other parts of South Africa. With more than 80% of South Africa's coal sourced in Mpumalanga, and the town of Witbank being the centre of the industry, mining activity has stimulated other activities in that area. Mining in Mpumalanga resulted in the establishment of Columbus Stainless in Middelburg which is a major producer of stainless steel. Middelburg Ferrochrome, Samancor, Evraz Highveld Steel and Vanadium and the Manganese Metal Company are among other important heavy industrial companies and are all a result of mining activities in Mpumalanga (Young, 2013).

4.4.2.2 Direct and/or indirect effects from MPM mining activity

Respondents were asked if the mining activities at MPM had directly or indirectly affected them both in a positive and negative way. The reason behind this was to assess whether the mine facility had affected respondents since its establishment.

In Diphale village, 66% of the respondents said the mine activity at MPM had directly and/or indirectly affected them while the remaining 34% said no, it had not. In Magabaneng village, 46% of the respondents said they had been affected and 54% said they were not affected. In Seuwe village, 43% of the respondents said they had been affected by the mining activity and the remaining 57% said they had not been affected by the mining activity (table 4.6).

Table 4.6 Direct and indirect impacts of mine

Name of village	**Yes (%)**	**No (%)**
Diphale	66	34
Magabaneng	46	54
Seuwe	43	57

Positive direct and indirect impact mentioned by respondents include employment from the mine, stimulation of micro businesses in the local area and accessibility of water. On the other hand, there were also negative direct (dust generation) and indirect impacts (cracked walls). Dust generation and cracked walls and floors on houses due to vibrations from blasting was a major problem in the area.

Figure 4.11 shows a fixed cracked floor in one of the respondents' house surrounding MPM facility in Diphale village. The arrows are pointing at the cracks that were fixed by the respondent who is the owner of the house. This is an example of negative physical impacts caused by vibration and explosions from MPM.

Figure 4.12 shows a cracked wall from the same house in figure 4.11. This was also caused by the explosion and vibrations from the mine. The arrow on the left show where the crack was found in the house of the respondents. *I am constantly having to patch the cracked walls and floor caused by these vibrations and even when I do so, another part of my house cracks. Between having to buy the materials and pay for labour to fix the cracks, this has affected me financially as I am currently unemployed. My house is falling before my eyes and it is as if there is not much I can do about it to save it,* said one of the female respondents. Multiple cases of cracked walls and floors were seen in many houses during data collection.

Figure 4.11: Cracked fixed floors from blasting and vibrations in Diphale village

In Ga-Puka village near Mokopane in Limpopo province, the blasting typically takes place every other week, within 500m of homes. Villagers have to evacuate their houses during blasting, and they are paid R300 per person each time (Curtis, 2008). ActionAid believes the practice of paying residents to evacuate their homes is unacceptable as it exploits poor people as well as exposing their homes to harm.

There is also little doubt that the seismic shocks produced by blasting have created or at least exacerbated the cracks evident in the walls of numerous villagers' homes. During the period of the study, ActionAid heard that one Ga-Puka village resident was injured by flying glass from a window that shattered during a blast. Rock and debris from the blasting regularly fall within the residential area. Two walls in one of the residents' house are now held together by wire and would otherwise fall apart due to a large crack apparently caused by blasting (Curtis, 2008).

Figure 4.12: Cracked wall from blasting and vibrations in Diphale village

4.4.2.3 Respondents opinion/perception on effects of their physical environment caused by MPM activity and cases of waste disposal in surrounding villages

Respondents were asked if they thought the mining activities at MPM can affect the environment that they inhabit. The reason behind this was to establish whether the respondents were aware of the environmental impacts associated with mining so that they could establish a link and be able to conclude if MPM has caused environmental impacts in their villages.

Ninety seven percent (97%) of the respondents in Diphale village said that they think that the mining activity can affect their environment while the remaining 3% said it cannot. In Magabaneng village, 89% of the respondents said yes, MPM could have environmental impacts in the village while 11% said no it cannot affect their environment. In Seuwe village, 92% of the respondents thought that MPM can negatively affect their environment while 8% said it cannot (table 4.7).

Table 4.7 Perception on impacts on the environment

Name of village	**Yes (%)**	**No (%)**
Diphale	97	3
Magabaneng	89	11
Seuwe	92	8

In total, 93% of the entire sample size from the three villages seem to think that the mining activity at MPM can have environmental impacts in the surrounding area. Environmental impacts that were mentioned included pollution of natural entities (land, air and water), land degradation, vegetation clearance, soil erosion and ecological fragmentation. The remaining 7% thought that it would be a good idea if the mine facility implements proper management of waste.

Comparison across levels of education and perception using Pearson Chi-Square Test on whether respondents thought that MPM can affect their environment was undertaken in order to show if there was a link between the two (X^2= 4.617, df=3 (7.81), P= 0.202). The results revealed that there was in fact no link between the two as X^2 was less than df and significance value of 0.202 was greater than significance level of 0.05. Whether educated or not, respondents from all the three villages seemed to be aware of the impacts that mining can have on their environment (table 4.8).than the mine could prevent these negative environmental impacts.

Table 4.8 Pearson Chi-Square Test results on comparison across level of education and perception on environmental impacts caused by mining

	Value	Degree of freedom (df)	Significance (P)
Pearson Chi-Square (X^2)	4.671	3	0.202
Likelihood ratio	4.794	3	0.188
No of valid cases	232		

Significance level of 0.05

Pollution is one of the biggest problems associated with mining activities mainly caused by poor waste management strategies. Water, land and air can be polluted throughout the life span of a mine mainly because of the waste generation associated with any mining activity. Physical environmental pollution is mainly caused by disposal of waste either in water bodies or on land. Respondents were asked if there were cases of the mine disposing its waste in rivers or anywhere close to residential areas.

Table 4.9 Cases of waste disposal in surrounding villages

Name of village	**Yes (%)**	**No (%)**
Diphale	3	97
Magabaneng	13	87
Seuwe	9	91

In Diphale village, only 3% of the respondents said that the mine facility (MPM) was disposing waste in the village while 97% said it was not disposing waste in the village. In Magabaneng village, 13% of the respondents mentioned that there were incidents where the mine had disposed wastes in the surrounding village while 87% said there were no incidents of waste disposal in their village by MPM. In Seuwe village, 9% of the respondents said that the mine was disposing wastes in the village while 91% said the mine was not disposing waste in the village (table 4.9). In total, only 8% of the entire sample size of the study said that the mine facility at MPM was disposing its waste on land or in water bodies while a vast majority of the respondents (92%) said no, MPM was not disposing its wastes on the physical environment.

- Water pollution

Pollution has been identified as one of the many pressures affecting freshwater systems and resources in South Africa (Younger, 2001). Mine water is a growing concern in water quality management. Mine water impacts negatively on the water environment by increasing the levels of suspended solids, leading to mobilization of elements such as iron, aluminum, cadmium, cobalt, manganese and zinc and also decreasing pH of the receiving water. The overall effect of mine water is the deterioration in water quality in many surface water sources that may impact on the domestic, industrial and agricultural users in surrounding communities (Wamsley and Mazury, 1999).

MPM mine waste water is controlled in such a way that only two dams are used for all their water use demands and these dams are treated after a certain period of time. A company called SRK Consulting manages these dams. SRK Consulting is an independent, international consulting practice providing focused advice and solutions to the earth and water resource industries. The consulting company visits the mine every month to sample water from the dams to check contaminants level and if they find that the water is polluted, they apply chemicals to bring the water back close to a usable state. The mine reuse water in order to save water resources. The mine also uses water from the storm water dam which is not polluted and they are using it in their operations when the other dam is being treated. Thus MPM is not really causing pollution impacts on the surrounding environment since they are not directly using water from the river (EMPARMPM, 2017).

For the people of Diphale, Magabaneng and Seuwe villages, water is a very important resource in their lives particularly in their daily routines and the fact that some still practice subsistence farming to sustain their lives. Water bodies such as Moopetsi River, are a source of drinking water for the people as well as for irrigating their crops especially during planting seasons. The water from the river was also used for a wide range of family and household chores and constituted an important component in the daily activities until it stopped flowing. As stated above, a minority of the respondents (3% in Diphale village, 13% in Magabaneng village and 9% in Seuwe village) amounting to 8% of the entire sample size indicated that there were incidents of the mine disposing its wastes in the surrounding communities and water bodies.

One of the male respondents said that*, prior to mining activities the Moopetsi River never used to dry up and now it not only has the water level significantly reduced but what has remained is contaminated and they no longer use the water*. Although the mine claims that it is not disposing its wastes in the surrounding communities, there is a chance, although significantly low (8%) based on the respondent's response, that the mine is disposing its wastes in water bodies.

A study by Yeboah (2008) in Obuasi community of Ghana revealed that mining in the area had caused pollution. A greater percentage of the respondents (71%) complained of incidences of pollution of various types. Types of pollution mentioned by respondents were water, air and noise. The research revealed that mining activities, particularly surface mining, had been a major source of both surface and underground water pollution, just like mining activities had polluted water bodies in surrounding villages. At Sanso, Anyimadukrom and Abompe, three main problems of water pollution included chemical pollution of groundwater and streams, increased faecal matter and siltation of water bodies through increased sediment load. Residents in these towns no longer depended on groundwater and streams for drinking water and those who did were at risk of waterborne diseases. Major rivers in the municipality that had been polluted included Kwabrafo, Pompo, Jimi, San, and Nyame Rivers (Yeboah, 2008).

Mine dumps, also known as tailings or slime dams, were once a major distinguishing feature of Johannesburg and adjoining towns. They were also once a major source of pollution. After the gold had been extracted from it, the crushed rock brought to the surface was deposited on to these dumps. There it combined with rainwater to form sulphuric acid which then dissolved uranium and other metals as it flowed or seeped into the local groundwater. The dumps also produced airborne radioactive material, although very often people living near them were unaware of the resulting health risks (FSD, 2018).

In more recent years, as gold mines have been worked out they have often been abandoned, filling up with rainwater. The gold mines have become acidic and enriched in heavy metals, thereafter finding their way into the underground water supply as well as into rivers and dams. Once abandoned, coal mines have also contributed to pollution of the water supply. The Vaal, Crocodile, and Olifants rivers and their tributaries, along with the Middelburg and Witbank dams in Mpumalanga province, are among the major water sources in the country that have become polluted via this process, commonly known as “acid mine drainage”. The resulting contamination is harmful to aquatic life and dangerous to anyone reliant on the water for agriculture or household use (Kane-Berman, 2017).

In late 2007, ActionAid commissioned an independent water expert to conduct sampling and analysis of river and drinking water in the vicinity of some Anglo Platinum mines and the new villages in Limpopo. These samples were submitted for analysis in November 2007 to a South African National Accreditation System (SANAS) at an accredited laboratory. The report found that the water was unfit for human consumption at five sites out of the ten sampled, with the most likely cause being mining activities at four of these sites (Curtis, 2008).

Water in Ga-Molekane village, near the Potgietersrust Platinums Limited (PPL) mine at a primary and secondary school as well as a community drinking tap was highly polluted due to mining activities. The water in the area was found to be unfit for human consumption, containing high levels of Total Dissolved Salts (TDS) and nitrate. Although the possible cause could be raw sewage seeping into the groundwater recharge zone, the report noted that the most probable cause was mining activities. Contrary to the claims made by Anglo Platinum on their webpage, the report showed high levels of nitrate detected at the primary school which originated from blasting and other activities at the neighbouring platinum mine. The findings raised serious concerns regarding health risks, including cancer and methemaglobinemia, to which these children are exposed as a result of the high levels of nitrate in their drinking water (Curtis, 2008).

In a study by Curtis (2008), water samples were taken at Ga-Pila village near Mokopane, Limpopo and was found to be unfit for human consumption, containing high concentrations of TDS, sulphate and nitrate. The report stated that it could be safely deduced that the cause of contamination was mining activities. Furthermore, water samples were also taken at some other sites near Anglo Platinum mines of the river Maotsi near the Twickenham mine and at another point in the same river near Magobading village. It was found that water quality was characteristic of an average river in a rural area with some industrial activity (Curtis, 2008).

- Land pollution

Land is inevitably a valuable asset to many people and the same applies to villages surrounding MPM. This resource is so important to them because it is the very source of their livelihood especially since agriculture is still heavily practiced (Jones, 2010). Community members were asked whether this resource has been impacted in any way with the start of mining and whether they feel this resource and their livelihoods are threatened by mining operations. Generally, there were hardly any complaints about mine waste disposal by MPM from the respondents as 92% of the entire sample size said that there were no cases of mine waste disposal in their villages. Of the 8% that mentioned waste disposal in the villages, one of the male respondents complained about waste disposal in the Moopetsi River and along road sides in a form of waste rock piles.

According to a source that works at the mine, the mine has supplied the villages with refuse bags and bins to help combat problems in the area since there is no waste service provider and community members were complaining about illegal diaper disposal in the villages. The source also said that MPM was responsible for collecting the waste which is collected twice a week by the same company that is responsible for waste services for the mine.

There were cases in South Africa in terms of waste problems from mining activities on land that were different from those in this study. According to a study produced for the Gauteng city region in 2015, the province contained 374 mine residue areas which included tailings dams as well as other sites of localised mine waste. In addition there were 6 152 ownerless and derelict mines, which continued to pollute the soil, air, and water. Partly as a result of poor environmental regulations or the absence thereof, rehabilitation costs have been estimated by the auditor general at R30 billion or more (Kane-Berman, 2017).

- Air pollution

Air is a very important natural resource for humans, animals and even plant life. Its pollution may have serious consequences on health. However, access to good and quality air can be challenging and a problem when there are mining activities. Respondents were asked if mining operations in MPM had resulted in air pollution due to the use of mining machines and other equipment from the mining site and if the air pollution had become a problem since the commencement of MPM.

Respondents indicated that air pollution from the mines is non-existent in the community because the machines used by the mining company do not produce fumes and smoke. However, there was a problem of dust generation caused by vibration and blasting of explosives from the mine. One of the respondents that mentioned dust as a problem stated, *the village has become very dusty since the mining activity started, because everywhere I look there is dust. Rooftops are covered with dust, vegetation is covered* *with dust, even when doing laundry I think of the dust. It is just dust everywhere.* Air pollution caused by dust was generally a concern in all of the three villages, and it was mentioned as the main cause of respiratory complications on health.

According to a study conducted by Mathabatha (2011) in Ga-Pila village in Limpopo province, air pollution from mining activities was a huge concern for local community members in villages surrounding MPM. Although dust was not the primary concern like in the study, community members in Ga-Pila village complained about smoke from processing and machinery and how it was affecting people's health at an alarming rate. Besides air pollution caused by smoke from processing and machinery by mining industries, the burning of coal in power stations causes pollution in the form of oxides of nitrogen and sulphur. These problems are particularly acute on the Mpumalanga Highveld, home to 12 of Eskom's 16 coal-fired power stations and the numerous mines feeding them. This part of the country also hosts the coal mines supplying Sasol's coal-to-liquids (CTL) plant at Secunda (Kane-Berman, 2017).

- Land degradation and loss of biodiversity

Marula Platinum Mine to a lesser extent, has caused destruction on the vegetation cover. This is because the mine operates underground and not all the waste rock is taken out from the excavators, and some rocks are piled close to the operation site for later use (EMPARMPM, 2017). However, clearance of land resulted in a lot of vegetation removed for road and infrastructure construction such as offices, health center and parking lots. Moreover, the piling of mine tailings has in fact caused destruction to surrounding vegetation cover.

Figure 4.13: Land clearance for the establishment of MPM facility (Thovhakale, 2015)

Figure 4.13 depicts the loss of vegetation through land clearance during the establishment of the mining facility. The arrow on the bottom right side shows land that was cleared for purpose of offices and plant of MPM. The arrow on the top right shows land that was cleared for road construction and the arrow on the top left side shows piles of soil on the plant facility of the mine.

A study by Yeboah (2008) in Obuasi, Ghana revealed that Ashanti Anglogold mining company had caused land degradation in the area just like findings in this study. One of the major effects of surface mining, according to the respondents interviewed, was in fact land degradation. First, removal of the top soils, trees and vegetation with heavy machines by mining operations deprives the land of its nutrients and renders the land infertile for agricultural purposes. For instance, at Sanso, there were areas where the land had been covered by rocks and other debris from mining activities. These have not only impeded plant growth on the land but has also rendered the surface rugged, making it impossible for farming activities to take place there. In addition, respondents complained that pits and deep holes/trenches are created as a result of these activities and such areas eventually become inaccessible to the people as they become fatal zones. Field observations by Yeboah (2008), confirmed this as such pits were observed at Anyinam and Binsere with depths ranging from about 50-75m. Even where such pits are backfilled by the company, they are either covered with rocks (which render the land infertile) or are converted into tailings dams where waste and other toxic materials are deposited. There were scenes of tailings dams close to villages such as Kokoteasua, Abompe and others. Scenes of death trapped pits and rugged surfaces were also observed at a location close to the Company's Pompola Treatment Plant near Wawase.

Similar to results in the study, a study of impacts on mining on the environment in Khenyasi Ghana by Jones (2010) revealed that mining had caused land degradation in the area. Majority of the respondents (80%) indicated that their land was hugely degraded and destroyed by Newmont mining operations. People who believed in the destruction of the land by Newmont mining operations indicated that huge equipment is used to excavate the land, clear large areas and dig huge pits that destroy the topography and landscape of the area which they believed would be difficult to reclaim in the future for use. They believe that since illegal miners in Kenyasi do not use heavy equipment like Newmont, their pits can easily be covered and the land levelled easily when the need arises. On the contrary, Newmont pits are so big and wide with heaps of sand rising to mountain levels and the respondents believed that such areas would be difficult to cover and level for use in future. Those who believe that only a small portion have been destroyed by Newmont mining operations noted that their lands have not been affected and therefore believed that lands are still intact as they used to be. Others who thought illegal miners were rather destroying the land believed that since the illegal miners do not obtain permission before mining and also mine without the use of any geological data, they mine indiscriminately irrespective of whether the area bears gold or not. They dig pits anywhere they like only to find no gold deposits and then move to other areas and start digging without covering or levelling the land previously destroyed.

4.4.2.4 Change in environment and natural state of resources since MPM started

Mining is an inherently destructive industry and the effects of even a single operation can have a severe impact on the environment and the wildlife that lives nearby. Although there are some regulations in place that are intended to minimise the damage, they are not enough to allow mining and wildlife to exist in harmony, especially in cases where the regulations are difficult to enforce or not even enforced at all (Fraser Institute, 2017). The mining industry has the potential to disrupt ecosystems ultimately changing the state of the environment altogether. The disruption affects wildlife and community members in several ways.

Table 4.10 Change in environment

Name of village	**Yes (%)**	**No (%)**
Diphale	64	36
Magabaneng	54	46
Seuwe	75	25

Respondents were asked if the state of the environment had changed since the mining operation started at MPM. Sixty four percent (64%) of the respondents in Diphale village stated that their environment had changed since MPM started operating while 36% said there was no change. In Magabaneng village, 54% of the respondents said there were changes on the environment and 46% said there were no changes. In Seuwe village, 75% of the respondents said that there were changes on the environment while the remaining 25% said there were no changes (table 4.10). The respondents who said that there were environmental changes, mentioned land clearance to create space for the mine and road construction as the causes of change to the environment.

Respondents also stated that major changes in the environment were mainly caused by air pollution in the atmosphere from the huge cars and vehicles that are used in the transportation of heavy equipment and from blasting and vibrations from the mine. By observation during collection of data, the researcher noted that indeed the place was dusty. Vegetation cover, roofing and the whole area was generally dusty.

Comparison between change in environment and number of years of respondents residing in the village was conducted between the two using a Pearsons Chi-Square Test to see if there was a link between the two (X2= 7.23 df=3 (7.81), P=0.065). There was no link between the two from all the three villages as X2 value was less than df and significance value of 0.065 was greater than significance level of 0.05. Although 64% of the sample size that had been residing in the villages for more than 15 years said that there had been environmental changes, there was also a number of respondents (36%) who said that there had been no environmental changes even though they had been residing in the villages for more than 15 years (table 4.11).

Table 4.11 Pearsons Chi-Square Test results on comparison of change in environment and number of years respondent residing in village

	Value	Degree of freedom (df)	Significance (P)
Pearsons Chi-Square	7.230	3	0.065
Likelihood ratio	7.905	3	0.048
No of valid cases	232		

Significance level of 0.05

Different trends to the findings of the study were observed in a study by Yeboah (2008) in Obuasi, Ghana. The longer the years the respondents had been residing in the village, the more they said that mining activities had caused environmental changes. All of the respondents that had been residing in villages around the mines stated that there were environmental changes while those who had been residing in the surrounding villages for a shorter period stated that there were no changes.

Dominant activities before the mining activity were from commercial agriculture and local community members who used the land for subsistence farming. According to elderly respondents in the villages, land that was cleared was earlier used for agricultural purposes. The elderly respondents indicated that even though parts of the land was cleared on a seasonal basis for agricultural purposes, they believed that the damage that resulted from their agricultural practices were very insignificant compared to the devastation of these resources from MPM activities. *Mining activities from MPM have* *resulted in community members not practicing farming due to the fact that we have been removed from the land for the purpose of mining. Before the mining activity, we used to farm for both commercial and subsistence reasons and now we can only practice subsistence farming in our home stands and we were not even compensated fairly*, said one of the elderly female respondents.

A similar trend in terms of change in environment found in the study was also noted in other studies. A study by Jones (2010) in Kenyasi Ghana, indicated massive changes in the natural environment of the community especially with the start of mining by Newmont mining operations in the community. Respondents indicated how large areas of land, forests and trees have been destroyed by the mining company for the purposes of mining gold. These lands and forest areas were earlier used for agricultural purposes and even though parts of the land and forest areas were cleared on a seasonal basis for agricultural purposes, they believed that the damage that resulted from their agricultural practices were very insignificant compared to the devastation of these resources for mining by Newmont.

Within the Obuasi municipality in Ghana, domestic food production is low compared to the needs of the entire area. Respondents attributed this to the mining activities, as several farmlands have either been reserved for mining activities or degraded. Land degradation has resulted from the removal of the top soils, trees and vegetation with heavy machines for gold deposits. This has deprived the land of its nutrients and rendered it infertile for agricultural purposes. Consequently, few farmlands are available for farming activities. Even on the lands available, some have been contaminated with chemicals from mining activities. An official from the Ministry of Food and Agricultural Directorate at Obuasi claimed that there are cyanide and arsenic concentrations in the lands that were previously used for farming purposes due to mining activities. These are no more used for such activities since they are unproductive (Yeboah, 2008).

A study by Mathabatha (2011) in Dilokong village (Sekhukhune district) and Ga-Pila village (Waterberg district), Limpopo province, South Africa revealed similar characteristics as those noted in the study in terms of farming land. Two farmers in Ga-Pila village complained that Anglo Platinum took away their farmlands and were never compensated for the loss of income. According to them, some other people lost large plantations of ground nuts and sugar canes without any compensation from the company. These actions were taken without any prior notice to them and without warning; they just destroyed their farms and took away the land for mining. Their land was taken from them because they happened to be on concession land and by the time they might be done using the land, it would no longer be 'useful' as it would have lost most, if not all, its nutrient content. They had to buy expensive chemical fertilizers before they could cultivate their crops.

4.4.3 Socio-cultural impacts caused by the MPM mining activity

Knowledge Whaton High School (KWHS) (2015) defines social impacts as the effect an organisation's actions have on the well-being of the community. Johnson (2013) defines social impacts as the effect of an activity or project on the social fabric of the community and well-being of the individuals and families. Section 2(2) NEMA (1998) states that environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably. In most cases, mining operations can disrupt the livelihood of nearby community members which in turn affects their socio-cultural conduct. Socio-cultural situations discussed are relocation of community members, impacts on infrastructure development, impacts on health, impacts on social behavior, impacts on crime, impacts on social norms and impacts on culture.

4.4.3.1 Distance of mine from village and relocation of communities since the mining activity started

Relocation is the act of moving people from one location to another (Dictionary.com, 2015b). Mining activities can ultimately affect lives and the livelihood of community members in close proximity to the mine both in a positive and negative way. Before mining activities can commence, people are often relocated so as to make space for mining the resource, especially those in close proximity of the mine. In the process of relocation, people lose their homes and their farm lands. As part of its consultation with the landowner or lawful occupier, the mining company may come to an agreement to pay for the loss of use of the land or the damage that mining might do to the land. This is called compensation. On communal land, compensation should not be paid only to the community at large or to its leaders, since individual holders of informal rights are also entitled to compensation. It is important that a community or individual who agrees to be paid compensation understands exactly how much, when, how and for how long that compensation will be paid (CER, 2014).

All three of the villages are relatively close to the mining establishment. Diphale village is about 3km from the mining facility, while Magabaneng and Seuwe villages are about 2km from the mine. Although all the villages are relatively close to the mine facility, there were no cases of relocation mentioned by respondents. All of the respondents from Diphale, Magabaneng and Seuwe villages said that they were not forced to move elsewhere. However, there was a small number of respondents that mentioned that they had lost their farming land for the purpose of mining and were poorly compensated.

In a study by Curtis (2008), unlike the case at MPM, most of the 7 000 residents of Ga-Pila village in Limpopo province, were resettled in 2003 to make way for the expansion of the PPL mine. They were offered R5000.00 per family plus a replacement home in a new village that was built for them by Anglo Platinum, known as Sterkwater. According to interviews with local villagers, this relocation was in practice a forced removal. Villagers were not offered the choice of being resettled or not. They also claimed that they were not fully informed of their rights and were thus unable to negotiate the terms of the compensation or relocation. A similar problem was also noted by Jewett (2016) in Mothlathla village, Limpopo province. In the early 2000's, community members were relocated from Mothlathla village to Mapela village so that Mogalakwena Platinum Mine could be established. Community members inspected the houses and felt that they were made with inferior building materials and were prone to water damage.

Anglo Platinum has been working purposefully to turn Mohlohlo village (the Ga-Puka and Ga-Sekhaolelo villages) into a ghetto by cutting off the communities' access to the resources that sustain them, including land for food production, water, grazing, roads and schooling. It has created conditions that are difficult, dangerous and unhealthy in an effort to force people to relocate. Nearly 1 000 families of around 10 000 residents of two villages were further relocated to two new villages to make way for expansion of the PPL mine 2008 (Cronje and Chenga, 2008).

4.4.3.2 Community improvement since the MPM mining activity started

Community can be described and divided into two main groups: geographical and functional. The geographical community is based on locality while the functional community is based on a common sense of identity. The concept of geographical community is used in relation to issues of community development and community-based services (Ife, 2002). There are common characteristics that bind communities such as human scale involving size of the community guaranteed interaction; identity and belonging, which entails cohesion and commitment to common goals; enjoying rights bestowed by the community with obligations for community engagement which include the preservation of community structures. Lastly, harnessing local talent and abilities which impact on the betterment of the community as a whole and the formation of a culture which allows the sprouting of producers/protagonists instead of passive consumers thereof and nurturing inter-community diversity and broad-based participation (Ife, 2002).

Community improvement is understood as a togetherness of the ecological perspective, incorporating issues of sustainability, diversity, holism and equilibrium, together with the social justice perspective related to issues of social equity, oppression, human right and so on. Therefore, community needs should be decided by the community itself through empowerment and thus it is fundamental to remove continuing unequal power structures by linking the needs with the social justice perspective of empowerment and structural disadvantage (Ife, 2002). Mining can be a vehicle through which the aspirations of the people for empowerment, social justice, self-reliance and self-determination can be achieved.

Community improvement can be grouped into two, infrastructural development and social development. Infrastructural development basically refers to those physical structures that enhance the life and living conditions of people in any place. These usually include electricity, roads, schools, social amenities etc. Social development is about putting people at the center of development. This means a commitment that development processes need to benefit people, particularly, but not only the poor (ISD, 2005). Both infrastructural and social developments make life more comfortable for community members (Jones, 2010). Diphale, Magabaneng and Seuwe villages typically still lack certain infrastructure facilities and social amenities just like many rural areas in South Africa where mining operations take place.

Respondents were asked whether there were any community development, both in terms of infrastructure and social amenities in the villages since the commencing of the mine at MPM. A total of 70% of the respondents from the three villages said that there had been an improvement in terms of community development, 23% of the respondents said there were no developments at all while the remaining 7% of the respondents said they did not know if there were any developments by the mine since mining activity started (table 4.12). Mentioned infrastructure developments included road construction and building of a school facility. Social amenities included business opportunities and community projects.

Table 4.12 Community improvement

Name of village	**Yes (%)**	**No (%)**	**I don't know (%)**
Diphale	61	29	10
Magabaneng	70	24	6
Seuwe	81	16	3

In Diphale village, 61% of the respondents agreed and said that there were community improvements, 29% said no and the remaining 10% said that they did not know of any developments provided by the mine. In Magabaneng village, 70% of the respondents said that there were community improvement, 24% of the respondents said no and the remaining 6% said that they did not know of any developments provided by the mine. In Seuwe village, 81% of the respondents said that there were community improvements, 16% said no and the remaining 3% said that they did not know of any developments provided by the mine.

Figure 4.14 shows the types of community improvements mentioned by respondents. From 61% of the respondents in Diphale village that mentioned community improvements within the community, 51% stated road construction, 34% said business opportunities, 9% noted building of a school and 6% said community projects.

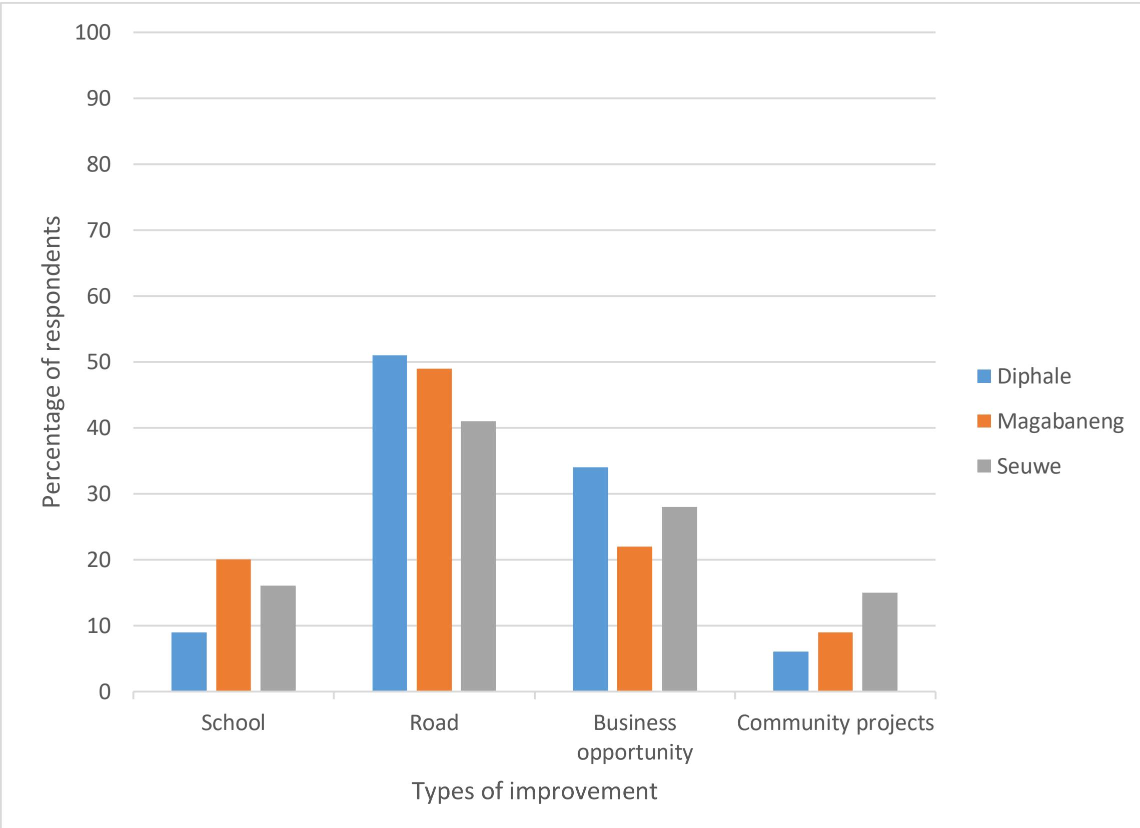


Figure 4.14: Types of community improvements in the villages

From 70% of the respondents in Magabaneng village that mentioned community improvements within the community, 49% stated road construction, 22% said business opportunities, 20% noted building of a school and 9% said community projects. From 81% of the respondents in Seuwe village that mentioned community improvements within the community, 41% stated road construction, 28% said business opportunities, 15% noted building of schools and 16% said community projects.

From the above, one can conclude that the mining activity has indeed resulted in community improvements in the three villages. Out of 7% of the respondents who did not know whether there were any improvements in the villages or not, it was either because some of them had less than 10 years residing in the villages or they were at school so they were not sure if improvements were from the mine or the government.

Figure 4.15: Road construction by MPM (Implats, 2004)

Figure 4.15 shows infrastructural development (road) that was constructed by MPM facility. The road is joined from the main road (R37) up to the mine facility. Within the villages surrounding the mine, a road has not been constructed yet and it is still gravel.

Figure 4.16 shows a primary school called Hlahlana that was established by MPM facility. Social amenities mentioned by respondents included business opportunities (taxi association, local micro businesses) and community projects (Marula trust fund, brick-making yard and community hall) initiated by MPM.

Implats contributes to the development of the communities in which it operates by helping local government develop and implement integrated development plans and by engaging with local communities in these processes. Considerable work has been undertaken during the financial year 2004 by MPM, reflecting the developmental stages of the operation and its commitment to the socio-economic development of the area (Implats, 2004).

Figure 4.16: Hlahlana Primary School built by MPM (Implats, 2004)

Marula Platinum Mine (MPM) signed an agreement with the local communities on the 5th of August 2004 sealing the formation of the Marula Community Trust (the Trust) (figure 4.17). This marked the culmination of Implats' resolution that historically disadvantaged South Africans own 20% of the Marula operations. Five percent (5%) has been allocated to the Trust, while local business interests from the Sekhukhune district and the Limpopo province have earmarked 5% for direct investor participation in the project and 10% will be held by Mmakau Mining.

The Trust has been established for the benefit of the immediate communities and will undertake social and economic upliftment projects. In particular, the trust will support initiatives that promote education, enterprise development and job creation, health and welfare and social infrastructure. This is in keeping with Implats' philosophy that the

Marula community should be self-sustaining beyond the life of the mine, which is estimated at 25 to 30 years (Implats, 2004).

Figure 4.17: MPM donating R1 million for MPM Trust Fund (Marula, 2004)

According to a study by Mathabatha (2011), the introduction of mining and its operation in the communities of Ga-Pila and Dilokong villages has helped in enhancing the livelihoods of some of the people just like in the community members surrounding MPM. Asked whether mining companies contributed to the development of communities, the traditional leader of Ga-Pila village answered in the affirmative. He gave reasons that the company started giving small tenders to community members in the mine concession. He explained that giving small tenders to people involved capacity building of community members in supplying the mines with their produce, micro enterprises and supply of inputs for selected income generating projects. In his view the income generating projects had direct benefits to the livelihood activity in respect of livelihood community improvement.

Mining in Rustenburg had positive community development just like those noted in the study, although the type of community development differed from that in MPM. Over the last couple of years, the three main platinum companies in Rustenburg invested more than R370 million in local infrastructure, including in the expansion of water supply and treatment facilities, as well as in sport and tourism infrastructure. The private investments in infrastructure alone represented 8% of the total public expenditure in roads, energy, water and waste management (R4.3 billion) over the same period. One of the companies signed an off-take agreement with the Rustenburg Local Municipality to use treated sewerage effluent from its sewage treatment plant, as well as to expand water facilities in the local municipality. The companies also invested R12 million in Enterprise Development (ED) programmes. In addition, the platinum companies financed a number of cultural and artistic initiatives and social philanthropic activities. The objective of such investments was to promote local social coherence and public safety (Euromix, 2014).

Unfortunately in some cases, community development is low or non-existent in villages surrounding a mine facility. A study by Jones (2010) in Khenyasi, Ghana revealed different results as compared to those found in this study. When asked whether there were infrastructure provided by the mine in the community, 72% of the respondents said no. They instead indicated that the few that already existed had been worsened or destroyed because of the pressure that the company has brought into the community due to the large number of migrants and strangers moving into the community who compete with the local people for few existing ones. In terms of social development, the response was however different. Eight two percent (82%) of the respondents said that mining has generated petty businesses in the community, 7% of the respondents said that the mining has created some local jobs and businesses but not many as expected, and 14% of the respondents indicated that businesses in the community were already existing before mining started. Most of the respondents, however, said that those who own businesses are people whose lands and farms were taken over by Newmont and were given compensation. Such people decided to invest in petty business ventures that could provide them with a source of livelihood since their former source of livelihood, which was their farms, had been taken over by the mining company. Jones (2010) noticed that most of the businesses were mainly table top businesses like selling toffees, ice-water and roasting of ripe plantain known locally as “kokoo”. A review of the Newmont’s report indicates that the local businesses in Kenyasi was thriving very well since mining started in the community and that the installation of a communication tower has provided dozens of jobs for local phone service workers with about 20% of the population having purchased a mobile phone since its installation

4.4.3.3 Increase in health problems in the community since MPM started with its operation

Health problems can be defined as any physical damage to the body caused by industrial processes, violence, accident or fracture etc. It is a state in which one is unable to function normally and without pain (Vocabulary.com, 2018). Associated with the numerous environmental (physical, social and economic) impacts resulting from mining activities are the consequent health effects or problems. When water bodies, land and the air gets polluted the health of people in villages in close proximity to the mine can be affected by waterborne and respiratory diseases, among others.

Respondents were asked if there had been an increase of diseases among them since mining operation in MPM started (table 4.13). A total of 76% of the respondents on the entire sample size answered in the affirmative and mentioned that there were health problems of dust related respiratory diseases and Sexually Transmitted Diseases (STDs) while 24% of the respondents said no, there was no increase in diseases.

Table 4.13 Health issues in the villages

Name of village	**Yes (%)**	**No (%)**
Diphale	71	29
Magabaneng	73	27
Seuwe	83	17

One of the respondents said, *my health has become really affected since the mining activity started. I had sinus problems before but now it has just gotten worse because of all the dust generation. Sometimes my sinus gets so bad due to dust from blasting and heavy vehicle movement that my chest feels heavy on me.*

From Diphale village, 71% of the respondents said that there were health issues caused by the mine and 29% said no, there were not. From the respondents who mentioned health problems in the area, 69% stated respiratory problems and 31% noted STDs. In Magabaneng village, 73% of the respondents said that there were health issues caused by the mine and 27% said no. From the respondents who mentioned health problems in the area, 63% stated respiratory problems and 27% noted STDs.

In Seuwe village, 83% of the respondents said that there were health issues caused by the mine and 17% said there were none. From the respondents who mentioned health problems in the area, 71% stated respiratory problems and 29% noted STDs (Figure 4. 18).

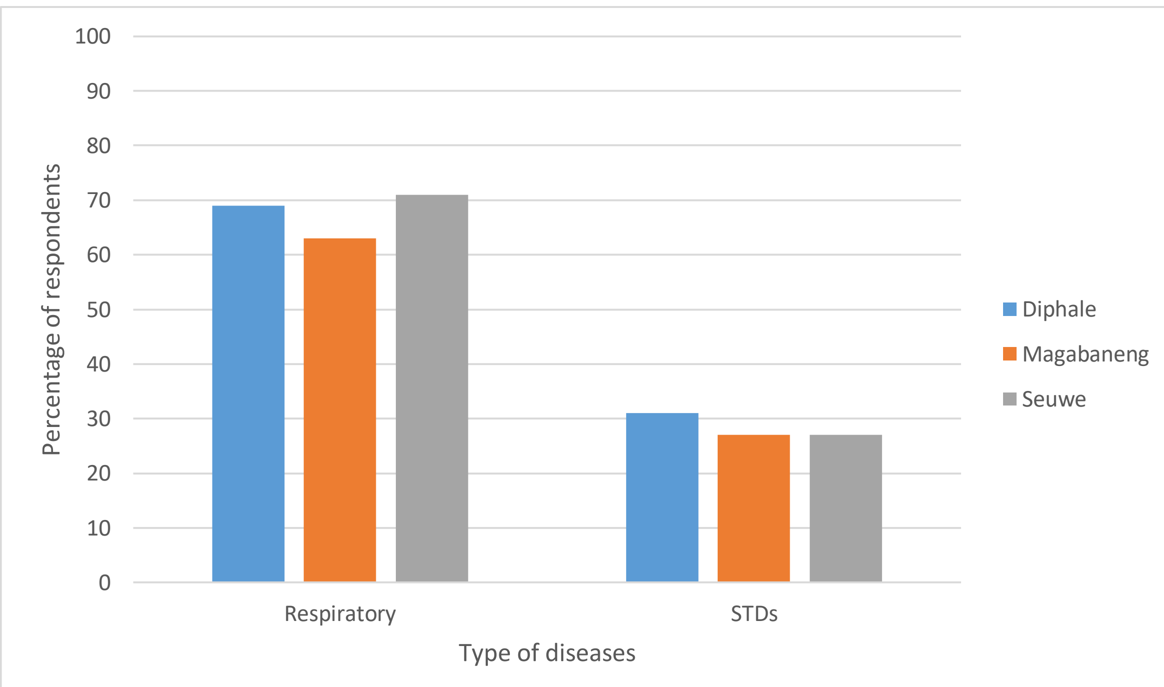


Figure 4.18: Types of diseases caused by MPM in the surrounding villages

A follow up question was asked on whether respondents who said there were health problems thought that MPM was the main cause of those problems. All the respondents from the three villages who said there were health problems said that the cause of the problem was the mine itself. They said that *the mine generates dust from mining operations and male migrants who come from other parts other than their villages are the ones responsible for the spreading of STDs in the community*. It is clear from the above that MPM has left its footprints on the health of community members surrounding the mine. All of the three villages mentioned health issues that were directly (dust) and indirectly (STDs) caused by the mine.

In Rustenburg, North West province (highest mining province in South Africa), health was a major problem in the area. Some of the health problems noted in Rustenburg were similar to those noted in the study, particularly STDs and respiratory problems. From 2001 to 2011, there was a 49% increase in the number of HIV-infected people and it is believed that mining played a role in the increase of HIV and other STDs (Census, 2011).

Further health problems among mine workers included Tuberculosis (TB), malnutrition, and respiratory illnesses. Other local interviewees noted high levels of substance abuse (Euromix, 2014). According to a judgment handed down by the South Gauteng High Court in May 2016, South Africa's gold mining industry "left in its trail, tens of thousands, if not hundreds of thousands, of current and former underground mineworkers who suffered from debilitating and incurable silicosis and pulmonary tuberculosis". Many mineworkers have died from the disease (Kane-Berman, 2017).

There were different scenarios in terms of mine impacts on health. Mine impacts on health were reported from surrounding community members while others were directly on mine workers, but were still similar health problems as those noted in the study. South African gold mines are among the deepest in the world, with a depth of up to 3.9km. Underground working conditions are arduous if not brutal. Rock face temperatures are up to 55^{o}C, humidity levels are high and poor control of exposure to dust, coupled with poor health surveillance systems, give rise to a high incidence of dust related diseases (SPG Media Group, 2013). Importantly, the proportion of black gold miners found to have silicosis at autopsy increased from 3% in 1975 to 32% in 2007. Biological and social factors combine to create a 'perfect storm' for the interaction among silicosis, TB, and HIV. Silicosis substantially increases the risk of TB to a magnitude similar to that of HIV infection. Importantly, silica exposure is associated with TB even in the absence of silicosis and the increased risk is life-long. Risk factors such as migrancy and single-sex compounds increase high-risk sexual behaviour, and thus HIV rates, which are close to 30% among these miners. The TB risks of silicosis and HIV infection combine multiplicatively.

Consequently, the highest recorded rates of TB worldwide have been reported in South African gold miners. Mortality from TB is higher than that from mine accidents. The prevalence of TB in gold miners has increased from 806 per 100 000 in 1991 to 3821 in 2004. HIV prevalence rose from less than 1% in 1987 to 27% in 2000 (Cairncross *et al.*, 2013).

Gold mining in Gauteng province has left community members in Tudor with health problems similar to some cases (respiratory problems) in the study and other cases were different (Vomiting, diarrhea, skin problems). Residents complained about their children being sick from birth with flu and chest problems. They had to take their young children, some aged a year and younger to the clinic almost every week with a runny nose and cough. The water was not good and there were only 4 taps for all of the community members. Children in the area commonly had diarrhea and were vomiting. Itching of the skin was common and worse for children. TB cases getting worse and dust from the new mining, and on the dumps made coughing worse for residents. Residents stated that they went to the nearby clinic but the treatment for TB was not helping anymore (Cairncross *et al.*, 2013).

4.4.3.4 Social problems since the commencing of the operation of MPM

Social problems, also called social issues, are undesirable conditions that people believe should be corrected. They include general factors that affect and damage society (Yourdictionary, 2018). Mining communities enjoy certain facilities such as electricity, construction of good roads and other social and economic amenities. However, these facilities may not make people overlook the negative social impact of mining as their quantity and quality may not be up to the people's expectations (Mathabatha, 2011). Mining operations are often associated with social problems such as prostitution, substance abuse and strikes, among others.

Community members were asked if there had been any social problems since the mining activities at MPM started. Fifty five percent (55%) of all the respondents in the three villages said that there were social problems in the villages and 45% said there were none. The social problems that were mentioned included prostitution, drug usage (weed), abuse of intake of alcohol, crime and strikes.

Table 4.14 Social problems in the villages

Name of village	Yes (%)	No (%)
Diphale	57	43
Magabaneng	56	44
Seuwe	52	48

In Diphale village, 57% of the respondents mentioned that there were social problems in the village and 43% of the respondents said there were no social problems. In Magabaneng village, 56% of the respondents mentioned that there were social problems in the village and 44% of the respondents said there were no social problems. In Seuwe village, 52% mentioned that there were social problems and 48% said there were no social problems in the village (table 4.14).

Figure 4.19 shows the type of social problems that were mentioned by respondents in the three villages. From the 57% of the respondents that mentioned social problems in the Diphale village, 44% mentioned drinking of alcohol, 3% indicated crime, 22% said drug abuse, 4% mentioned prostitution and 27% said strikes. From the 56% of the respondents that mentioned social problems in the Magabaneng village, 46% mentioned drinking of alcohol, 5% indicated crime, 15% said drug abuse, 8% mentioned prostitution and 26% said strikes. From the 52% of the respondents that mentioned social problems in Seuwe village, 44% mentioned drinking of alcohol, 4% indicated crime, 15% said drug abuse, 9% mentioned prostitution and 28% said strikes.

One elderly respondent said: *before mining activities, our villages were peaceful filled with youngsters with morals but now all that has changed. These young people drink like there is no tomorrow, people are selling weed and our young local girls sell their bodies to men who work at the mine*.

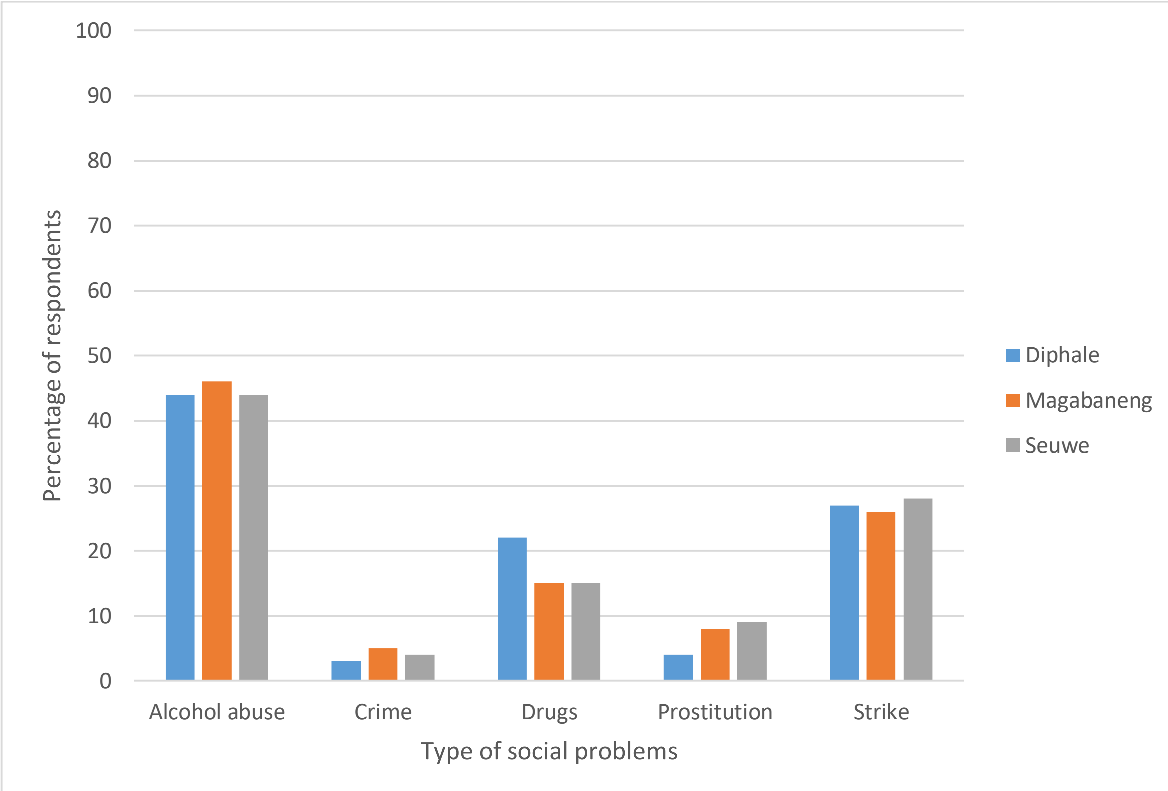


Figure 4.19: Type of social problems in surrounding villages since MPM started

There were similarities in terms of ranking of social problems from all three villages. Alcohol abuse was number one followed by strikes, drug abuse then prostitution in that order while crime rate was the lowest. Before this survey was conducted, there was a strike in the beginning of the year 2017. Just a month after data collection, there was another strike in April 2017. Within a period of four month, there were two strike incidents.

We are tired of the local chiefs (Magoshi) being the only ones that benefit. They take money that is supposed to be used for communal benefits and share it among themselves while we get nothing. Indeed the poor get poorer while they are living a good life and their kids go to fancy schools, said a local community member from Magabaneng.

The strike was so bad that the chiefs were even forced to move from Magabaneng village because the local community members were very angry and did not want any explanations as they were tired of the same old lies and promises. Figure 4.20 shows an example of an angry mob of community members chanting and striking.

Figure 4.20: Angry mob striking community members (CER, 2014)

According to an article by Matseo (2017), angry community members from Diphale and Seuwe villages prevented MPM workers from reporting for duty on the morning of 11th April 2017.The community members blocked roads leading to the mine and threatened some of the miners who were eager to work. They also dug a trench on the gravel road, this led to most learners from local schools failing to attend their classes. The local clinic was also not operating that morning as the staff were unable to report for duty. The residents told the paper that the mine was sidelining them and hiring outsiders. The residents alleged that the chiefs in their villages sold jobs to the outsiders.

The chiefs are the only people benefiting from the mine, they sell jobs and enrich themselves while we suffer. They also hire their cronies and families while accessing tenders at the mine. We demand to see the mine bosses, we want to tell them to stop hiring people at the tribal houses, they said.

Figure 4.21: Protest/strike against PGM mining (CER, 2014)

They also complained about the lack of development in their communities insisting that they needed a tarred road. *The mine facility only does something when it is beneficial to them. Look at the tarred road, it is only constructed from the main road (R37) to where the mine facility ends. We still do not have access to water in our homes and our children are unemployed,* said one of the respondents in an angry tone.

Although the Marikana strike was not influenced by the same factors as those found in the study, the incident showed how platinum mining can have dire impacts on the society and the nation as a whole. On 16 August 2012, the South African Police Service (SAPS) opened fire on a crowd of striking mineworkers at Marikana, in the North West Province. The police killed 34 mineworkers, and left 78 seriously injured. The mine protest was called the “Marikana massacre” because of the number of people who were killed. Following the open fire assault, where 250 of the miners were arrested. The event culminated after an intense week long protest in which the miners were demanding a wage increase at the Lonmin platinum mine in a wildcat strike. A wildcat strike, or 'unofficial industrial action', is strike action undertaken by unionised workers without the union-leadership's authorisation, support, or approval. On 9 August about three thousand miners went on strike to demand a living wage. On 10 August, a large group of the striking miners approached the National Union for Miners (NUM) local office in order to demand support from their union, and were instead met with the firing of live ammunition, fatally wounding two miners (SIHO, 2012). Figure 4.21 shows protesting against PGM mining.

According to Mail guardian (2012), what happened during the fatal miners' strike did not end there. For miners who survived and were arrested, there were reports that they were tortured and brutalised by the police. Ordinary citizens also died, violently, before and after the day of the massacre and families were left without husbands, brothers, sons and fathers. The nuclear and extended families in rural areas were shattered by the violent manner in which their loved ones died and were struggling to deal with the trauma. They were also struggling in a material sense, deprived of their breadwinner's wages and remittances, so important for survival (Mail guardian, 2012). Marikana massacre changed families and communities across South Africa.

Crime rate in all of the three villages was relatively low. Criminal activities mentioned included house robbery and armed robbery. *People think just because there is a mine in the area people now have jobs and money, which is not the case. Maybe that is why there are now cases of armed robbery and house break-ins,* said one of the respondents. Other people were amused when asked if there were any criminal activity in the village since MPM started operating*. From a young age we are taught not to take things that do not belong to us. Before the mine the village has been peaceful with other nearby villages. If there are any criminal activities, they are not committed by local members,* said another respondent.

Unfortunately, there are places, even in South Africa, that face challenges of increase in criminal activities in areas surrounding mining establishments unlike findings in this study. The city of Johannesburg, South Africa is known to be the city of gold and also one city with a high number of crime rate. From armed robbery, to murder or even getting one's car stolen. Since the increase in mining activities in Rustenburg, there is now a higher number of reported thefts, sex crimes, drug-related crimes and residential burglaries than in other South African cities of similar size (Eunomix, 2014).

Prostitution is usually described as “an old age” profession. It employs people in most countries although its widespread could be very devastating and could have long term social and health impacts for any society if not properly controlled especially when certain categories of people are involved (Jones, 2010). In total, only 9% of the respondents from the entire sample size said that there was prostitution in the villages since MPM started operations. When they were asked if there were any usual pick up points where women and girls exercise this practices, none of the respondents were able to give the researcher a direct answer but they suspected that it usually takes place at taverns and drinking spots. The survey part was conducted during the day and the researcher did not go to taverns and drinking spots for safety reasons hence there were no signs of prostitution observed during field survey.

A study by Jones (2010), revealed different results than those in this study. Almost all the respondents interviewed indicated an upward and significant increase in prostitution and other forms of sexual relationships that have developed in the community with the start of Newmont mining. Some of the respondents stated that it was so common that even young girls and children were involved in the practice. Community members said that girls had been deceived into it because of money and it was the money they wanted because people in the village were poor and they had to cater for their needs as well. According to the researcher, observing at night, he could easily see young girls standing around some major guest houses and hotels in Kenyasi. Some of them were also seen moving in and out of the hotels and guest houses with men, some of whom were expatriates, supposedly, top officials of Newmont in the community. Usually, girls of ages ranging from 16 years to 35 years were mostly spotted.

4.4.3.5 Effects on social norms and culture of community members

Social norms are informal understandings that govern the behavior of members of a society (Wikipedia, 2018f). Mining activities can affect social norms and culture of host community in different forms in any community, whether it be change in social behavior of people. The social effects of mineral development must be seen in the context of the many social problems associated with mining operations. These mines may be accompanied by the widespread availability and consumption of alcohol, an increase in gambling, the introduction of or increase in prostitution and a widely perceived breakdown in law and order. Violence, alcohol-induced and domestic, may also increase. As at the Porgera mine in Papua New Guinea, migrants may encourage traditional forms of violence such as tribal fighting (Amnesty International, 2010).

Mining can also have effects on the culture of the indigenous people in the community. The presence of mining companies and the removal of forest areas sometimes interfere with the rich culture of the people living in the community especially when they are in a way attached to the natural settings of the area being cleared. Indigenous people and their communities have a historical relationship with their lands and are generally descendants of the original inhabitants of such lands. In another sense, any interference with the natural settings of a community can have an adverse effect on their history and culture as a people (IACHR, 2008). All of the respondents from the three villages said that there were no changes in culture and tradition since the mining activity at MPM started, meaning that they still had access to their sacred grounds.

Table 4.15 Change in social norms

Name of village	**Yes (%)**	**No (%)**
Diphale	58	42
Magabaneng	50	50
Seuwe	49	51

Community members were then asked if there had been any social problems since mining at MPM started. In Diphale village, 58% of the respondents mentioned that there were changes in social norms and 42% said there were not. In Magabaneng village, 50% of the respondents mentioned that there were changes in social norms and 50% said there were not. In Seuwe village, 49% of the respondents mentioned that there were changes in social norms while 51% said there were not (table 4.15).

Change in social norms from all the three villages was almost a 50/50 situation where 52% of the total respondents said that there were changes and the remaining 48% said that there were no changes. Change in social behaviour included some of the social problems (alcohol abuse, drug abuse, and prostitution) as noted earlier. Most of the respondents complained about how young people were drinking too much since the mining activity at MPM started.

4.4.4. Economic impacts caused by the mining activity at MPM

Mining creates different kinds of jobs, stimulates micro businesses in the area and sometimes have socio-economic obligations to local communities in the surrounding area (CER, 2014). Some require few skills and others require highly skilled workers. Mining companies also have different ways of employing people. Sometimes they use labour brokers and the Department of Labour. These will assist a company to find workers with the right kind of skills (in terms of educational qualification, experience and exposure). The fact that a mine is near a community does not mean that the members of that community are guaranteed jobs on the mine. The mining company however is obliged to contribute towards the socio-economic development of the area or more broadly, the province in which they are operating. Participation by the affected community is essential in determining the contribution a mining company should make (CER, 2014).

4.4.4.1. Perception on increase of employment level in the communities surrounding MPM

The promise of jobs has been one of the major incentives for most communities to allow companies to open up mining activities. Before mining activity begins, local community members are promised jobs so that they give the go ahead for the mine to operate on their land (Jones, 2010). The MPRDA prescribes that all mining operations in South Africa develop and implement a Social and Labour Plan (SLP). The SLP is a plan which entails how many people will be working for the mine and how the mining company is going to train its employees and develop skills in the area where it operates (CER, 2014). The mining company must also describe how it will contribute to and benefit the community in the area where it is mining. The SLP might include social projects or plans to build schools or other infrastructure in the community. According to the MPRDA (2002), the objectives of the SLP are to:

- Promote employment and advancing the social and economic welfare of all South Africans,
- Contribute to the transformation of the mining industry,

- Ensure that holders of mining rights contribute towards the socio-economic development of the areas in which they are operating,
- Avoid the establishment of settlements which cannot be sustained after the closure of mines.

Implats provides all temporary, contract and permanent employees access to Human Resource Development Programs (HRDP), facilitated or managed by either the operations or the contracting companies. Timeframes and targets have been established for each program and progress is supposed to be reported annually. The group's HRDP are derived from an annual Human Resource (HR) strategic planning process which takes cognizance of the company's business plan (i.e. production and sustainability needs). The HRDP also takes into account legislation, community and environment perspectives. The latter include the Mining Charter, the SLP and local economic development program, workplace skills plans and annual training report. The infrastructure to manage such programs is still evolving. HRDPs are still developing at MPM as it commenced production in 2002, however, these programmes are well developed at the Rustenburg operations and Springs Refineries (Implats, 2004).

Respondents were asked on their perception on the employment situation in the community since the mining activity in MPM began. In Diphale village, 84% of the respondents said that there was an increase in employment and 16% said there was none. In Magabaneng village, 83% of the respondents said that there was an increase in employment while 17% said there was none. In Seuwe village, 83% of the respondents said that there was an increase in employment and 17% said there was no increase (table 4.16).

Respondents for all three villages seem to consider that there was an increase of employment in the villages since the mining operation at MPM began. Eighty three percent (83%) of the respondents from the three villages believed that there was an increase in employment in the surrounding villages and it was caused by the existence of the mine.

Table 4.16 Perception on increase of employment in the villages since MPM started

Name of village	Yes (%)	No (%)
Diphale	84	16
Magabaneng	83	17
Seuwe	83	17

On a follow up question, respondent were asked if they themselves or anyone living in their household had been hired from the mine. The aim of this question was to establish if there was a link between job creation in the villages and if it was really caused by the mine. In Diphale village, 31% of the respondents said that a family member or themselves were hired by the mine facility at MPM while 69% said none of their family member was employed by the mine. In Magabaneng village, 21% of the respondents said that a family member or themselves were hired by the mine facility at MPM while 79% said neither themselves nor a family member was employed by the mine. In Seuwe village, 19% of the respondents said that themselves or a family member were hired by the mine facility at MPM while 81% said none of their family member was employed by the mine (table 4.17).

From the table above, one can tell that there actually has not been much work created in the villages since the mining operation at MPM started. In Diphale village, the actual number of employment was 31% instead of the perceived percentage of 69. In Magabanenbg village, the actual number of employment was 21% instead of the perceived percentage of 79. In Seuwe village, the actual number of employment was 19% instead of the perceived percentage of 81.This shows that although people think that the mine has resulted in job creation for many, only a small percentage of community members are actually hired.

The reason behind the trend of high perception of employment and low actual employment rate was based on the fact that people generally associate mining and any kind of development with employment. When a mine, mall or school is established, neighbouring community members of such establishments will often have a perception that this will result in job creation for the host community. In reality that might not be the case as the mine facility will require people to have qualifications, experience and expertise for certain jobs and community members might not have these, thus forcing the mine to outsource.

Table 4.17 Employment of household member by MPM

Name of village	**Yes (%)**	**No (%)**
Diphale	31	69
Magabaneng	21	79
Seuwe	19	81

As indicated in the section of level of education, only 19% of respondents from the entire sample size had up to tertiary level and from those respondents, majority were either nurses, teachers or administrative workers. Those respondents that were employed or whose family member was employed at the mine, were asked what kind of employment they were involved in, whether it was a learnership/internship, contract, permanent or other.

In Diphale village, 69% of the respondents said they had permanent employment, 22% of the respondents had contract employment and 9% of the respondents had permanent employment. In Magabaneng village, 80% of the respondents said they had permanent employment and 20% of the respondents had contract employment. No one in this village mentioned learnership/internship type of employment. In Seuwe village, 93% of the respondents said they had permanent employment and 7% of the respondents had contract employment. No one in this village mentioned learnership/internship type of employment (figure 4.22).

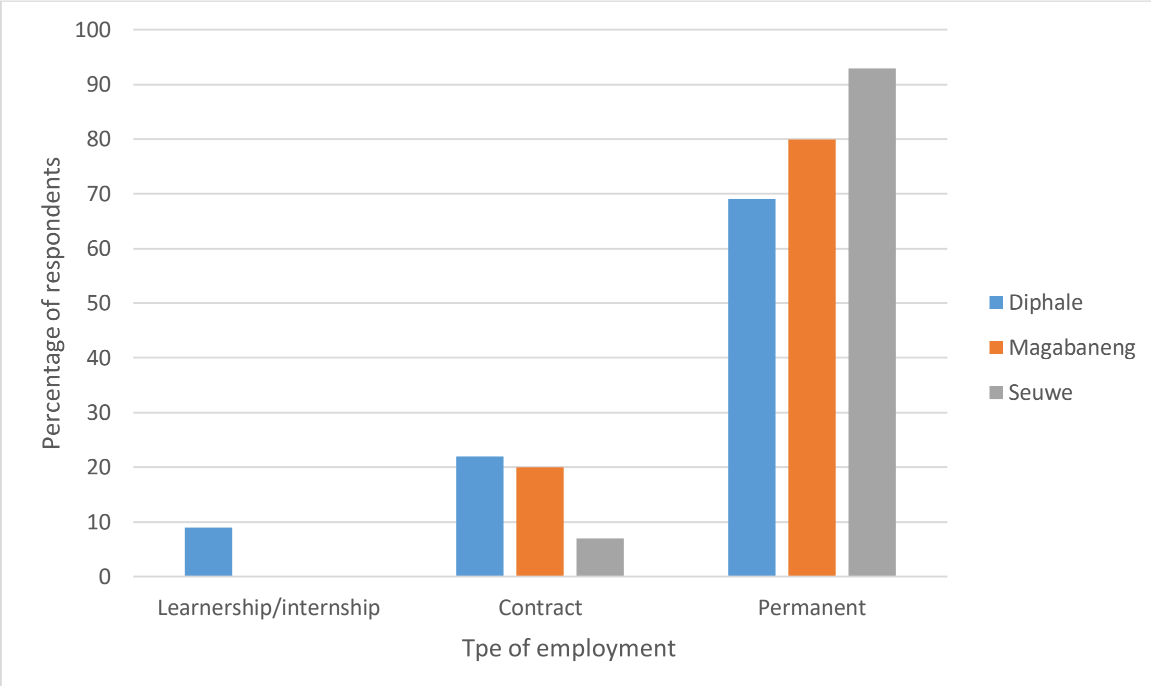


Figure 4.22: Types of employment offered by MPM

In a study by Jones (2010) in Kenyasi, Ghana, there was also lack of employment in the community, similar trends to the findings of this study. Ninety six percent (96%) of the respondents reacted angrily to this question and stated that they have not been provided with the promised employment. Neither their children nor any relative had been provided with any form of employment linked with mining activities in the community. Only 4% of the respondents stated that they had one of their relatives working with the company. When probed further, these respondents revealed that they were relatives of the Kenyasi chief and as a result the chief supposedly used his influence as the community leader to get them employed in the company. Ninety percent (90%) of the respondents indicated that the mining company failed to employ them because they complained that the local people did not have the relevant and requisite skills to work in mining companies. Ten percent (10%) of the respondents attributed the situation to bribery and corruption (particularly impersonation) on the part of the community leaders and Newmont officials (mainly Ghanaian managers) to employ people who paid them.

4.4.4.2 Expectations and Socio-economic obligations from MPM by the host community

Mining can have significant economic, social and environmental impacts at the local, provincial and national level. At a local level, a mine has the potential to significantly benefit the local population through the creation of direct and indirect employment, skills transfer, enhancing the capacity of health and education services, improved infrastructure, and small and medium business opportunities (Akabzaa, 2009).

Respondents were asked what their general expectation from MPM as the host community were. Expectations mentioned included job creation, infrastructure development, access to better healthcare, access to fresh clean water, community developments, alleviation of poverty and bursary opportunities for students.

There is a general belief that the presence of a huge mining company such as MPM (Implats LTD) in any particular area would inject massive capital investments into the area or community which would in effect trigger capital or cash flows, put more money in the system and hence reduce poverty since economic activities would be generated. Before mining activities take place in any area, mining companies promise the local community members employment, investment in community development projects, improvement of livelihood situation (access to water and road as well as infrastructure development) and offering bursaries and learnership programs (Jones, 2010). Respondents were asked whether there were any obligations by the mine and if they were fulfilled. As a response to this question, all the respondents from the three villages (100%) responded affirmatively and said yes. Promised obligation included access to water, job creation, development of infrastructure and bursaries/learnership.

In a follow up question, respondents were asked on whether the obligations had been fulfilled. In Diphale village, 61% of the respondents said that the socio-economic obligations had been met while 39% said none were met. In Magabaneng village, 67% of the respondents said that the socio-economic obligations had been met while 33% said the socio-economic obligations were not met. In Seuwe village, 68% of the respondents said that the socio-economic obligations had been met while 32% said obligations were not met (table 4.18).

Table 4.18 Obligation of socio-economic

Name of village	Yes (%)	No (%)
Diphale	61	39
Magabaneng	67	33
Seuwe	68	32

The mine has made promises but failed to deliver them. We still do not have jobs, water, bursaries and roads in our villages, but they took away our farmland. This is why people are striking, we had so many expectations and yet none have been met, said one of the respondents. *The mine has kept some of the promises but definitely not all of them. They might have constructed a road but it is mainly for their benefit, it is constructed from the R37 up to where the mine ends. How is that for the benefit of the community,* said another respondent.

Other respondents however seemed a bit more appreciative of the little that the mine has been able to fulfill. *Before the mine, we did not have water but now there are communal taps. Yes, the mine did not construct the road in all the villages but it is a start. We have a trust fund, communal hall and community projects such as the brick yard,* said one of the respondents.

In a study by Mathabatha (2011) in Dilokong and Ga-pila villages, there were some respondents who shared similar views as those noted in this study in terms of socio-economic obligations. Some members of the community felt that the improved roads were used for the purpose of carrying out the interest of mining activities as opposed to community interests. The community was of the opinion that mining companies were only interested in making profit through mining activities, while it could, on the other hand developing the community in one way or the other.

4.4.4.3 Financial gain made from the mining activity in MPM

While others financially gain directly from job employment, other people resort to other forms of financial gain they can get from mining activities. This could be from opening a vendor market next to the mine, offering accommodation for non-local people who work at the mine or offer transport for those who work at the mine etc.

Respondents were asked if they make any financial gain from the mine, whether directly or indirectly. In Diphale village, only 23% of the respondents said that they obtained financial gain from the mine and 77% of the respondents said they did not. In Magabaneng village, 17% of the respondents said that they obtained financial gain from the mine and 83% of the respondents said they did not. In Seuwe village, 19% of the respondents said that they obtained financial gain from the mine and 81% of the respondents said they did not obtain any financial gain (table 4.19).

Table 4.19 Financial gain from MPM

Name of village	**Yes (%)**	**No (%)**
Diphale	23	77
Magabaneng	17	83
Seuwe	19	81

Mentioned ways of financial gain from the mine included direct employment from the mine, vendors selling at the mine, micro businesses (taxi) and offering accommodation. From the above, it is evident that the majority of community members surrounding the mine are not making financial gain despite being the hosting villages of the mine. In total, only 20% of the respondents from the three villages were making some sort of financial gain from the mine with the majority of the 20% coming from direct employment in the mine facility.

4.4.4.4 Additional information from respondents about the effects of MPM on surrounding villages

There were mixed feeling in terms of how individuals in the study felt towards the mine facility at MPM from all of the three villages. There were those who had no problem with the mine, those who had a negative feeling towards the mine and those that felt like the existence of the mine does not add or reduce any value in their lives. Those who had a negative feeling towards the mine was mainly because of the environmental impacts (physical, social and economic), failed economic obligations and the fact that they did not benefit directly from the mine. Lack of employment, land taken away for mining purposes, dust generation, cracked walls/floors from vibrations and lack of community development made the respondents to have negative feeling towards the mine.

There were those who had a positive feeling towards the mine because they benefited from the mine. Although the mine facility could not hire everyone in the nearby villages, it created direct employment for some of the local residents and also stimulated micro businesses in the villages. Because of the mine, there were vendors who sold food to mine workers, some vendors even travelled from other nearby villages that were not included in the study. Taxi drivers said that their business could now thrive because of the movement of people who work at the mine and those that had micro businesses and needed transport to carry their good.

People who had no interest in the mine were mostly those that had tertiary level of education and were employed elsewhere. A retired teacher stated that he had no feelings towards the mine facility. This could have been based on the fact that he had been employed at a local government school and whether the mine had been built or not he could have still lived the same life as he did.

4.5 Summary of the chapter

South African legislation and policy play a huge role in environmental compliance from mining operations, whether mandatory or voluntarily. From the findings, MPM was compliant with environmental legislation and policies put in place by the South African government although there were some areas that needed improvement. Just like any other type of mining operation, MPM has had its imprints on the environment (physical, social and economic) in which it is operating. On the physical environment, MPM has resulted in land degradation through vegetation removal and air pollution from vibrations, explosions and machinery used at the facility. On the social environment, MPM has resulted in positive community development (road, schools, and community projects) as well as negative impacts on heath (STDs and respiratory problems) and social norms (strike, prostitution and substance abuse). On the economic environment, MPM has resulted in job creation and stimulation of micro businesses in the three villages. The next chapter covers summary, conclusions and recommendations of the study.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of key findings and conclusions on the environmental compliance with solid waste management practices at Marula Platinum Mine (MPM). The objectives of the study were to examine the level of environmental compliance of solid waste management practices at MPM, assess challenges that hinder environmental compliance of solid waste management practices in MPM and evaluate effects of waste management practices on the communities surrounding MPM. The environmental compliance was based on mandatory practices as per the South African legislation and policies mainly guided by the Constitution of the Republic of South Africa (1996), the National Environmental Management Act (NEMA) (107 of 1998) and the Mineral and Petroleum Resource Development Act (MPRDA) (28 of 2002), as well as voluntary practices implemented by MPM.

5.2 Summary of the findings

Mining operations can cause severe environmental (physical, social and economic) problems unless properly managed. Environmental legislations and regulations play a vital role in ensuring the protection of the environment while promoting sustainable development of resources. If these environmental legislations are not put in place by mining operations in South Africa, the Department of Mineral Resources (DMR), Department of Environmental Affairs (DEA) and Department of Water and Sanitation (DWS) have the power to stop the mining company from continuing its operations. Discussed below is the condensed summary of the three objectives.

5.2.1 Objective 1: To examine the level of environmental compliance with solid waste management practices at MPM

5.2.1.1 Environmental authorisation

Environmental authorisation for mining operations and activities in South Africa is governed by appropriate legislations and regulations such as The Constitution of the Republic of South Africa (1996), NEMA (107 of 1998), MPRDA (28 of 2002) and

Environmental Impact Assessment Regulations (EIA) among others. For MPM, environmental authorisation was obtained from the provincial authority which is the Department of Economic Development, Environment and Tourism (LEDET) in Limpopo province. MPM had hired an Environmental Assessment Practitioner (EAP) who was responsible for the conduction of a full EIA as it is a large scale mining operation.

5.2.1.2 Environmental Management Performance Assessment Report (EMPAR)

An EMPAR is important as it outlines the overall management of a mining company from the planning stage until the decommissioning and closure stage. MPM facility had hired an environmental consulting company called SRK Consulting which was responsible for conducting EMPAR and compiling a compliance assessment report for the DMR. The EMPAR is conducted once every two years as stipulated in the company's Environmental Management Plan (EMP) for environmental authorisation. The latest EMPAR was conducted in 2017.

5.2.1.3 Type of waste generated

MPM facility generated both general and hazardous waste. General waste was mostly generated in the offices and kitchen (domestic waste), which included paper, plastic, boxes, food wrapping and broken equipments (chairs, tables, fax machines, computers, etc.). Hazardous waste was generated in the plant facility in all three states of matter and included overburden, dust, tailings and waste rock.

5.2.1.4 Solid waste management practices

According to NEMA (1998), all solid waste (general and hazardous) should be characterised, classified and separated at point of generation based on the chemical and physical properties. MPM has adopted the above solid waste management practices as per NEMA regulations. Furthermore, a colour coding system is used to store the different types of waste that was generated in MPM mine facility. The containers in the offices and skips in the shaft had a hazardous sign on them and a name tag showing which type of wastes should be stored in the containers. The waste was temporarily stored at point of generation and then transferred by trained staff to the salvage yard where it was collected by a waste management company hired by MPM called Waste Legends for treatment and disposal. MPM was found not to practice onsite treatment and disposal of waste.

Rehabilitation and post closure monitoring plans are not yet in place as the mine facility is still in the operational phase. However, the plans were outlined on the originally approved EMP application submitted to the DMR for license permit.

5.2.1.5 Environmental compliance assessment

Based on the compliance assessment checklist table specifically optimised for MPM, it was observed that the mine facility was 65% compliant and 21% partially compliant with solid waste management practices as stated from MPRDA and NEMA legislation. Only 14% of information on solid waste management practices could not be accessed by the researcher. Information that could not be accessed by the researcher was about implementation of after care and rehabilitation plans.

5.2.1.6 Voluntary solid waste management practices

Marula Platinum Mine (MPM) has an environmental office for all health, safety and environmental issues within the mine facility also known as National Occupational Safety Association (NOSA). The environmental office is responsible for ensuring that waste management practices as per the South African laws (mandatory and voluntary) are put into place and followed.

5.2.2 Objective 2: To assess challenges that hinder environmental compliance of solid waste management practices in MPM

5.2.2.1 Challenges on implementation of solid waste management practices

Challenges noted from the MPM's EMPAR in terms of implementation of solid waste management practices were not related to NEMA and MPRDA solid waste management practices, but they were from the Anti-waste document obtained from LEDET. Although the waste is characterised, classified and separated at point of generation, they were not properly separated at the salvage yard where all solid wastes generated in the facility were stored until the day of collection for treatment and disposal. Another challenge noted in terms of implementation of waste management practices was that oil storage tanks in the aschem area were not properly labeled and did not have hazardous signs on them.

5.2.2.2 Challenges on maintenance of infrastructure

Same as challenges on implementation of solid waste management practice, maintenance of infrastructure problems were also mainly based on the Anti-waste document rather than NEMA and MPRDA solid waste management practices. Maintenance of infrastructure problems noted in the company's EMPAR were in the salvage yard, wash-bay and fencing of the mine facility. The salvage yard was poorly maintained, the bund-wall was broken and the ground was bare. In the wash-bay, there were minor cracks on the floor. The bare ground in the salvage yard and cracked floor in the wash-bay could result in seepage ultimately contaminating groundwater. According to MPMs EMPAR, there were parts of the fencing that was broken and did not meet the requirements in the Anti-waste document.

5.2.3 Objective 3: To evaluate effects of waste management practices on the communities surrounding MPM

5.2.3.1 Physical environmental impacts

The findings of the research indicated that MPM operations have had physical environmental impacts on the surrounding villages. Negative physical environmental impacts mentioned by respondents included dust generation and cracks on the floors and walls of their homes caused by blasting of explosives and vibrations from mining operations. Only 8% of the entire sample size stated that there had been cases of MPM disposing wastes in the surrounding communities and water bodies while the vast majority (92%) of the respondents said that the mine was not disposing its waste in the surrounding communities or water bodies. According to a source that works at the mine facility, the mine had donated refuse bins to help combat solid waste management problems in the villages. Respondents who stated that MPM changed the physical environment said the impacts were caused by vegetation clearance for construction of the mine facility and water contamination of the Moopetsi River.

5.2.3.2 Social impacts

MPM has had both positive and negative social impacts on the surrounding communities. Positive social impacts were mainly through community improvements initiated by the mine facility. Seventy percent (70%) of the respondents from the three villages said that there had been an improvement in terms of community development, 23% of the respondents said there were no developments at all while the remaining 7% of the respondents said they did not know if there were any developments. Mentioned community improvements by respondents included road construction, building of the Hlahlana primary school, stimulation of business opportunities and community projects (MPM trust fund, brick yard and community hall). Negative social impacts were on the health issues and change in social norms of community members. Dust generation from mining operation had caused respiratory problems among village members. Furthermore, respondents believed that the influx of migrant workers had resulted in the spread of STDs and HIV. The respondents also stated that the mine had caused other social problems such as substance abuse (alcohol and drugs), strikes, prostitution and criminal activities (house breaking and armed robbery) within the communities.

5.2.3.3 Economic impacts

According to the respondents in the three villages, MPM offered three types of employment which included learnership/internship, contract and permanent jobs. The level of employment from MPM was still very low in all of the three villages. Only 24% of the entire sample size and/or their family member had been offered employment by MPM. Respondents also stated that there were socio-economic obligations by the mine and some of them had not been met. Although the mine facility had resulted in some of the community members being offered employment and some form of community improvements, they still had no access to clean water and the mine did not offer bursaries in the communities.

5.3 Conclusions

The conclusions of the study are:

- MPM obtained environmental authorisation from LEDET prior to commencing mining operations
- MPM has implemented both mandatory (NEMA and MPRDA) and voluntary (NOSA) solid waste management practices

- Based on the optimised checklist for environmental compliance assessment for MPM, the mine facility was compliant with environmental legislations for solid waste management practices but still had room for improvement
- MPM mine facility generated both general and hazardous wastes
- Although waste was characterised, classified and separated at point of generation, the waste was not properly separated at the salvage yard
- Oil tanks in the aschem area did not have label tags and hazardous signs on them.
- The salvage yard had bare ground and was poorly maintained
- Certain parts of fencing of MPM facility are broken and/or damaged
- Only a few respondents from the entire sample size complained about solid waste being disposed in the surrounding communities and water bodies
- Dust generation and cracks on floors and walls of respondents' houses was a major physical environmental impact in the surrounding villages
- MPM had resulted in positive social impacts in the surrounding villages through building of the Hlahlana primary school, construction of a road, stimulation of micro businesses and community projects
- Negative social impacts caused by MPM were on health issues and change in social norms of community members
- MPM has had low levels of employment of local community members
- Not all socio-economic obligations promised by the mine to local community members were fulfilled, such as access to clean water and bursaries

5.4 Recommendations

- The mine facility should adopt the same solid waste management practices in the salvage yard as those in point of generation (characterisation, classification and separation) to avoid mixing up of the wastes
- Proper label tags and hazardous signs should be provided on the tanks used to store oil in the aschem area
- The inadequate housekeeping of the salvage yard should be addressed by cleaning up after spills and have good maintenance of infrastructure.
- The mine facility should either fix the broken parts of the fence or have a new fencing done all together

- MPM mine facility should provide other mitigation measures for blasting of explosives to reduce dust generation and problems of cracks on houses of surrounding village members
- MPM should try to hire more local community members rather than outsourcing work elsewhere in order to increase employment in the area
- MPM facility should provide community taps in order to fulfil its obligation on water provision for community members as well as provide training for community members on how to apply for bursaries on the Implats site
- Mining facilities that have not adopted any method for assessing compliance with environmental laws and regulations in South Africa should consider adopting the checklist method as an assessment tool
- Further research could focus on the evolution of environmental laws and regulations as well as how the above has turned mining operations in South Africa from a dirty practice that damages the environment to a more sustainable practice

5.5 Conclusion

The study is grounded on the human environment interaction theory. Mining is a human activity on the environment which can cause severe environmental damage if not properly managed. Marula Platinum Mine (MPM) complies with both mandatory (NEMA, MPRDA) and voluntary (NOSA) solid waste management practices, however, it still has room for improvement concerning some aspects such as challenges on implementation of solid waste management practices and maintenance of infrastructure. The findings of the study were that MPM is compliant with 65% and partially compliant with 21% regulations regarding solid waste management practices within its operation. In order to achieve the 100% compliant rate, it is important that all solid waste management (mandatory and voluntary) are implemented and adhered to, from point of generation of waste throughout its cycle until its final stage of either treatment of disposal. Due to the mine being compliant with environmental legislation with solid waste management practices, it resulted in minimal complains from surrounding community members of occurrences of illegal waste dumpsites from MPMs operation.

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APPENDIX A: KEY INFORMANT INTERVIEW QUESTIONS

I am a student from the University of Limpopo in the Department of Geography and Environmental Studies conducting a research on "Evaluation of Environmental Compliance of Solid Waste Management Practices from Mining Activities. This interview set of questions are designed for the Limpopo Department of Economic Development and Tourism (LEDET) to get a standardize expectation of solid waste management practices expected from mining operations as per the Mineral Resource Petroleum Development Act (MPRDA) and the National Environmental Management Act (NEMA).

1. What are the responsibilities of the license holder (licensing conditions) in terms of solid waste management before, during and after the operation of mining activities?
2. What are the solid waste management practices, such as separation, containers, collection, storage, transportation, treatment and disposal, expectations from mining activities?
3. What are the expectations from mining activities in terms of rehabilitation and closure plans?
4. What are the expectations of monitoring and report publishing on environmental impacts (waste management plans) from the mining activity?

APPENDIX B: ETHICAL CLEARANCE

University of Limpopo

Department of Research Administration and Development

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TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING: **15 May 2018**

PROJECT NUMBER: **TREC/102/2018: PG**

PROJECT:

Title:	Evaluation of Environmental Compliance with Solid Waste Management Practices from Mining Activities: A Case Study of Marula Platinum Mine.
Researcher:	DL Manyekwane
Supervisor:	MHN Mollel
Co-Supervisors:	Mrs JM Letsoalo
School:	Agricultural and Environmental Sciences
Degree:	Master of Science in Geography

PROF TAB MASHEGO

CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

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

Note:

i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**

ii) **The budget for the research will be considered separately from the protocol.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

APPENDIX C: COMMUNITY QUESTIONNAIRE (SURVEY)

I am a student at the University of Limpopo conducting a research titled "Evaluation of Environmental Compliance with Solid Waste Management Practices from Mining Activities: A Case Study of Marula Platinum Mine". The aim of this questionnaire is to find out how the mining activity has affected the community members surrounding the mine on an environmental, social and economic level. Your participation will be highly appreciated. There is no right or wrong answer and where you need clarity please feel free to ask. Please tick where applicable and fill in answers in the provided spaces.

<u>Background Information</u>

1. Residence

a. Diphale { }
b. Magabaneng { }
c. Seuwe { }

2. Gender

a. Female { }
b. Male { }

3. Age group (years)

a. 18-27 { }
b. 28-37 { }
c. 38-47 { }
d. 48-57 { }
e. ≥58 { }

4. Marital status

a. Single { }
b. Married { }
c. Widowed { }
d. Divorced { }

5. Level of education

a. No formal education { }
b. Primary { }

c. Secondary { }
d. Tertiary { }
e. ABET { }

6. Employment status

………………………………………………………………………………………………

7. Income

a.≤R2000 { }
b.R2001-R4000 { }
c.R4001-R6000 { }
d.R6001-R8000 { }
e.R8001-R10000 { }
f.>R10000 { }

8. How many people live in your house?

a.≤2 { }
b. 3-6 { }
c. 7-10 { }
d. >10 { }

9. Period (years) of staying in village

a. 1-5 { }
b. 6-10 { }
c.11-15 { }
d. >15 { }

<u>Environmental Impacts Caused By The Mining Activity</u>

10. Do you know if there are mines in your village?

a. Yes { }
b. No { }

10.1 If yes, what is/are the name(s) of the mine?

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………………………………………………………………………………………………
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11. How far is your village from MPM?

a. ≤1km { }
b. 2km { }
c. 3km { }
d. 4km { }
e. 5km { }
f. >5km { }

12. Has the mining activity from MPM affected you directly or indirectly?

a. Yes { }
b. No { }

12.1. If yes, how?

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13. Do you think the mining activity at Marula Platinum Mine can affect the environment you inhabit?

a. Yes { }
b. No { }

13.1 Please elaborate

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14. Have there been cases of the mine disposing wastes in your surrounding environment?

a. Yes { }
b. No { }

14.1 If yes, explain

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15. Has the state of the community's natural resources and environment changed since the mining operation started?

a. Yes { }
b. No { }

15.1 Please elaborate

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Social-cultural Impacts Caused By The Mining Activity

16. Have there been any relocation of communities since the mining activity started?

a. Yes { }
b. No { }

16.1 If yes, explain
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17. Has there been improvement of infrastructure since the mining activity started?

a. Yes { }
b. No { }
c. I don't know { }

17.1 If yes, tick all that apply

a. School { }
b. Roads { }
c. Business opportunities { }
d. Community projects { }
e. Other, specify
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18. Has there been any new/ increase in health problem in the community since mining started in the community?

a. Yes { }
b. No { }

18.1 If yes, tick all that apply

a. Water borne diseases { }
b. Lung diseases { }
c. Sexually Transmitted Infections (STI's) { }
d. Other, specify
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18.2 Do you think the health problems and conditions are related in one way or another to the mining activities?

a. Yes { }
b. No { }

18.3 If yes, explain
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19. Have there been social problems since the commencing of the operation of MPM?

a. Yes { }
b. No { }

19.1 If yes, what are the social problems? Tick all that apply

a. Prostitution { }
b. Drug selling and usage { }
c. Drinking problems { }
d. Other, specify
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20. Has there been an increase in crime rate in your community since the mining operation started?

a. Yes { }
b. No { }

20.1 If yes, what type of crime?

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21. Has the social norms of the community been affected by mining operations?

a. Yes { }
b. No { }

21.1 Please elaborate

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22. Has the culture/tradition of the community been affected by mining operations? For example, not being able to access sacred ground

a. Yes { }
b. No { }

22.1 If yes, explain

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<u>Economic Impacts Caused By The Mining Activity</u>

23. Has the employment level in your community increased since the mining activity in MPM started?

a. Yes { }
b. No { }

24. Are you or any family member(s) employed at the MPM?

a. Yes { }
b. No { }

24.1 If yes, what type of employment?

a. Learnership/ Internship { }
b. Contract employment { }
c. Permanent { }
d. Other, specify

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25. Are there any community based projects initiated by the MPM?

a. Yes { }
b. No { }
c. I don't know { }

25.1 If yes, explain

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26. What did you expect from MPM as the host community?

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27. Are there any social and economic obligation(s) that MPM has to the community?

a. Yes { }
b. No { }

27.1 If yes, what are the obligation(s)?

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27.2 Have the social and economic obligation(s) been met since the commence of the mining activity?

a. Yes { }
b. No { }

27.3 Please elaborate

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28. Do you make financial gain from the mining activity in MPM?. i.e offer accommodation, sell to mine workers etc

a. Yes { }
b. No { }

28.1 If yes, how do you make financial gains?

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29. Is there any additional information you think might be useful to know concerning how the mining activity has affected the community or you as an individual?

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