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IMPACT OF OIL POLLUTION ON SOIL PROPERTIES CASE OF SABLE CHEMICAL INDUSTRIES.

BY

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APPROVAL FORM

The undersigned certify that they have read and recommended to the Midlands State University for acceptance a dissertation entitled: **IMPACT OF OIL POLLUTION ON SOIL PROPERTIES CASE OF SABLE CHEMICAL INDUSTRIES.**

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A dissertation submitted in partial fulfillment of the requirements of the Bachelor of Science Honours Degree in Geography and Environmental Studies.

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ABSTRACT

The study examined the impact of oil pollution on soil properties at Sable Chemical Industries. The researcher used a descriptive case study research design. The research encompassed both qualitative and quantitative research paradigms and use of primary and secondary methods of data collection. Primary data was gathered through questionnaires, direct field observations, interviews and soil sample collection while secondary data was obtained from the journals and Sable Chemical Industries SHE incident records. Data analysis was done using Statistical Package for Social Scientists (SPSS), content analysis and Microsoft Excel. The research findings identified mechanical failure, breakdown maintenance and human error as the major causes of oil spills at Sable Chemical Industries. The level of knowledge on oil handling practices amongst Sable Chemical industries' employees is still low due to lack training and Managemental commitment. The collected soil samples were subjected to laboratory tests and the results obtained showed variations in pH, electrical conductivity and moisture content. The range of electrical conductivity of the unpolluted sites was 20-49(mS/m) compared to the 31-99(mS/m) for the polluted sites with an average of 78% increase. The soil pH drastically decreased from 7.12 (control) to 5.48 whilst the soil moisture content has decreased by 60%. Due to hydrocarbon pollution the soils have become highly acidic, compacted, negatively charged (ions) with low moisture content. The result from the chi-square test shows that there is a significant relationship ($p<0.05$; $p=0.04$) between oil pollution and physic- chemical alteration of soil properties. The research recommends Sable Chemical Industries to formulate an oil spill response team and draft an oil spill response procedure which clearly outlines the responsibilities, targets and action plans towards oil spill reduction to reduce environmental pollution. Environmental Management Agency should also educate waste oil producing entities on how to practice safe and sound waste oil disposal.

DEDICATION

This project is dedicated to my husband Allen; brothers, Blessing and Tatenda as well as my parents, for without their prayers, support and encouragement it would have been impossible to reach this far.

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ACRONYMS/ ABBREVIATIONS

AGRITEX	Agricultural Technical Extension Services
EMA	Environmental Management Agency
EC	Electrical Conductivity
NOX	Nitrous oxide
PAH	Poly Aromatic Hydrocarbons
SHE	Safety Health And Environment
SHEQ	Safety Health Environment and Quality
SPSS	Statistical Package for Social Scientist ZFC

Zimbabwe Fertilizer Company

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Oil has had a profound impact on the world civilization than any single natural resource in recorded history. Hunter (2015) postulates that the current world energy consumption growth rate is 2% and crude oil accounts for 36.4% of the world primary energy consumption. Crude oil is an important national economic mainstay of many nations and it has gained so much deification that very few are concerned about its impact on the environment**.** The extraction, refining, transportation and storage processes are accompanied by operational spills, seepages and leakages (Ibeawuchi, 2016).

Oil spillage has become a global menace that accounts for 65% of World pollution and that has been occurring since the discovery, exploration and exploitation of crude oil (Kadafa, 2012). The total spillage of petroleum into the oceans, seas, rivers and land through human activities is estimated to range 0.7-1.9 million tons per year (www.science.irank.org). Oil spills have posed a major threat to the environment and that can lead to a total destruction of ecosystems.

According to O'Rourke and Connolly (2003), cumulatively significant amounts of spills emanate from pipelines, shipping and leaks. 185 gallons of oil leaked into the Gulf of Mexico in 2010. The accident killed 15,000 birds and damaged 30 kilometers of the coastal lines. A number of birds including the Kemp's Ridley Turtle are at risk of extinction. The hydrocarbon water pollution affected cities as far as Florida, Louisiana and Mississippi in United States of America (Ko and Day, 2014).

Natural microbial communities, chemical and physical properties of soils are influenced by oil spills and petroleum hydrocarbons have been considered the strongest soil pollutants (Marinescu et al., 2012). Hundred and two tons of oil was spilled in Ennore, India 2017. The oil spill destroyed thousand acres of farmlands and some palm trees in the area became infertile. There was physical, biological and chemical degradation of soil as the soil particles coagulated resulting in reduced soil moisture content, aeration and water holding capacity. The micro-biome community was altered as well thus leading to low crop output (Anobeme, 2017).

Heavy metals are typical constituents of crude oil and are released to the environment following an oil spill (Fingas, 2010). In 2006 an accidental spillage of oil in Guangzhou City China led to heavy metal contamination of fields. Excessive accumulation of Arsenic (As), Copper (Cu), Nickel (Ni) and cadmium in soil led to increased heavy metal uptake by crops. Traces of heavy metals were detected in the harvest. This compromised food security and quality (Lu, 2011).

Africa accounts for 15% of global oil production, with sub-Saharan Africa, contributing 7.25%. Most of the sub-Saharan production takes place in Nigeria (Donnelly et al 2011). Crude oil makes up a significant portion of the Nigeria's exports. The Nigerian Oil Spill Monitor recorded some 8,296 oil spills between January 2005 and July 2016 (Karl, 2015). About 70% of land and wetlands are contaminated by petroleum hydrocarbon. Bello and Pelz (2017) remarked that oil spills have become an alarmingly common event, devastating swathes of forest and waterways. United Nations' Human Development Report of the Niger Delta (2016) asserts that there is a strong feeling in the region that the degree and rate of degradation are pushing the delta towards ecological disaster. Emoyan *et al.*, (2006) also highlighted that the Niger Delta soils have become arid because of the increased levels of heavy metal and high toxicity due to soaring rates of oil exploration.

Donnelly et al (2011) also highlighted that apart from Nigeria other African countries produce oil on a smaller scale or are still in the exploratory phase. Countries like Zimbabwe do not have oil or gas resources of their own; they are completely dependent on imports. Pipelines from Mozambique Port of Beira to Mutare provide the majority of Zimbabwe's refined petroleum and diesel oil, the rest comes from Republic of South Africa (Chinhanga, 2011). Major oil spills occur during transportation but the data on the quantity of oil spilled is highly contested or missing (Donnelly et al, 2011). Only a few amongst other incidents like the March 2017 incident are recorded and published.

Moyo et al (2017) highlighted that in March 2017 an oil spill incident occurred in Victoria Falls near the Zimbabwe and Zambia boarder, 51 tones of oil was spilled.

Environmental Management Agency pays attention to oil spills that occurs during transportation (Thompson, 2010). A little to no attention is paid to formal and informal industrial oil spills and waste oil. Jerie (2016) states that Garages, industries, repair and maintenance sectors dispose waste oil into the water bodies and soil releasing petroleum hydrocarbons, halogenated compounds and heavy metals thus environmental pollution.

Jerie (2016) also postulated that both formal and informal industries dispose waste oil on soil. Current knowledge on waste oil disposal and oil spill response is limited in both formal and informal sectors. Sable chemical industries is one of the industries without waste oil disposal procedure. Waste oil is being disposed in uncovered tanks and during the rainy season oil over flows and pollutes the environment. Oil pollution alters the soil physical and chemical properties such as pore spaces, pH, electrical conductivity, nutrient content and moisture content. Conditions created are not conducive for any flora or fauna therefore it is against this background that the study seeks to examine the impact of oil pollution on the soil ecosystem at Sable Chemical Industries.

1.2 Statement of the Problem.

Oil pollution is a widespread environmental problem. It is one of the major causes of Environmental degradation in Sub-Saharan Africa. Oil contamination accounts for approximately 35% of land and water pollution in Zimbabwe (Moyana, 2012). Due to lack of awareness on how to handle oil related issues hydrocarbon contamination is continuously increasing. As postulated by Jerie (2016) Current knowledge on waste oil management and oil spill response is limited in both formal and informal sectors. From the period of December 2016 to November 2017, 10 oil spill incidents were recorded at Sable Chemical Industries and the highest oil spill loses were 98 tones. Tones of oil are being spilled arbitrarily and there are no oil spill reduction controls in place to curb the oil spills. There is no waste oil management procedure stating the proper disposal method of oil. As a result waste oil is being disposed in uncovered tanks and during the rainy season oil over flows and pollutes the environment. Oil is a visible form of pollution which degrades and alters the aesthetic value of the land. Waste oil releases petroleum hydrocarbons that are made exclusively from carbon and hydrogen atoms. These poly aromatic hydrocarbons are persistent organic pollutants that can not be degraded and they can exist in the soil ecosystem for more than 10 years depending on climatic variables (African Journal of Agricultural Research, 2017). As a result the levels of potential Hydrogen (pH) decreases, soil moisture content decreases, Electrical conductivity increases, bulk density increases and the texture and colour of soils are greatly altered (Aliyev and Khalilova, 2014).Oil contamination drastically alters the chemical properties and physical structure of soil. Therefore it is against this argument that the research seeks to examine the impacts of oil pollution on the soil ecosystem at Sable Chemical Industries.

1.3 Objectives

1.3.1 General Objective

To examine the impact of oil pollution on the soil ecosystem at Sable Chemical Industries.

1.3.2 Specific Objectives

- To identify the causes of oil spills at Sable Chemical Industries ➢ To analyze the impact of oil pollution on soil properties.
- To evaluate the waste oil management practices at Sable Chemical Industries.

1.4 Hypothesis

$H_{0:}$ There is no significant relationship between oil pollution and physical alterations of soil properties (soil moisture content, electrical conductivity and pH).

$H_{1:}$ There is a significant relationship between oil pollution and physical alterations of soil properties (soil moisture content, electrical conductivity and pH).

1.5 Significance of Study

A study on the impact of oil pollution on soil properties in present day is vital to the society. There is scarcity of researched data on the effects of oil pollution on soil properties in Zimbabwe. Oil spill incidents inflict significant cost to the environment, the company and society. It alters the aesthetic value of the land, cause biodiversity loss, water and soil and pollution. Since oil is a valuable source of energy to the company, when tones of oil leaks and spills it inflicts substantial loss to the company. Therefore the study is significant as fills in the knowledge gap on the impacts of oil pollution on the physical and chemical properties of soil. The study also aims to identify the chief causes of oil spills and proposes techniques that should be utilized to prevent and control oil spill incidents at Sable Chemical Industries. The facts gathered can be used to adopt an oil spill response plan and waste oil management procedure which will reduce environmental pollution. Waste oil management plan and land reclamation program have proved to be progressive in the industries that it has been introduced like Chaptel in Nigeria. It is thus important in industries like Sable Chemical Industries as it will assist in reduced environmental pollution.

1.6 Study Area

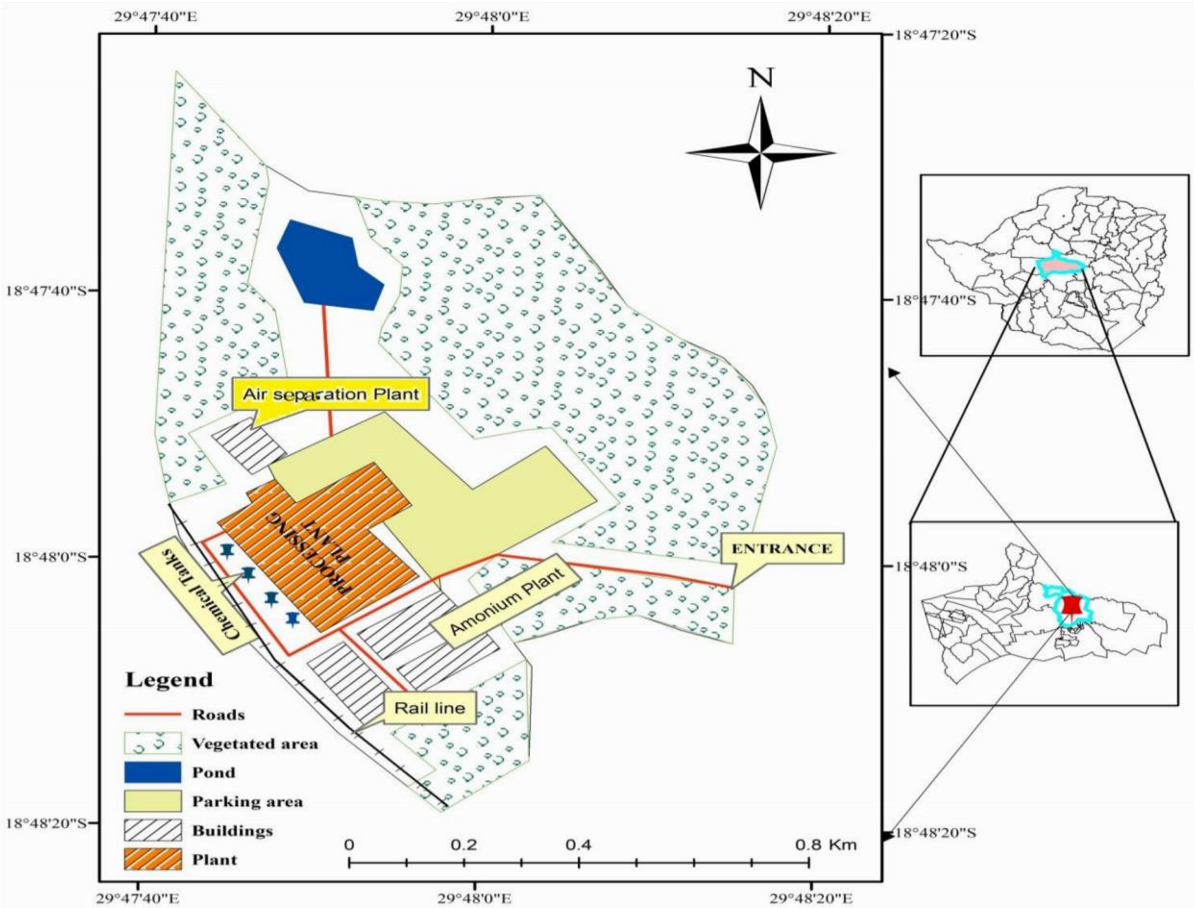

Figure 1.1 Map of Sable Chemical Industries, Kwekwe

1.6.1 Physical characteristics of the Study Area

Sable Chemical Industries is located in Midlands Province, approximately sixteen kilometers north of Kwekwe along the Harare-Bulawayo road (about 1.5km from the main road). The company owns and is situated on 65 000 acres of land.

The study are is situated in between small mountains along the granite green stone terrain, which is intruded by a lopolith Y- shaped dyke commonly known as the Great Dyke (Mumanyi, 2015). Ministry of mines report (2016) states that the dominant type of rock is granite. Basaltic, dacitic, meta-sedimental felsic and meta-volcanics rocks are also found along the great dyke. The area has various soil types varying from sandy loams, to black and red clay soils which are fertile. The most dominant soil type is the sandy loam. Sodic soils are found adjacent to water sources in gneissic granite regions (Mumanyi, 2015)

The study area falls under agro ecological zone III which is a semi-intensive farming region prone to sporadic seasonal droughts, long-lasting mid-season dry spells and the unpredictable onset of the rainy season. It receives an annual rainfall of between 500mm and 700mm (Agritex report 2013). The mean annual temperature is 20 degrees Celsius (Climate data Org, 2014).

Dominating tree species are *Mopane, Mutondo, Mususu* and *Mubhondo* while the dominating grass species are *Heteropogoncontontus, Sporoboluscocladas* and *Hyphaeran* thatch grass (Mumanyi 2015). The fauna found around the study area include *Aepyseros melampus* (impala, *mhara*, impala), *Sylvica pragrimmia* (duiker, *mhembwe, impunzi*),and *Lepus capensis* (scrub hares, *tsuro*, *umvundla*) are still found while some like sable, *Taurotragusoryx* (eland, *mhofu*, *impofu*) and *Tragelaphus strepsiceros* (greater kudu, *nhoro,ibhalabhala*) are almost extinct since they were quite easy to hunt down while some relocated as forests became industrialized and emergence of human settlements. The bird commonly found and hunted or at times domesticated was *Numida meleagris* (guinea fowl, *hanga, itendeli*)(EMA Report, 2013).

1.6.2 Socio-economic characteristic of the study Area

Sable Chemical Industries Ltd is a chemical processing industry which is Zimbabwe's sole manufacturer of the ammonium nitrate. The company also produces industrial grade nitric acid (57 w/w %) and explosive grade ammonium nitrate. Before the shutdown of the ammonia synthesis section, the company produced and sold gaseous and liquid oxygen as well as anhydrous ammonia. The company has approximately 180 employees, including shift and non-shift workers, who live in the town of Kwekwe and commute daily by company-provided transport.

Sable markets Ammonium Nitrate fertilizer on its own and there are also agreements with ZFC, Omnia and Windmill to distribute the product, along with other fertilizers. Some of the other Sable's main customers are Maguires and Profert.

Sable Chemical Industries is surrounded by legal and illegal mines. DUZI mine is adjacent to Sable Chemicals. On the northern part of the study area there are Sebakwe large scale commercial farmers. On the southern part of the study area there are illegal settlers who are settled in the proximity of the industry. Their lifestyle is depended on small scale farming and illegal mining activities. Fishing activities are also quite common near water sources (Munyati and Sebakwe Rivers). Sebakwe Township provides basic services for the Sebakwe residents but Kwekwe town is their major service provider.

CHAPTER TWO: LITERATURE REVIEW

2.1 Impact of oil pollution on soil properties.

Soil is a valuable, natural ecosystem that provides for the environment through the regulation of biogeochemical cycles, remediation of pollutants and enables food production. However, when an oil spill or leak occurs, liquid petroleum hydrocarbon is released into the soil ecosystem. Biological, chemical and physical properties of soil are influenced by these petroleum hydrocarbons. The soil texture, structure, aeration, water holding capacity and biological activities of oil contaminated soils are altered (Benka and Ekundayo, 2013).

Oil is a complex mixture of hydrocarbons containing Poly Aromatic Hydrocarbons (PAHs) that are carcinogenic, mutagenic and toxigenic (Lipińska et al. 2013). Hydrocarbons are organic compounds that only consist of hydrogen and carbon. The simplest group is the saturated hydrocarbons which have single bonds and are fully saturated with hydrogen. These are called alkanes. Unsaturated hydrocarbons have double or triple bonds and are called alkenes or alkynes. Cycloalkanes are constructed of one or more carbon rings. The aromatic hydrocarbons, also called arenes, have one or more aromatic rings. It is the saturated hydrocarbons that create the basis for petroleum products. The soil system is considered the most important long-term repository for PAHs, and it is also considered to be a steady indicator of the state of environmental pollution (Guryanova et al, 2017). Spilled oil also contains non-hydrocarbon(s) compounds like heavy metals which are potentially phyto-toxic and may interfere with normal plant development and reproduction (Kisic, 2009).

2.1.1 Impact of oil pollution on soil pH pH is an abbreviation of "potential hydrogen" and it is the measure for soil acidity and alkalinity (African Journal of Agricultural Research, 2017). A scale of 0 to 14 is used and pH of 7 is neutral. Oil contamination lowers the soil pH and acidic soils frequently experience deficiencies in calcium, phosphorus and magnesium (Clemson Cooperative Extension, 2016). Toxic conditions created by acidity affects the behaviour of soil microbes, encouraging or inhibiting the growth of pathogens and affecting how well helpful microbes are able to break down organic material that increases soil nutrients (Thumma, 2014).

2.1.2 Impact of oil pollution on soil moisture content

Soil moisture content is the total volume of water in the soil. It is an important factor for soil development. Oil pollution coats the soil particles through coagulation impeding infiltration. (Rank, 2013). Soil compaction results in uneven moisture distribution, and it also impedes infiltration there by lessening the volume of water in the soil (Marín-García and Jones, 2016). The volume and movement of water in the soil is the single most important factor determining soil development therefore the decrease in soil moisture content affect the quality of the soil.(Eregh and Irughe, 2015). The hydrophobic nature of hydrocarbons can modify the wet ability of the surface of soil particles and they contribute to soil water repellency when coating soil particles (Rank, 2013). Soil water repellency affects hydrological and ecological soil functions by decreasing water infiltration, increasing surface runoff and erosion, and impeding plant growth (Marín-García and Jones, 2016).Water repellency of soils limits their water sorptivity and results in uneven moisture distribution, forming preferential water flow in the soil profile (Wang, 2013). Oil contamination strongly increases the hydrophobicity of the soil, it loses its ability to absorb and retain water, displacing the air from the soil pores and ultimately destroying the water and air regime, leading to enhanced surface runoff, erosion and reduced soil moisture content (Marín-García and Jones, 2016). Hydrocarbon contaminated soils Kana, Nigeria indicated a significant decrease in the soil moisture content of 7.17% and it was attributed to insufficient aeration of soil due to increased bulk density (Rank, 2013).

2.1.3 Impacts of oil pollution on soil Electrical Conductivity.

Soil electrical conductivity (EC) is a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil health. Poly Aromatic Hydrocarbons induces charged ions (cations, and anions) in soils (Rawand, 2016). This increase in the amount of charged ions or salts affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes (United States department of Agriculture). There is a strong correlation between soil microorganism activity and EC, the micro-organism activities decreased as EC increases. This impacts important soil processes such as respiration, residue decomposition, nitrification, and denitrification. Oil spills in Tarjan, Kurdistan Region, Iraq resulted in the loss of arable land since oil pollution is closely linked to aridity (Rawand, 2016). Adviento (2016) states that, soils with a high concentration of sodium salts (sodic conditions) have additional problems, such as poor structure, poor infiltration or drainage, and toxicity for many crops since each has a salt tolerance range.

2.1.4 Impacts of oil pollution on soil micro-organisms

Poly Aromatic Hydrocarbons affect the activity of soil enzymes, which can be used to evaluate soil microbial properties (Shen et al. 2006).The activity of soil enzymes is one of the approved parameters used for the evaluation of soil quality polluted with organic compounds (Lipińska et al. 2014). Contamination with hydrocarbons has a profound effect on soil fauna; PAHs greatly affect the survival and reproduction of earthworms (Shen et al. 2006).. The microbial population near root surfaces which includes the rhizosphere bacteria population is negatively affected by the toxic conditions created by the poly aromatic hydrocarbons. When the rhizosphere bacteria population is affected it inversely decreases the amount of nutrient available for the plant from the soil (Benka and Ekundayo, 2013).

2.2 Causes of Industrial oil spills.

Abosede (2013) postulated that an oil spill is the release of a liquid petroleum hydrocarbon into the environment. There are natural and anthropogenic causes of oil spills and industrial spills are mainly anthropogenic (Joye, 2013). Environmental Pollution Center (2017) also alludes that anthropogenic sources of oil spill pollution determine the type and amount of oil spilled, as well as the location of the oil spill, the type of the oil spill pollution. Industrial oil spills often results from sabotage or theft, human error, accidents and operational discharges of petroleum hydrocarbon into the environment. Oil bunkering is also a source of oil spill (Adams et al, 2016). According to Fingas (2016), 30% to 50% of oil spills are either directly or indirectly caused by human error and 20% to 40% of oil spills is caused by equipment failure or malfunctioning.

2.2.1 Industrial mechanical failure

Fingas (2016) postulated that equipment failure or malfunctioning accounts for the 40% of oil spills. Rank (2013) supports the view by stating that any equipment can breakdown or fail unexpectedly, and when it does, serious outcomes can follow particularly depending on the function of the equipment. In the petroleum industry, breakdown and failure of equipment has led to a number of oil spills and it's usually the most dreaded. Be it in the drilling rig or refineries, their mechanical breakdown or malfunction have caused unprecedented oil spill catastrophes.

Mechanical failure of the BP's drilling rig, for example, partly contributed to the Gulf spill – one of the world's major oil blowouts in history. Top BP officials at the time admitted that enormous mechanical failure prevented the rig from sustaining the mounting pressure from below, which caused the blowout (Institute of Marine Affairs, 2017).

Abosede (2013) states that mechanical failure from the main pipeline led to the leakage of over 18,000 gallons of oil at Chevron Pipe Line Company. The Coast Guard worked with staff from the Louisiana Oil Spill Coordinator's Office to minimize the environmental impact of the spill.

2.2.2 Human error

Carelessness or mistakes or errors made by people is one of the primary causes of oil spills which accounts for 20% of the causes of oil spills. According to Abosede (2013) majority of the oil spill cases are associated with human error, carelessness and mistakes that could be avoided. Such cases are normally noted where there are petroleum refineries, barrages, tankers, storage facilities and pipelines.

For instance, all acts of human mistakes and carelessness were linked to the Exxon Valdez Oil Spill in March 1989 (Rankesh, 2009). On a separate case, the BP's head of safety party blamed human error for the oil spill in 2010. Further, reports indicated that five key human errors led to the Gulf oil rig blowout, causing one of the biggest oil spills in history.

2.2.3 Sabotage and theft

Deliberate acts by terrorists, vandals, or countries at war have contributed to a number of oil spillages. Marine habitats and inland water systems have been polluted by oil spills especially by acts of vandalism, sabotage or terror activities with an aim of completely destroying the perceived enemy's economic wealth base. Most of the criminals target major pipelines. Such incidences are rampant in war and petroleum resource zones.

A prime example is the 2015 Revolutionary Armed Forces of Colombia (FARC) attacks against

Columbia's oil industry which caused a spill of approximately 400,000 gallons of crude oil. Wars such as the Gulf War also resulted in colossal oil spills. The Gulf War oil spill is recorded as one of the leading oil spills in history.

2.2.4 Illegal dumping of used oil

Illegal dumping of used oil a wide spread environmental problem particularly to industries in developing countries (Rankesh, 2009). Due to inadequate waste oil collection facilities and ignorance tones of oil are dumped into the water bodies and land. In certain cases some industries just choose not to abide by the rules of waste oil management. Rankesh (2009) states that although illegal dumping does not account much for the oil spillages, some people or industries just choose not to follow the right channels for dumping used oil. Instead, they choose to dump or discharge the used oil directly into water bodies. Illegal dumping of used oil in inland areas also contributes to the problem because it causes oil spills which eventually get washed into the water systems by storm water. Similarly a number of formal and informal sectors in Zimbabwe are illegally dumping used oil due to inadequate waste collection and disposal facilities (EMA, 2012)

2.2.5 Corrosion of oil storage tanks

Oil can be stored underground and aboveground storage tanks. In time the storage tanks may develop leaks. Schneiderman (2017) states that oil spills from leaking storage tanks is the largest environmental threat being faced by countries including America present day. Estimates of one hundred and two million underground tanks are leaking in United States of America and roughly 100 gallons of oil have leaked. This polluted the underground water and remediation of this type of pollution is hard to resolve (Rankesh, 2009). Corrosion of oil storage tanks takes place quickly when buried unprotected in the soil. Corrosion, and other factors such as improper installation and piping failures, has already caused more than 400,000 confirmed underground storage tank leaks nationwide.

2.3 Global waste oil management.

Waste oil management is better in developed countries as compared to developing countries. A number of technologies have been used to store, transfer, recover and dispose waste oil. The United States of America produces 1.3 billion gallons of waste oil each year, of which 1 billion gallons are recycled. Recycled used motor oil can is re-refined into new oil, processed into fuel oils and used as raw materials for the petroleum industry (Green, 2017).

In china, waste oil is a value resource; waste oil is used in waste oil boilers. Energy Logic waste oil boilers are designed specifically for waste oil. Unlike traditional boilers made with cast iron, these boilers are made from carbon steel and are ASME certified. With this type of technology every drop of waste oil is valuable (Webb, 2016).

When storing waste oil in Canada, overfill sensors are attached inside the roof of a storage or transfer tank and identify when the desired level of waste oil has been achieved within the tank, triggering an automatic shut-off valve to prevent overfilling (Canadian spill response, 2016).

In Malaysia, when decanting used oil from the storage tanks, metered pumps are programmed to deliver a pre-set amount of product from a storage facility to a tanker car, providing a safeguard against accidental overfilling and spillages (Agamuthu, 2012). The operator monitors the transfer and can utilize a manual shut-off-valve to stop the loading, if necessary.

Concrete traps are constructed beneath above-ground tanks to protect against groundwater contamination and facilitate the rapid identification of a spill in the unlikely event of structural failure. A circular, gravel-filled trough collects any spilled product.

In Mexico, waste oil is either burnt or buried. Waste oil is incinerated and the ash residues are buried at hazardous waste disposal site (Field and Murphy, 2014). However incineration emits nitrogen oxides (NOx), sulfur dioxide, methane, carbon dioxide, particulate matter (PM) and volatile organic compounds (VOC)). The VOCs (especially Benzene, Toluene, Ethylbenzene and Xylene (BTEX) are often referred to as air toxics are very harmful to public health. There is direct transfer of water and land pollution to air pollution (Webb, 2016).

2.3.1 Waste oil management in Zimbabwe

Proper waste oil management at all stages is a challenge all over the world especially in enforced and Zimbabwe is not an exception (Jerie, 2016)

Jerie (2016) states that oil is derived from minerals and synthetic source therefore it is considered a hazardous waste. In most developing countries very few facilities exist for safe storage of hazardous waste. Generally hazardous waste created is stored in the producer's backyard, often in unsuitable containers. The storage is usually extended resulting in waste oil spillage (EMA 2012).

Hazardous waste is collected and transported by local authorities and a few private companies but significantly these wastes are not collected in time and they end up being dumped illegally due to massive accumulation (EMA Report, 2014). Most common challenge facing institutions and organizations in waste oil management is the absence of waste oil disposal facilities the country. There is no adequate waste collection and disposal facilities except for few individual companies that require used oil for their own purposes (Jerie, 2016). He further postulated that lack of oil disposal facilities explains why oil management has chocked enterprise operators.

2.3.2 Legal instrument which governs waste oil management in Zimbabwe.

Waste oil is classified under the hazardous waste in the Environmental Management Act 20:27. The hazardous waste management under the EMA 20:27, section 140 Statutory Instrument 10 is the regulation that manages hazardous waste and under this regulation, no person store, sell, transport, recycle, discharge or dispose any hazardous substance into the environment except under EMA licensing. The licenses are categorized into four colour codes blue- safe, green- low hazardous, yellow-medium hazardous, red- extremely hazardous. The licenses are renewed annually and the polluter pays according to the quantity and quality of waste generated. The holder of a red-class license pays 50% of the monitoring fee plus environmental fee. Every year the polluter drafts waste management plan stating amount of waste to be generated, specific goals for reduction of quantities.

However this instrument is not properly implemented, a number of formal and informal sectors are not licensed thus their waste oil management practices can not be tracked, monitored and corrected thereby it leaves a room for environmental pollution.

2.4 Knowledge gap

Previous studies on oil hydrocarbon pollution have greatly contributed to the pool of knowledge available. Eregh and Irughe (2009), Rank (2013) and Abosede (2013) amongst others have carried out studies in oil producing countries identifying the impacts of oil pollution on the marine ecosystem and socio-economic environment. Much work on oil pollution covers the oil producing countries. The researcher noticed a gap in the information and knowledge available on impact of oil pollution on soil ecosystem in Zimbabwe specifically at a fertilizer manufacturing industry. Moreover due to limited data on the subject, formal and informal sectors of Zimbabwe that produces waste oil lack awareness and they are continuously dumping it into the environment. Formal and informal sectors present different sources of oil pollution; therefore different recommendations should be given accordingly depending on the situation at hand. Henceforth, this study aims to bridge the knowledge gap of oil pollution on soil properties between oil producing countries and the Zimbabwean fertilizer producing company.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

Remenyi et al (2013) defines research design as the overall strategy that is chosen to integrate the different components of the study in a coherent and logical way thereby ensuring one will effectively address the research problem**.** Kothari (2004) also states that a research design is the conceptual structure within which research is conducted which constitutes the blueprint for the collection, measurement and analysis of data.

Creswell (2013) states that a descriptive case study research refers to an in-depth, detailed study of an individual or a small group of individuals. The researcher adopted the descriptive case study research design because the data is collected in a natural setting and context. Case study descriptive research emphasizes in-depth content and it is able to combine both objective and subjective data to achieve an in-depth understanding. The researcher used triangulation method of qualitative and quantitative techniques so that they could complement each other. Rahman (2016) supports the view by stating that, use of methodological triangulation research design, enables the researcher to obtain valid and reliable results since the flaws of one method are neutralized by the other method thereby strengthen the research results.

Rahman (2016) postulates that qualitative approach is about recording, analyzing and attempting to uncover the deeper meaning and significance of human behaviour and experience. Qualitative approach is known by its aims which lean to understand some characteristics of the social life and methods used to generate words, instead of numbers (Alzheimer Europe 2013).In this case it was meant to explore the causes of oil spills and the waste oil management practices at Sable Chemical Industries. The techniques that were used included administering semi- structured questionnaires, interviews and direct field observations.

Quantitative approach refers to the systematic process of obtaining data through mathematical, measurements, statistical or numeral analysis (Bryman, 2012). The technique was adopted in this research as in order to obtain the actual data on the level of pollution. Soil samples were collected and analyzed in the laboratory in order to assess the level of oil pollution on the soil ecosystem.

Secondary data from oil spill incident records was also manipulated in order to obtain information on the quantity of oil spilled and frequency of oil spill incidents.

3.2 Target population

Holloway and Wheeler (2012) postulates that targeted population refers to the whole group of people in which researchers are interested in coming up with their conclusions from. The target population comprised of employers and employees at Sable Chemical Industries. Environmental Management Agent was also part of the targeted population.

3.2.1 Determination of sample size and sampling procedure

Trochim (2016) postulates that sample size is defined as an element of research design that the researcher need to put into consideration as they plan their study. Sample size is one of the major factors affecting the power of the study to produce reliable conclusive results (Smith, 2017). Knight (2002) also state that sampling is about selecting who or what is to be studied and that a good sample is one that represents the whole population. By the time the research was conducted the target population was 180, the researcher purposively selected one third of the population to represent the whole group and the sample size became 60. The sampling involved all divisions at the company. These comprised of the SHEQ, Production, mechanical engineering, garage, civil engineering, Finance and Human Resources department

As noted above the study population was divided into several subdivisions though they can be divided into two main groups that are production and administration. Stratified sampling was to be adopted thus dividing the whole population into relatively homogeneous sub entities referred to as a strata then random sampling can be carried out in each strata. The random samples in each stratum are chosen in a way that there is proportional representation of the whole population or stratum.

3.3 Research Instruments

Research instrument is a device or technique that a researcher uses to collect data. These maybe understood as those methods or techniques that are used for conducting a research (Avison, 2005). They are simply referred to as methods that the researcher used in performing research operations (Kothari, 2004). In this research, the researcher used questionnaires, interviews, field observations, soil samples and secondary data sources from the SHEQ incident records.

3.3.1 Questionnaires

A questionnaire is a document containing questions and other types of items designed to solicit information appropriate for analysis (Babbie, 2012). A questionnaire according to Gillham (2008) is a research instrument comprising of various inquiries and different prompts with the end goal of collecting information from the targeted population. The researcher requested permission from the General Manager and the Projects Manager and self administered sixty open-ended and close-ended questionnaires randomly across divisions. The researcher distributed questionnaires randomly across divisions namely the production services, mechanical engineering, garage, civil engineering, SHE, Finance and Human Resources department. Closed and open questions were used; the open questions allowed the respondents to freely express their views, observations and opinions. The method was selected because it allowed the researcher to investigate and prompt vital information that cannot be observed such as thoughts, values, prejudices, views, feelings and perceptions.

3.3.2 Interviews

Lagan (2018) states that a research interview involves an interviewer who coordinates the process of the conversation and interviewee to respond to the questions, thus the essence of asking and answering of questions as scheduled in an interview guide. The researcher applied the structured interview, different questions were asked to participants depending on occupation and educational level (Bryman, 2012). The interviews were of interest since they inflicted a better understanding of questions to the respondents as the interviewer had flexibility to rephrase and interpret the questions for better understanding. However the interviews were also detrimental in the sense that the researcher had to plan for appointments and mostly the key informants were hardly available due to work commitments. Some of the interviews had to be done over the phone.

Table 3.1 Interviewee and Rationale for selection

Interviewee	**Reasons for selection**
Productions manager: Sable Chemical Industries	Head of production : to obtain information on ✓ the chief causes of oil spills ✓ oil spill response plan ✓ waste oil management ✓ oil spill clean up methods ✓ Quantity of oil lost during each oil spill
SHE Officer: Sable Chemical Industries	Safety Health and Environmental officer ; to acquire information about ✓ Frequency of oil spill incidents ✓ The effectiveness of the current waste oil management practices. ✓ Current oil spill response procedure ✓ Waste oil disposal methods
Environmental Officer: Sable Chemical Industries	✓ Responsible for environmental and quality assurance at the company level ✓ Views about oil pollution ✓ To obtain information about the effectiveness of waste oil management practices
Stores controller: Sable Chemical Industries	✓ Responsible for the storage and management of waste oil
Nitric acid plant operator: Sable Chemical Industries	✓ Responsible for conducting Plant checks, ✓ Obtains information on what causes Plant oil spills
Manufacturing Plant Assistant: Sable Chemical Industries	✓ Responsible to conducting plant maintenance, remediation of polluted sites, refill and exchanges oil and conducts compressor purges

Environmental management Officer EMA (Gweru)	✓ Responsible for environmental monitoring ✓ The EMA is responsible for the management and monitoring of hazardous substances (in which oil is classified) under the Environmental Management Agency 20:27 S.I 10

3.3.3 Observations

Observation is a systematic recording of observable phenomena or behaviour in natural setting (Baker, 2006), by observing and measuring the world around, including people and other measurable events. Direct observations were employed with the aid of an observation checklist. Direct observation was preferred because the researcher obtained visual evidence of pollution. The researcher was also able to observe the attitude of employees towards oil spill response and oil waste management. Observations were undertaken and they complemented the interviews and the questionnaires. The observations were carried out for 12 months when the student was conducting work related learning at the company, notes were taken down and images were also captured using a camera.

3.3.4 Soil Sampling

A soil test is a chemical evaluation of the nutrient-supplying capability of a soil at the time of sampling (Keren, 2016).Soil samples were collected from the polluted and unpolluted sites (Control samples). Two core samples at the depth 0-5 cm and 5-10 cm were collected using an Auger. Two replicates from four different places (quarters) or locations –Nitric Acid Plant, waste oil disposal site, ammonia storage sphere purging site and the garage. Soil samples from each sampling location were put in a sterile polyethylene bag flamed sealed, labeled and taken to the laboratory. The soil sampling was done at ANTECH laboratories Kwekwe. The parameters analyzed were soil moisture content, electrical conductivity and pH.

Table 3.2 Parameters and reasons for analyzing them

Parameter	Rationale for Analysis
pH Potential Hydrogen Normal soil pH range (6.1 - 7.5)	➢ pH determination is an indispensable means for characterizing soil from the standard point of nutrient availability and physical condition, structure, permeability. ➢ It provides information on the potency of toxic substances present in the soil. ➢ It is indicative of the status of microbial communities and its net effect on the neutralization of organic residue and the immobilization of available nutrients.
Electrical Conductivity	➢ Soils contaminated with polynuclear aromatic hydrocarbons are usually saline. Saline soils have a high content of soluble salts, as sodium (Na+) predominates, saline soils can become *sodic*. Sodic
Capacity of soil to exchange cations (positively charged ions).	soils present particular challenges because they tend to have poor structure, preventing water infiltration and drainage and that hinder plant growth by affecting the soil-water balance. ➢ Soil microorganism activity declines as EC increases. This impacts important soil processes such as respiration, residue decomposition, nitrification, and denitrification thus affecting the soil quality. ➢ It is an important indicator of soil health. It affects crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes. ➢ It is an important indicator of soil status. It affects crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes.

Soil Moisture content	➢ The volume and movement of water in the soil is the single most important factor determining plant growth. Depending on the plant, water comprises 50% to 90% of the plant tissue. ➢ Photosynthesis and nutrient availability depend on water. Water is the solvent in which all chemical reactions take place. ➢ Similarly, water is the most important factor determining remediation of salt water and hydrocarbon spills.

3.3.5 Laboratory tests methods of parameters

Brief description of the methods used to analyze the soil properties at the laboratory

3.3.5.1 pH value

The first step was with the addition of 30g of soil into the glass beaker, after that adding 30ml of distilled water to the glass beaker, and mixed well to produce soil slurry. The sample was held for about one hour in the glass beaker, and was stirred every 10 or 15 minutes. This process stabilized the pH of the soil flurry. Then the temperature of the sample was measured, and the temperature of the pH meter managed according to the temperature of the sample. The pH meter was calibrated by using the stand solutions.

3.3.5.2 Electrical Conductivity (mS/m)

The Electrical Conductivity Probe and Meter was used. The accuracy of EC meter is very high. The soil sample was dried, and sieved (2mm). 25g of soil was mixed with 40 ml of pure water, after 4 hours the solution was at equilibrium. Without stirring, the mixture was filtered through a Whatman number. 40 filter papers were added into a flask. The probe was inserted into the solution and moved up and down for several times to avoid the air bubbles. The results were displayed on the EC meter.

3.3.5.3 Soil moisture content %

Thermo-gravimetric direct method was used. It is based on the weight measurement of a wet sample before and after oven drying at 105 °C for 24 h. A clean and dry the container was taken and weighed. 300g of soil was placed in that container and it was weighed. Afterwards the container was placed in the dry oven at 105 °C for 24 hours. After drying, the container was removed from the oven and to cool off. The container was weighed with the contents. The difference between (sample before drying) and (sample after drying) is expressed as percentage.

Calculation of the soil moisture content as a percentage of the dry soil weight.

$$\mathbf{MC\% = \frac{w^2 - w^3}{w^3 - w^1}}$$

Where: W^1 = Weight of tin (g)

W^2 = Weight of moist soil + tin (g)

W^3 = Weight of dried soil + tin (g)

3.3.6 Secondary data sources

The researcher obtained additional data from secondary data sources. Secondary data is the analysis of data which was collected for other purposes. This data can be contemporary or historical and may be qualitative or quantitative and usually needs adjustments and validation before being put to use (ACAP 2012). The researcher obtained information on oil spill incidents from the Sable Chemicals SHE department records. The records provided the information on oil spill incident statistics, which gives insight of the frequency, amount of oil spilled, root causes of the incidents and remediation actions taken. Information about waste oil was accessed from the articles by other researchers, published text books, journals and reports.

3.4 Data analysis and presentation

According to Statistics Canada (2014), data analysis is the process of evaluating data using analytical and logical reasoning to examine each component of the data provided. According to Felix (2015), raw data can only become useful information after it has been subjected to some form of analysis. Quantitative data from the close-ended questions from the questionnaires and was ranked and put into nominal-levels categories using the Statistical Package for Social Scientists (SPSS) software version

20.0 and Microsoft excel. Qualitative data collected from the interviews, field observations, and open-ended questionnaires was analyzed using content analysis. Data was categorized identifying themes, organized, coded and interpreted. It was used in this research to establish relationship between waste oil management practices and soil pollution. Descriptive analysis and chi-square hypothesis testing approach was used to analyze this qualitative data.

Correlation was calculated using Spearman's coefficient of correlation, which is a tool used to determine the relationship between two variables. It is used in case of ordinal data where ranks are given to the different values of the variables (De Langen, 2014). The researcher used it to determine the statistical associations between oil pollution and physical alterations of soil properties (soil moisture content, electrical conductivity and pH).

Data presentation is defined as visualization of data collected to communicate information clearly and efficiently through graphs (Baker, 2006). Tables, pie charts, and bar graphs were used to present the obtained in the study. Numerical data from the laboratory was presented in a comparative and descriptive way. Qualitative data was presented in a descriptive manner. Photographic images were presented as plates. Such data presentation gives a room to compare and analyze thereby enhances logic and coherence of the study.

3.5 Ethical Considerations

Saunders and Thornhill (2012) postulates that ethical considerations refer to the norms or standards for conduct that distinguish between right and wrong in research. They help to determine the difference between acceptable and unacceptable behaviors. Ethical standards prevent fabrication or falsifying of data and therefore, promote the pursuit of knowledge and truth which is the primary goal of research. The researcher obtained permission from Geography and Environmental Studies

Department at Midlands State University to carry out the study. The department provided the researcher with a letter of assurance to the targeted population that the research was specifically for academic purposes. The whole research project took ethical considerations from formulation of research project up to presentation and reporting. The research design and plan was structured in such a way that it did not deprive some participants of their privacy. The research participants were assured that they were not susceptible to any risks as a result of this research project. The research methods and procedures employed allowed the participants to give information willingly without deception and manipulation in gaining access. Confidentiality, anonymity and privacy were fully guaranteed to all participants so that they could express their views freely and without fear of being identified.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Socio-demographic Characteristics of Respondents

The socio-demographic characteristics of the research undertaken at Sable Chemical Industries consolidated information on gender, age, level of education as well as duration of work experience.

4.1.1 Response Rate

Total of number questionnaires distributed	Number of questionnaires returned	% number of questionnaires returned
60	60	100%

The study targeted 60 respondents from Sable Chemical Industries. The researcher distributed 63 questionnaires and 60 were returned yielding a response rate of 100% since the research targeted 60 respondents.

4.1.2 Gender of respondents

Sable Chemical Industries is a fertilizer manufacturing industry; a lot of manual handling is involved so the number of women employed is very low. Out of 60 respondents, male respondents constituted 87% whilst women constituted 13% which was 52 males and 8 females. The research was not gender biased and there was proper representation of both males and females considering that there are 20 female employees (in total) at the company as shown on (Figure 4.1)

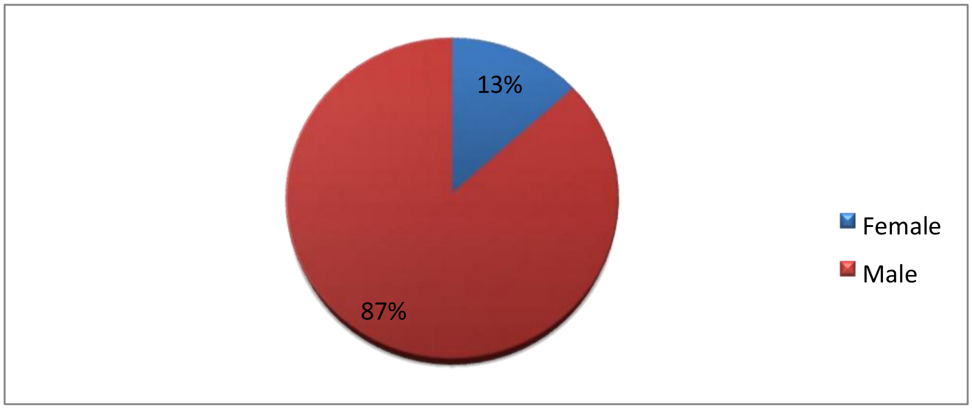

Figure 4.1 Sex compositions of respondents at Sable Chemical Industries Source: Field data (2018)

4.1.3 Age of respondents

The most dominant group of respondents is 31-40. It is part of the economically active group. Its dominance is relevant to the research since it consist of mature individuals who have work experience and they easily identified the causes of oil spills.

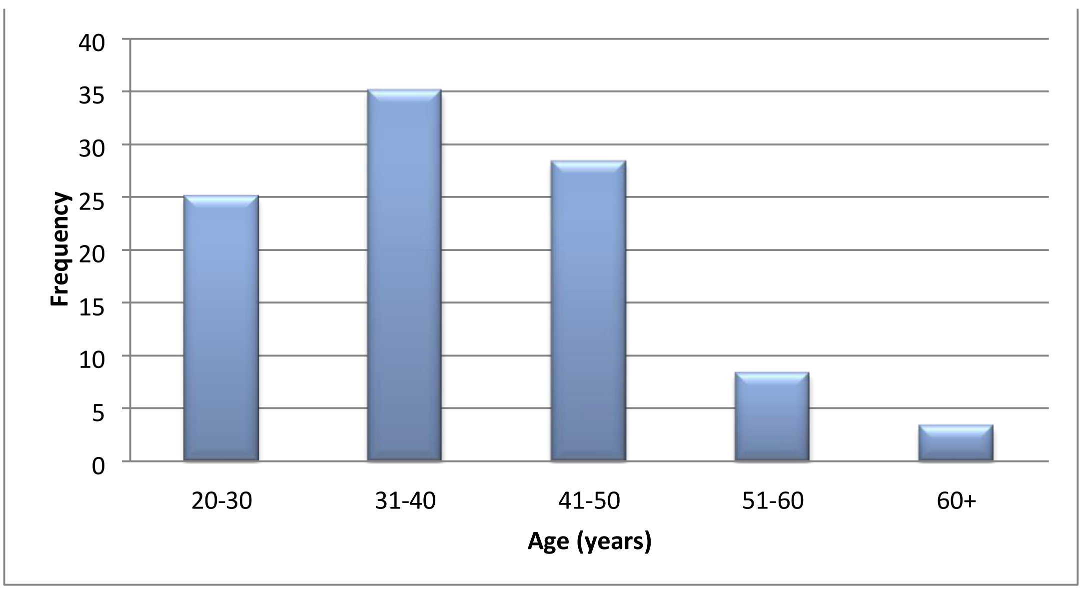

Figure 4.2: Age of respondents

Source: Field data (2018)

4.1.4 Educational level of Respondents

The educational attainment of respondents was also another crucial socio-demographic data solicited by the researcher in order to acquire information on their knowledge and understanding of the impact of oil pollution on the soil ecosystem. Table 4.1 reflects that 28.3% of the respondents had achieved primary level, whilst 40% had attained secondary level achievement as their highest level of education, making it a large proportion of the total. This large proportion of the respondents with secondary education contributes significantly to the validity of the results. Respondents who reached the tertiary level constitute 31.7%. Education attainment of respondents determined the different levels of understanding as well as perceptions and attitudes towards the relationship between oil pollution and land degradation.

Table 4.1 Educational levels of respondents

	Frequency	Percent	Valid Percent	Cumulative Percent
Primary	17	28.3	28.3	28.3
Secondary	24	40.0	40.0	68.3
Tertiary	19	31.7	31.7	100.0
Total	60	100.0	100.0	

Source: Field data (2018)

4.1.5 Work Experience

The duration of stay at Sable determines the amount of knowledge gained on systems, habits and culture of the company. The longer the duration of stay, the more relevant a respondent became. Some respondents would have witnessed all the oil spill incidents and they know the root causes of oil spills. The dominating group is 11-15 thus the respondents' duration of stay was long enough for them to provide relevant information in the survey.

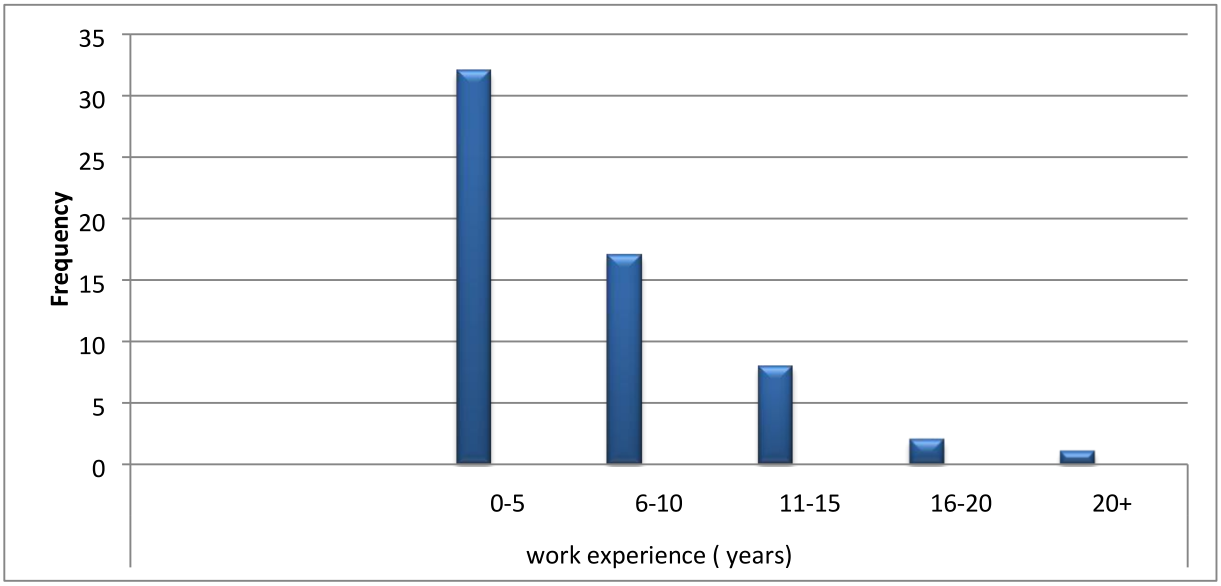

Figure 4.3: Work experience of respondents

Source: Field data (2018)

4.2 Causes of oil spills at Sable Chemical Industries

The responses from the employees revealed that causes of oil spill incidents were mostly due to mechanical failure, decanting, oil refill and exchange, purging of compressors and breakdown maintenance. This is represented in table 4.2

Table 4.2 Causes of oil spills at Sable Chemical Industries (%).

	Frequency	Percent	Valid Percent	Cumulative Percent
Oil refill and exchange	4	6.7	6.7	6.7
Decanting	14	23.3	23.3	30.0
Purging of compressors	9	15.0	15.0	45.0
Breakdown maintenance	5	8.3	8.3	53.3
Mechanical failure	28	46.7	46.7	100.0
Total	60	100.0	100.0	

Source: Field data (2018)

From the administered questionnaires, it was established that 47% of the oil spills are caused by mechanical failure, 23% decanting, 15% purging, 8% breakdown maintenance and 7% by oil refill and exchange.

4.2.1 Mechanical failures

Mechanical failures are ruptures and fissures that occur when stresses in the system exceed the allowable stress (Martin, 2008). At Sable Chemical Industries mechanical failure incidents are usually associated with the Nitric Acid Plant. According to the Sable Chemical Industries SHE incident records, 15 oil spills incidents were recorded from December 2016 to April 2018. From the interview held with the Production Manager, the researcher established that oil leaks were attributed to the corrosion of valve seats, deterioration of flange gaskets, reduced tension in bolts and internal corrosion of the hydraulic valves. All these owe to the lack of scheduled Plant maintenance, installation and replacement of equipment timeously.

The Nitric Acid manufacturing Plant at Sable Chemical Industries was manufactured in 1962 and it was installed at the company in 1972. Frequency in oil spill incidents may be credited to the fact that the machinery is old and plant equipment is gradually corroding with time. The possibility of leakage through valves is dependent on design, aging, maintenance, fluid properties, and especially sealing design (Svendsen, 2014).

The research also established that the company has not been operating at its full capacity, which means that the manufacturing Plant would be decommissioned for a period of time. Alternative commissioning and decommissioning of the manufacturing Plant has a significant effect on the maintenance of Plant equipment.

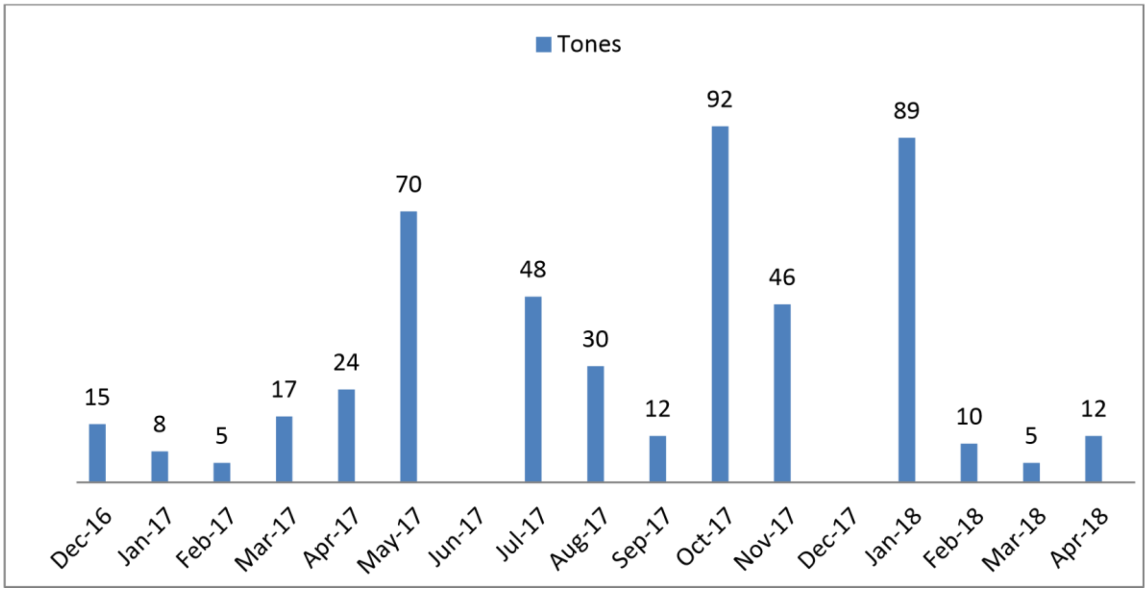

Figure 4.4 Oil spill incidents from the Nitric Acid Plant (2016-2018) Source: Sable Chemical Industries SHE records.

Figure 4.4 shows a trend in oil spill incidents at Sable Chemical Industries. The highest oil spill was recorded in the month of August 2017. According to the incident register these oil spills were due to inconsistent or poor maintenance of the manufacturing Plant. The amount of oil lost also varied and the estimated amounts were recorded in tones. The highest oil spill was recorded

4.2.2 Decanting

Decanting refers to transfer of oil from the storage tank into a drum; due to lack of facilities like oil pumps, oil transfer is done using half cut drums or containers. Some times employees overfill the drum during decanting and oil spills into the environment. Due to poor handling of the waste oil, decanting constitutes 26% of oil spills.

Plate 4.1 Employees transferring oil from storage tanks to drum using containers.
Source: Field data (2018)

Table 4.3 Oil handling practices and employees' level of awareness

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.206[a]	6	.003
Likelihood Ratio	15.555	6	.016
N of Valid Cases	60		

Chi-square test was done, using the variables on the above cross table, to test the relationship between oil handling practices and level of awareness. The Chi-square results are read as follows, H_1 means that there is a relationship between the variables whilst H_O implies that there is no relationship. When our product value is below 0.05, we reject H_O and accept H_1, when our product value is greater than 0.05, we accept H_O and reject H_1.The chi-square test was 0.03 meaning there is association between waste oil handling practices and knowledge on the proper handling of waste oil, therefore we reject H_O and accept H_1. Employees are not trained and they lack knowledge in waste oil handling practices that is the reason why they use half cut plastic containers to decant oil from the storage tank into the drums.

4.2.3 Breakdown maintenance

From the internal investigations held by the SHEQ department, breakdown maintenance is mainly caused by human error. In some of the incidents, more than one factor resulted in the leak. Plant operators stated that during the breakdown maintenance, sometimes valves are left in wrong position especially when the maintenance is conducted by inexperienced employees. Another oil leak incident occurred as a result of improper mounting of gaskets after maintenance. However, breakdown maintenance issues are being managed through training and supervision.

4.2.4 Oil refill and exchange

The chief cause of the oil spills related to oil refill and exchange is lack of training. The researcher established that oil refill and exchange constitute 7% of oil spills causes.

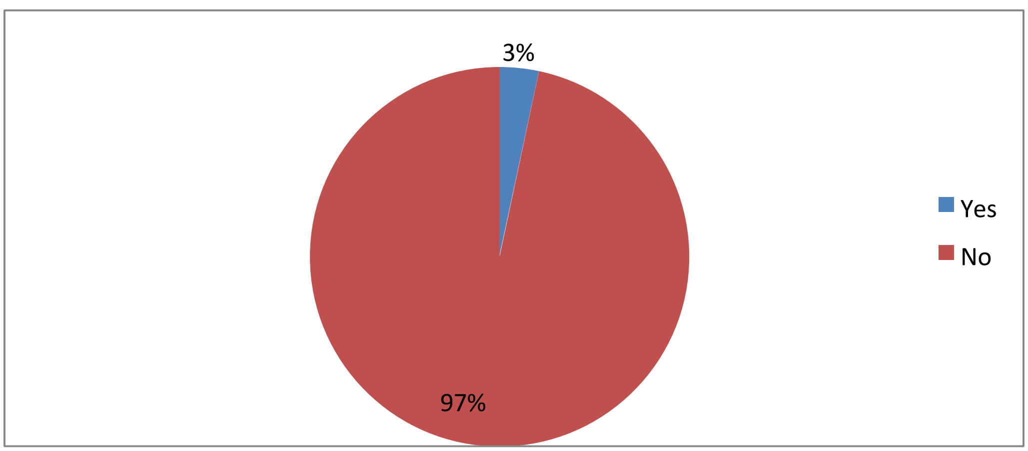

Figure 4.5 Distribution of respondents who are trained to handle oil. Source: Field data (2018)

97% of the respondents indicated that they were not trained to handle oil related issues. This answers the question why the employees spill oil during refill and exchange.

4.2.5 Purging

Air compressors intake is breathable atmosphere where humidity in the air is sucked in on every cycle. Due to atmospheric air properties water droplets accumulate in the tank/s therefore, it is imperative to purge the tank/s at least once a week (Bendix, 2004). Air compressors without oil filters eventually release oil when the purging release valves are opened. The interview with the Plant serviceman indicated that only one air compressor has an oil filter at Sable Chemical Industries.

"*Ma compressor acho haana ma oil filters aya, kunze kwe yeku Electrical uko, haa oil inototi irasike hapana zvekuzviita*".

This implies that only one out of six air compressors has an oil filter, the rest of the compressors release oil into the environment. Purging constitute 15% of the total oil spills.

Plate 4.2: Oil pollution from the ammonia storage plant air compressor Source: Field data (2018).

4.3 Waste oil management at Sable Chemical Industries

According to EMA Report (2012) the most common challenge facing institutions and organizations in waste oil management is the absence of waste oil disposal facilities in the country. There is no adequate waste collection except for few individual companies that require used oil for their own purposes. Generally waste oil is stored in the producer's backyard, often in unsuitable containers. The storage is usually extended resulting in waste oil spillage; Sable Chemicals Industries is not an exception.

Waste oil is stored at the backyard at Sable Chemicals, popularly known as the savage or scrap yard. Waste oil is stored in the tank which is not covered at the top. From the interviews held, it was established that there are waste oil management practices in place.

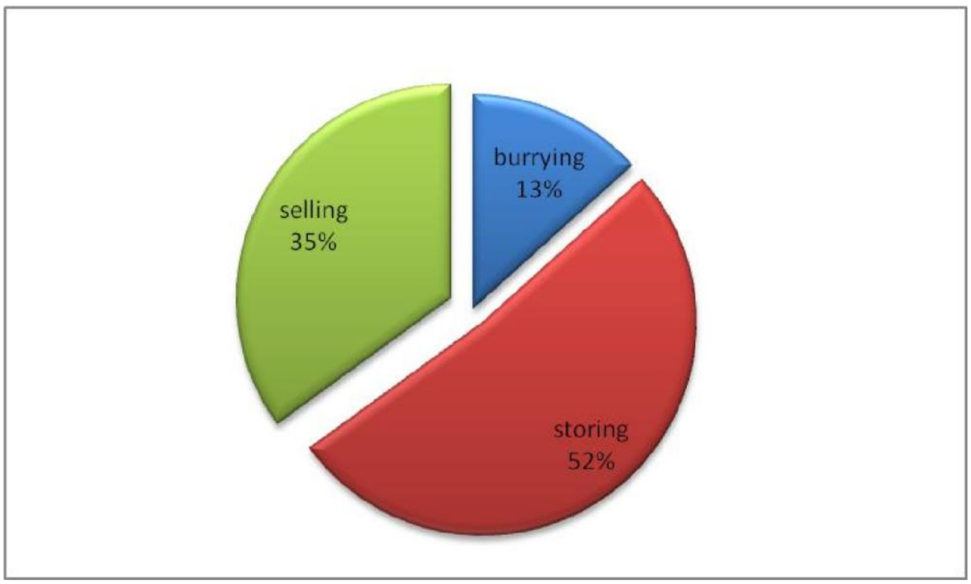

Figure 4.6 Waste oil management practices at Sable Chemical Industries Source: Field data (2018)

4.3.1 Selling Waste oil

Waste oil in usable state is sold to companies or individuals who re-use it for their own purpose. From the interview conducted with the stores controller at Sable, the researcher established that there has been a decrease in the number of waste oil customers. He stated that "due to economic hardships, the buyers have ceased buying waste oil; the company has not been selling oil for a while." The stores controller also unveiled that selling waste oil during the rainy season is hard because the storage tank is not covered on top, rain water falls into the drum contaminating the waste oil.

4.3.2 Waste oil storage at Sable Chemical Industries.

The waste oil is stored in a tank, which is not covered at the top. As mentioned above, market for waste oil is continuously decreasing due to the prevailing economic meltdown. As a result the amount of waste oil to be stored increases.

The waste oil is stored outdoor, alternative increase and decrease of temperatures, consequently cause expansion and contraction of steams and this may lead to leakage and wastage of oil. The likelihood of contamination is also increased. Rain water also affects the nature of oil, making it useless.

Waste oil is stored in bulk, the storage tank does not have a rooftop and water accumulates and fine dust finds its way into the tank. Eventually, a layer of sludge-like material builds up at the bottom of the tank and leads, in time, to contamination of the oil. Gross contamination with water may render the used oil unsuitable for use.

Plate A

Plate B

Plate 4.3 Waste oil storage tank during the rainy season.

Source: Field data (2017)

Plates 4.3, A an B were taken in 2017 after a heavy rainfall; the rainy water filled the tank and waste oil overflowed from the tank resulting in land pollution.

4.3.3 Waste oil disposal at Sable Chemical industries

Waste oil, which is highly contaminated, should be disposed off at the hazardous waste disposal site. The company rarely uses this method. Most of the times contaminated oil is sold by the company at give away prices to employees. The researcher established that the sludge formed by contaminants in the storage tank and the polluted soil from the reclaimed sites are packed into metallic drums and taken to the hazardous waste disposal site. The hazardous waste disposal pit is not concretized at the bottom and it poses a threat to the environment because in time the drums erode and the hydrocarbons are released into the environment. Underground water is prone to hydrocarbon contamination through leaching and seepage processes.

4.4 Impacts of oil pollution on soil properties

Table 4.4 Laboratory tests results of the impact of oil pollution on soil electrical conductivity, soil moisture content and pH.

Sample point	Soil sample	Depths (cm)	pH	Soil moisture content %	Electrical conductivity (mS/m)
Nitric Acid Plant	CS	0-5cm	7.11±0.124	0.64	27
		5-10cm	6.25±0.099	0.57	20
	PS	0-5cm	5.64±0.67	0.43	34
		5-10cm	4.99±0.83	0.34	31
Ammonia Storage Sphere	CS	0-5cm	7.82±0.04	0.68	41
		5-10cm	7.79±0.08	0.65	38
	PS	0-5cm	5.83±0.04	0.48	68
		5-10cm	5.99±0.45	0.34	60
Waste oil storage site	CS	0-5cm	7.14±0.088	0.58	51
		5-10cm	7.07.±0.03	0.45	49
	PS	0-5cm	5.13±0.088	0.34	99
		5-10cm	5.30±0.173	0.22	86

PS= Polluted Soil Sample

CS= Control Sample

4.3.1 Impact of oil on soil pH

The soil pH was tested using a calibrated pH meter. From the data obtained, the average pH value in samples analyzed at the Nitric Acid was 5.49, Ammonia storage spheres 6.85 and waste oil storage site 5.66. These values show that the soils in these areas are acidic. At the Nitric Acid Plant, at 0-5cm pH decreased from 7.11 to 5.64 and at 5-10 the pH values decreased from 6.25 to 4.99.At the ammonia storage plant the pH the 0-5cm depth decreased by 68%, whilst the pH of 10-15cm depth decreased by 56.59%. The pH at the waste oil storage Plant at 0-5 cm decreased by 94% whilst at 10-15cm it decreased by 84%. These percentages show that there has been a significant decrease in the soil pH. The soils have become highly acidic and the pH range between 6.5 and 7.5 is considered optimum for the growth of many plants and micro-organisms including the earthworms thus one can note that oil pollution greatly affects the soil ecosystem through the alteration of soil properties.

4.3.2 Impact on soil moisture content

Soil moisture content of the unpolluted soil sample at the Nitric Acid Plant had 0.64% moisture content at depth of 0-5cm and 0.57% at the depth of 5-10cm compared to the 0.43% and 0.34% value respectively. This shows that there is 0.21% moisture decrease at 0-5cm depth and 0.23% at 5-10cm depth.

At the Ammonia Storage Plant the unpolluted soil sample was 0.68% at depth of 0-5cm and 0.65% at the depth of 5-10cm compared to the polluted sites with 0.48% and 0.34%. This shows that there is 0.2% and 0.31% decrease of soil moisture content respectively.

At the Waste oil storage site the unpolluted soil sample was 0.58% at depth of 0-5cm and 0.45% at depth of 5-10cm compared to the polluted site with 0.34% at 0-5cm and 0.22% at 510 cm respectively This shows that there is 0.24% decrease of soil moisture content at 0-5cm and 0.22% decrease at 5-10cm.

It can be concluded that soil moisture content decreased at all depths and sites. The hydrophobic nature of hydrocarbons modified the water repellence and coated soil particles

(Grisso, 2009) Increased bulk density or soil compaction reduced the ability of soil to absorb and retain water, displacing the air from the soil pores and ultimately destroying the water and air regime, leading to reduced soil moisture content.

4.3.3 Impacts of oil pollution on Electrical conductivity (EC)

Electrical Conductivity is the measure of total dissolved salts or ions. The range of electrical conductivity of the unpolluted sites was 20-49(mS/m) compared to the 31-99(mS/m) for the polluted sites. The differences in the ranges show that there is a significant increase of electrical conductivity. Ammonia storage Plant and the Nitric Acid plant have relatively high electrical conductivity. The highest conductivity was recorded at the waste oil Storage site; there is high concentration of charged ions in the soil. Electrical conductivity has a strong correlation with the soil texture, so the increase in ions concentration owes to the silt loam to clay loam soil particles (Dahnke & Whitney, 2014). High presence of charged ions maybe attributed to the presence of heavy metals (cadmium, lead, chromium, copper, zinc, mercury and arsenic) from the waste oil. Dobberman (2006) states that as the Electrical conductivity of soil increases the soil micro-organism decreases and there is a strong correlation between the electrical conductivity and salinity.

4.3.1 Test of significance between oil pollution and chemical alterations of soil.

Table 4.5 Chi-Square Test of oil pollution and chemical alterations of soil properties.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.208[a]	6	.004
Likelihood Ratio	15.555	6	.015
N of Valid Cases	12		

Chi-square test shows that there is a significant relationship between oil pollution and the alterations of soil properties. The product value is 0.04 and it means we reject H_O and accept H_1. The Electrical conductivity, soil moisture content and soil pH is greatly altered by oil pollution therefore there is association between oil pollution and alterations of soil properties.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The investigation revealed that Sable Chemical industries experiences frequent oil spills from the manufacturing plants and waste oil storages tank. From the year 2016 up to April 2018 the company recorded 15 oil spills incidents where tones of oil were lost. The chief causes of these spills are mechanical failures and human error. According to the survey, there is lack of awareness towards oil pollution among employees. The company has a waste oil management plan that is being poorly implemented. The storage facilities and hazardous waste disposal sites need improvement.

The analysis has proved that oil pollution has increasing or decreasing effects on soil physical and chemical parameters. There has been a significant decrease of the soil pH. The mean pH value for unpolluted soil was 7.12 and the mean pH value for the polluted soil was 5.48. The soil moisture content has decreased by 60%. The range of electrical conductivity of the unpolluted sites was 2049(mS/m) compared to the 31-99(mS/m) for the polluted sites with an average of 78% increase. As a ressult the soils have become highly acidic, compacted, negatively charged (ions) with low moisture content. The condition created inhibits the growth and development of flora or fauna in the soil ecosystem meaning that the polluted soils are highly degraded.

5.2 Recommendations

From the derived results, findings and conclusion, the following recommendations are suggested:

5.2.1 Sable Chemical Industries

- There is need for training and education of employees on oil handling issues in order to increase knowledge and raise awareness and to reduce the frequency of oil spill incidents associated with human error.

- The company should consider lining up the hazardous waste disposal site to avoid hydrocarbon contamination of soils and underground water through leaching and seepage.

- The company should modify or purchase a waste oil storage tank that is covered on top and has a transfer pump in order to necessitate clean oil transfers to reduce oil spills.

- The company should also install oil filters on the compressors as well as concretizing the waste oil storage area in order to prevent oil pollution.

- The company should holistically enforce a scheduled, routine Plant maintenance. Installation and replacement of the manufacturing Plant equipment must be done by competent employees as per schedule to avoid leaks,

- The company should consider adding oil on its hazardous waste so that EMA would assist them by raising awareness through educating employees, being advised on appropriate ways to store oil (new and waste) and monitoring of oil disposal methods.

- There is need for the company to draft an oil spill response procedure clearing outlining the responsibilities, targets and action plans towards oil spill reduction.

- The company needs to form an oil spill response team which is trained and equipped to deal with oil spills and waste oil. In addition there is need for the adoption of the use of on site oil spill response kits such as chemical dispensations and emulsifiers to reduce the environmental impact of oil spills.

5.2.2 Environmental Management Agency

- The organization should consider conducting regular inspections on formal and informal companies that use, store and generate waste oil, to monitor their oil handling practices.

- Waste oil producing entities need to be educated on how to handle oil related issues appropriately and fines should be holistically given to those who are not compliant so that they comply with the regulations.
- EMA should consider waste oil collection to help curb illegal dumping of waste oil and reduce hydrocarbon contamination.

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APPENDICES

MIDLANDS STATE UNIVERSITY
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

QUESTIONNAIRE SURVEY: IMPACTS OF OIL POLLUTION ON THE SOIL ECOSYSTEM: CASE OF SABLE CHEMICAL INDUSTRIES.

My name is R147927H. I am a student at Midlands State University undertaking **BSC HONOURS DEGREE IN GEOGRAPHY AND ENVIRONMENTAL STUDIES**. I am carrying out a research

entitled "The impacts of oil pollution on soil ecosystem: Case of Sable Chemical Industries". I kindly ask you to participate in the research by answering questions with reliable and up to date information. May you kindly answer all questions and do no write your name on the questionnaire as the information is strictly confidential. Indicate your answer with a tick in the boxes provided. Data obtained from this will be used for academic purposes only.

DEPARTMENT……………………………OCCUPATION ………………………

DATE …………………………QUESTIONAIRRE NUMBER ……………………..

SECTION A: PERSONAL DETAILS

1. Sex: Male ☐ Female ☐
2. Age
   20-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61+ ☐
3. For how long have you been at Sable Chemical Industries?
   0-6 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ 21+ ☐
4. Highest level of education attained
   Primary ☐ Secondary ☐ Tertiary ☐

SECTION B

Objective: To identify the causes of oil spills at Sable Chemical Industries

5. What are likely causes of oil spills at Sable Chemical Industries?

Mechanical failure ☐ Breakdown maintenance ☐ purging of compressors ☐

Others……………………………………………………………………………………

……………………………………………………………………………………………

6. Where do oil spills usually occur?
Nitric Acid Plant ☐ Ammonia storage spheres ☐ Garage ☐ savage yard ☐

7 How often do you encounter oil leak incidents?
Rare ☐ Often ☐ Very often ☐

8. When was the last oil spill incident recorded? **……………………………………..**

9. Who is responsible for cleaning up the polluted sites and how do they do it?
……………………………………………………………………………………………..

(b) How: ………………………………………………………………………….

……………………………………………………………………………………………

10. From your observations, how has been the company responding to oil spills?
………………………………………………………………………………………

……………………………………………………………………………………………

11. What are the environmental problems associated with oil spills? …

……………………………………………………………………………………………

……………………………………………………………………………………………

12. Does top management demonstrate an interest in the environmental related issues?
    Yes ☐ No ☐

13. Does top management demonstrate an interest in the environmental related issues?
    Yes ☐ No ☐

14. Whose responsibility is it to manage and protect the environment?
    Top management ☐ EMA ☐ Collective responsibility ☐

15. Oil is a visible form of pollution. Are there oil polluted sites that you can identify at Sable Chemical
Industries? Yes ☐ No ☐

SECTION C

Objective: To evaluate the waste oil management practices at Sable Chemical Industries.

16. Where is the waste or used oil from the manufacturing Plants stored?

……………………………………………………………………………………………

15. Waste oil from the Plants, where is it stored?

…………………………………………………………………………………………..

16. What are the waste oil disposal methods?
    Selling ☐ Burying ☐ Dumping ☐

17. Are you trained to handle oil? Yes ☐ No ☐

In the following section indicate your response using the index:

(1) Agree strongly
(2) Agree
(3) Moderate
(4) Disagree
(5) Strongly disagree

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

18. Knowledge on oil spill response and waste oil handling practices is low amongst employees. ☐ ☐ ☐ ☐ ☐
19. The company lacks trained personnel who are trained and equipped to deal with oil spills. ☐ ☐ ☐ ☐ ☐
20. A number of employees lack knowledge in the Environmental aspects. ☐ ☐ ☐ ☐ ☐

APPENDIX 2: INTERVIEW GUIDE FOR THE SHE OFFICER: SABLE CHEMICAL INDUSTRIES

Interview date…………………………….

NB: Interviews were done after consent by respondents. ***Objective: To determine the causes of oil spill at Sable Chemicals.***

1. What are the root causes of Oil spill incidents?

2. How frequent do the incident occur?

3. When was the last oil spill incident?

4. Who is responsible for cleaning up the polluted sites? Have the responsibilities of all those likely to be involved been clearly specified?

5. Does Sable Chemical Industries have a documented oil spill response procedure?

***Objective: To evaluate the waste oil management practices at Sable Chemical Industries*.**

5 How do you manage waste oil from the manufacturing plants?

6 Does the company have waste oil disposal procedure?

7 I understand a certain percentage of oil is disposed through the burying method, where is it buried?

8 Is the pity concretized or lined?

APPENDIX 3: INTERVIEW GUIDE FOR THE PRODUCTION MANAGER

Objective: To determine the causes of oil spills

1. What are the chief causes of oil leak incidents?

2. How old is the Nitric Acid Plant?

3. What is the estimated amount of oil per gallons lost into the environment on the largest oil spill?

4. Who is responsible for cleaning up the polluted sites?

5. What are the productions, financial and environmental implications associated with the oil spills?
6. Were employees trained to handle oil or oil spills?

Objective: To evaluate waste oil disposal practices at Sable Chemical industries.

7. Who is responsible for environmental protection and management?

8. In your own opinion what should be done to curb reduce the frequency of oil spills?

APPENDIX 4: INTERVIEW GUIDE FOR THE NITRIC ACID PLANT OPERATOR

Objective: To determine the causes of oil spills

1. What are the sources/causes of oil leaks?
2. Who is responsible for Plant maintenance
3. How often do you conduct plant checks?
4. What are your immediate actions in an event of an oil spill?
5. Who is responsible for cleaning up the polluted sites?
6. How many compressors does the company have?

APPENDIX 5: INTERVIEW GUIDE FOR THE STORES CONTROLLER

Objective: To evaluate waste oil disposal practices at Sable Chemical industries

1. Where is the waste oil stored?
2. How do you manage the waste oil?
3. What mechanisms are used when transferring or decanting oil to and from the storage tank?
4. During the oil transfers do you experience oil spills? If yes how do you deal with them?
5. Does the company have trained personnel and appropriate oil response equipment to deal with spilled oil?
6. On a scale of 1-10 can you rate your waste oil management practices?

APPENDIX 6: INTERVIEW GUIDE FOR THE ENVIRONMENTAL OFFICER: SABLE CHEMICAL INDUSTRIES

Objective: To evaluate waste oil disposal practices at Sable Chemical industries

1. How is waste oil managed?
2. Oil is classified as a hazardous substance. What are the hazardous waste disposal methods in place?
3. Is oil included in the EMA registered hazardous waste products?
4. Are the employees aware of the impact of oil pollution on soil and water?
5. Does the company have oil spill response kit?

APPENDIX 7: INTERVIEW GUIDE FOR THE E ENVIRONMENT MANAGEMENT OFFICER (GWERU DISTRICT)

Objective:

1. Are you aware of the industrial oil spill incidents in Kwekwe district?
2. If yes which methods are you using to control and minimize the frequency of oil spills.
3. Do how often do you conduct a surveillance monitoring on waste oil producing entities?

4. Do you reach out to formal and informal sectors educating employees on the appropriate oil handling practices and waste oil management?
5. If yes how are the entities embracing the awareness campaigns?
6. Form the previous investigations what are the most prevalent causes of oil spills?
7. What are the constrains towards hazardous waste collection in Gweru district?
8. Is there any gap or loop hole in the waste oil management in Kwekwe?

APPENDIX 8: OBSERVATION CHECKLIST- SABLE CHEMICAL INDUSTRIES

What the researcher sought to observe.	What was actually observed
The visible impacts of oil pollution on land such as ➢ oil stains ➢ contaminated soils	
To determine the oil polluted locations	
To check if there is impaired growth of flora, around the polluted sites.	
To rate the level of damage brought upon soil the oil spills	
Waste oil handling practices.	
To observe the behavior and attitude of employees towards environmental management and oil related issues.	