AN ASSESSMENT OF EFFLUENT MANAGEMENT FACILITIES IN MOTOR VEHICLE GARAGES IN NAIROBI

BY

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DECLARATION

I, the undersigned, declare that this project is my original work and has not been submitted for any award to any other college, institution or university other than the University of Nairobi.

Signed: …….. Date: ……..

James Thiaine

(Reg. No. C50/71559/2008)

This project has been submitted for examination with our approval as the university supervisors.

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ABSTRACT

This study assessed effluent management facilities in selected motor vehicle garages in Nairobi. A sample size of 32 garages (10 corporate and 22 independent) were selected using simple random sampling method. Data was collected by means of interviews and observation checklists. Descriptive statistics and inferential statistics were used to analyze the data. In the descriptive statistics, relative frequencies and percentage were used and results presented in form of tables and charts. In inferential statistics, t-test was used to test the hypothesis. The study found that oil/water separators were the most common facilities used for effluent management. Most garages were discharging their untreated effluent into the sewer line and a few into land. Few (28.13 %) of the garages had effluent discharge licences with corporate garages being more compliant with this requirement at 70 % compared to only 9.09 % of the independent garages. 90 % of the corporate garages and 81.8 % of the independent garages had facilities for containment of accidental spills. 78% of the garages were not carrying out effluent quality monitoring. Only 22 % of the garages were compliant with effluent quality standards specified in the Water Quality Regulations, 2006. 60 % of the corporate garages had separated foul water from storm water compared to only 18.2 % of the independent garages. Whereas all corporate garages involved in the study had conducted annual environmental audits, only 59.1 % of the independent garages had conducted annual environmental audits from the study findings.

The study recommends that all garages should install appropriate effluent treatment facilities with oil/water separator as a minimum. Garages should discharge effluent into the sewer line, obtain effluent discharge licences and monitor effluent quality as per effluent discharge licence conditions. They should also provide suitable facilities for accidental spillage containment and clean up. Garages should conduct annual environmental audits and separate storm water from foul water. NEMA and other authorities should educate garage owners on effluent discharge and enforce environmental legislation more stringently. Further research could be conducted to identify the factors contributing to low compliance among independent garages and also to develop the most efficient, cost effective and sustainable systems for management of effluent.

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DEFINITION OF TERMS

Effluent: Gaseous waste, water or liquid or other fluid of domestic, agricultural, trade or industrial origin treated or untreated and discharged directly or indirectly into the aquatic environment.

Garage: Enclosed area of land set aside for repair of automobiles.

Oil Water Separator: Equipment used to separate oil and water mixtures into their separate components.

Point source of pollution: A single identifiable source of air, water, thermal, noise or light pollution.

Pollution: Introduction of contaminants into the natural environment that cause adverse change.

LIST OF ABBREVIATIONS

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
EMCA	Environmental Management and Coordination Act
EPA	Environmental Protection Agency
ERC	Energy Regulatory Commission
ETP	Effluent Treatment Plant
GPS	Global Positioning System
IFC	International Finance Corporation
M	Mean
NCC	Nairobi City County
NEMA	National Environment Management Authority
pH	Potential Hydrogen (measure of acidity/alkalinity)
SD	Standard Deviation
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
UK	United Kingdom
US	United States
VOC	Volatile Organic Compound

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Motor vehicle garages deal with petroleum based wastes that are potentially hazardous to humans and to other life forms. Motor vehicle garages use lubricating oils, fuels, paints, body fillers and other substances that are toxic in nature. During cleaning at garages, contaminated wastewater (effluent) is generated. Oils, fossil fuels, effluent and solid wastes from motor vehicle garages therefore have the potential to cause environmental pollution if they are not properly handled at source or if they are improperly disposed of. Garage waste is a major source of environmental pollution since it contains heavy metals (Mutuku, 2013). Exposure to a wide range of garage waste chemicals including heavy metals, contained in brake fluids, degreasers, detergents, lubricants, metal cleaners, paints and solvents results in various forms of chronic poisoning (Kiunsi & Lemeiruti, 2015).

Spills of oils are a common sight in many garages, which is an indicator that garages are potential point sources of water and land pollution. In Kenya, many of the open air garages are characterized by poor waste management practice (Mutuku, 2013). Most garages generate hazardous waste, wastewater, air emissions, and pollutants from such services as fluid replacement or operations like washing or painting parts.

This requires motor vehicle garages to have proper arrangements for the management of effluent so as to mitigate environmental pollution. This study assessed the effluent management systems in selected motor vehicle garages in Nairobi and targeted both corporate and independent motor vehicle garages in Nairobi City. Corporate motor vehicle garages are those that are owned by corporate motor vehicle sale and service companies such as Toyota Kenya, DT Dobie, Subaru, Simba Colt, CMC Motors, General Motors, Marshals, Foton and KIA Motors. The independent motor vehicle garages are those that are privately (or individually) owned and are not affiliated to corporate organizations. The latter are sometimes called "*Jua Kali"* garages.

1.2 Statement of the Research Problem

In Kenya, the business of motor vehicle garages is not adequately regulated with respect to location, standards and environmental management systems. There are numerous corporate and independent motor vehicle garages scattered in urban centres all over the country and Nairobi has hundreds of these motor vehicle garages. A number of garages in Nairobi are located by the roadside or even adjacent to rivers and in informal settlements.

Until the year 2006, there were no standards for effluent discharge or guidelines on where to discharge effluent in Kenya. Moreover, apart from corporate-specific standards for management of effluent from garages, there were no national guidelines for location of garages or for management of effluent from motor vehicle garages in Kenya. The Environmental Management and Coordination (Water Quality) Regulations of 2006, was the first legislation to give standards for effluent for various discharging facilities. Therefore, motor vehicle garages were not properly regulated.

Casual observation of operations in many motor vehicle garages in Nairobi indicates that these facilities do not have proper arrangements for the management of effluent and could actually be causing pollution of the environment. Oil spillage on the ground, poor disposal of solid waste and discharge of oily washwater into rivers and streams is a common sight in many independent garages in Nairobi. Most of the independent garages are not licenced by the County Government of Nairobi City or by NEMA, hence are not regulated. The workers in many independent garages usually do not wear or use required personal protective equipment. It is even suspect that the effluent from these garages does not meet the applicable standards for effluent discharge.

This study therefore assessed the systems for management of effluent in selected corporate and independent motor vehicle garages in Nairobi.

1.3 General and Specific Objectives

1.3.1 General Objective

The general objective of this study was to assess the effluent management facilities in motor vehicle garages in Nairobi.

1.3.2 Specific Objectives

The specific objectives of this research were:

i. To examine the types of effluent management facilities used by motor vehicle garages in Nairobi;

ii. To establish whether the effluent management facilities in motor vehicle garages meet applicable legal environmental requirements for motor vehicle garages in Kenya;

iii. To find out if there is any relationship between the types of motor vehicle garages and the degree of compliance with applicable legal environmental requirements; and

1.4 Research Questions

The study sought to answer the following three questions:

1) What types of effluent management facilities are used by motor vehicle garages in Nairobi?
2) Do the effluent management facilities used in motor vehicle garages meet applicable legal environmental requirements in Kenya?
3) Is there is any significant relationship between the types of motor vehicle garages and the degree of compliance with applicable legal environmental requirements?

1.5 Research Hypothesis

The null hypothesis of this research was that "There is no significant relationship between the type of motor vehicle garage and the degree of compliance with the legal environmental requirements for effluent management facilities for motor vehicle garages in Kenya".

The alternative hypothesis was that "There is a significant relationship between the type of motor vehicle garage and the degree of compliance with the legal environmental requirements for effluent management facilities for motor vehicle garages in Kenya".

1.6 Research Justification

Effluent from motor vehicle garages has the potential to cause land, air and water pollution and also have adverse effects on human health and safety if not well managed. In Nairobi, the Nairobi River is particularly vulnerable to pollution from hundreds of motor vehicle garages, some of which are located close to the river, such as the famous Grogan garages. Proper management of effluent from motor vehicle garages requires special facilities and systems. These among others include provision of accidental spillage prevention and containment facilities, installation of oil/water separators, separation of effluent from storm water drainage and routine analysis of effluent among others.

The research studied the effluent management systems in selected motor vehicle garages in Nairobi to find out their effectiveness and extent of compliance with the applicable legal environmental standards. The findings and recommendations of the research will be useful to garage owners and managers to improve on their environmental performance, especially on compliance with environmental regulatory requirements. The research findings and recommendations will also be useful to regulatory authorities such as NEMA and the Nairobi City County Government in helping motor vehicle garages to better comply with applicable legal environmental standards. Finally, the findings of the

research will contribute to the body of knowledge on environmental management in motor vehicle garages that is useful for academic purpose.

1.7 Scope and Limitations of the Study

The study assessed effluent management systems in selected motor vehicle garages in Nairobi. The study targeted both corporate and independent motor vehicle garages located in various parts of Nairobi City County. The study only focused on the effluent management aspect of motor vehicle garages. In the study, sampling and analysis of effluent was not done due to budget limitation. Instead, the study relied on effluent analysis reports from NEMA-approved laboratories.

CHAPTER TWO

2.0 LITERATURE REVIEW

Garages and service centres carry out a number of operations and processes that have the potential to damage the environment. These activities include the dewaxing and cleaning of vehicles, the storage, use and disposal of polluting liquids such as oils, paints, solvents, antifreeze and other coolant additives, brake fluids and solid wastes such as oil filters, exhaust systems, batteries and tyres. Unless the site drainage is correct, waste is properly managed and spillage control procedures are in place, environmental harm could occur (Environmental Alliance, 2014).

Most motor vehicle garages also have a car washing component in addition to their primary activities. All these activities impact on the environment negatively. Hazardous substances (fuel, oil, paints, chlorinated solvents and detergents) used in petrol stations and motor vehicle garages may be emitted with wastewater from washing vehicles or they may be spilled (IFC, 2005). According to Mazumder and Mukherjee (2011), contaminants in carwash wastewater include oil and grease, detergents, phosphates, hydrofluoric acid and ammonium bifluoride (ABF) products among others. According to Muia (2011), effluent from service stations indeed pollute the municipal waterways with specific regard to BOD and TSS. Kiunsi and Lemeiruti (2015) found that used water for cleaning cars at Mbeya, Tanzania return back to rivers, thus polluting the rivers.

The common characteristic about effluent from motor vehicle garages and petrol stations is that the effluent contains Total Petroleum Hydrocarbons (TPH). Total Petroleum Hydrocarbons (TPH) is a term used to describe a large family of several hundred chemical compounds that originally come from crude oil (Agency for Toxic Substances and Disease Registry (ATSDR), (1999). Some chemicals that may be found in TPH are hexane, jet petrol, mineral oils, benzene, toluene, xylenes, naphthalene, and fluorene, as well as other petroleum products and gasoline components (ATSDR, 1999).

Due to the presence of Total Petroleum Hydrocarbons among other potential pollutants, effluent from motor vehicle garages presents potentially adverse environmental and human health impacts if not well managed or disposed of. For instance, studies of the accidental and intentional release of gasoline and fuel oils to the aquatic environment indicate that aquatic organisms are able to bioaccumulate some TPH fractions, particularly Polycyclic Aromatic Hydrocarbons (Air Force, 1989; Farrington et al., 1982). If these hydrocarbons find their way into the soil, they can affect the soil organisms. A study by Handy, R.A. (2007) showed that contamination of the soil with Total Petroleum Hydrocarbons affects earthworms. Oil and grease and detergents, including biodegradable detergents can be poisonous to fish (Mazumder, D. and Mukherjee, S. 2011). Wastewater from car washing sites contributed a lot of risk environment to people, plants and other species using water from rivers in the city (Kiunsi and Lemeiruti, 2015).

Effluent from motor vehicle garages can have potentially adverse impacts on human health. According to the US Agency for Toxic Substances and Disease Registry (1999), some of the TPH compounds can affect the human central nervous system. One compound can cause headaches and dizziness at high levels in the air. Another compound can cause a nerve disorder called "peripheral neuropathy," consisting of numbness in the feet and legs. Other TPH compounds can cause effects on the blood, immune system, lungs, skin and eyes.

There are industry-specific guidelines and legislative requirements for effluent management in facilities discharging effluent in many parts of the world, especially in the developed countries. According to the UK Department for Environment, Food and Rural Affairs' Groundwater Protection Code for Petrol Stations and Other Fuel Dispensing Facilities Involving Underground Storage, the drainage system for petrol stations should to be designed to convey all potentially contaminated water and spills of fuel to suitable collection or containment points for disposal or treatment. In addition, the petrol interceptor should discharge to a foul sewer and prior approval should be sought from the sewerage undertaker. According to this code, the effluent from washing facilities in petrol stations should not pass into the same drainage system as the general surface (or

storm) water, but should also connect to foul sewer with prior approval of the sewerage undertaker. According to IFC Environmental, Health and Safety Guidelines for Retail Petroleum Outlets (2007), there must be segregation of clean drainage and potentially contaminated drainage, treating the latter through oil /water separators.

According to the Environment Agency for England & Wales, the Scottish Environment Protection Agency and the Environment and Heritage Service in Northern Ireland (Environmental Alliance), all garages should have an oil separator installed on the surface water drainage system. The separators must be regularly inspected and cleaned as required. According to these environmental agencies' Pollution Prevention Guidelines (Garages and Vehicle service Centres), all discharges of contaminated water from vehicle and component cleaning, wash basins and compressors should be discharged to the foul sewer and should not be connected to roof water down pipes. These discharges will require authorization by the appropriate sewerage undertaker and may be subject to the terms and conditions of a trade effluent consent.

The foul sewerage system is designed to take waste water from toilets and washrooms, vehicle washing and industrial processes while surface water drains are usually sited on roads, yards or under roof water down-pipes, and are designed to take clean rainwater only (National Health Service Scotland, 2005).

According to the US EPA Small Entity Compliance Guide for Motor Vehicle Businesses (2000), all floor drains and sinks in motor vehicle workshops must be connected to a municipal sewer. The operator of a service station must prevent the entry of oil into sewer systems, drains and the natural environment. According to the Toyota Motor Corporation (2004), service shops should create a drainage system where all the liquid from the stalls, washing area and any other workspace flows through an oil/water separator.

In Kenya, the Environmental Management and Coordination Act (EMCA) of 1999, in Section 74 (1), has specified that every owner or operator of a trade or industrial undertaking shall discharge any effluents or other pollutants originating from the trade or

industrial undertaking only into existing sewerage systems and the relevant entity operating or supervising such sewerage system shall issue, at a prescribed fee, the necessary licence for discharge. Section 74 (2) of EMCA (1999) goes on to state that the proponent or owner of a trade or an industrial undertaking shall, prior to being granted a licence to discharge effluents into the environment, install an appropriate plant for the treatment of such effluents before they are discharged into the environment. In addition, the Environmental Management and Coordination (Water Quality) Regulations of 2006, in the third and fifth schedules has provided standards for discharge of effluent into the environment and into public sewers respectively. The Environmental Management and Coordination Act of 1999 has further outlined penalties for facilities that do not comply with the legislative requirements for effluent disposal. For the case of Nairobi City County, the entity that owns and manages the city sewerage system is the Nairobi Water and Sewerage Company that is empowered by Section 74 (1) of EMCA 1999 to issue effluent discharge licences to entities discharging effluent into its sewerage system.

In the year 2012, the Energy Regulatory Commission came up with guidelines for pollution prevention in petroleum retail service stations. The ERC's Pollution Prevention Guidelines state that petroleum products contain hazardous substances known to cause health problems by polluting the air, soil and water environment. Therefore, these products must be stored safely to prevent leaks and spills and minimize Volatile Organic Compounds (VOC) emissions. According to the ERC's Pollution Prevention Guidelines, gasoline stations, car washes and automotive repair facilities shall be designed to minimize runoff of oil and grease, solvents, car battery acid, coolant and gasoline to the storm water system. The guidelines further specify that a repair/maintenance bay drainage system should be designed in such as a way as to capture all wash-water, leaks, and spills. Moreover, drains should be connected to a sump for collection and disposal. Under the guidelines, direct connection of the repair/maintenance bays to the storm drain system is prohibited.

2.1 Gaps in literature reviewed

Whereas various literature sources largely dwell on the impacts of garages on the environment and human health, there were no findings on the types of effluent management facilities in garages. There was no specific research focusing on the types of effluent management facilities in garages in Nairobi City County. This is one of the gaps that the current study sought to close. Moreover, literature review conducted did not come across any study showing the relationship between the type of garage and the degree of compliance with environmental legislative requirements.

Although Kiunsi and Lemeiruti (2015) recommends that garages should be located differently from residential areas in order to minimize the possible negative health effect to residents, the authors fail to provide guidance on the areas that garages should be located.

Muia (2011) studied quality of effluent but focused on effluent discharged by National Oil Petrol Stations and not effluent from garages. This study also only focused on the quality aspects of the effluent and did not look into effluent management facilities.

Although the Environmental Management and Coordination (Water Quality) Regulations of 2006 , in the third and fifth schedules provides standards for discharge of effluent into the environment and into public sewers respectively, these regulations do not specify what arrangements or facilities garages need to have in order to meet the effluent standards.

The various literature sources did not present any comparisons between effluent management facilities in corporate garages and those in independent garages.

2.2 Theoretical Framework

This research was based on the theory of compliance. Under this theory, compliance with environmental regulations by organisations is influenced by numerous factors including level of awareness with applicable environmental regulations. A study by Keriko et al (2012) established that awareness of environmental regulations influenced compliance with environmental regulations by Micro and Small Enterprises in the

Manufacturing Sector in Nairobi, Kenya. The factors influencing compliance with environmental regulations may be categorized as follows:

Table 2.1: Factors influencing compliance

Category	Factors motivating compliance	Barriers to compliance
Economic	Desire to avoid a penalty.	Lack of funds
	Desire to avoid future liability	Greed/desire to achieve competitive advantage
	Desire to save money by using more cost-efficient and environmentally sound practices	Competing demands for resources
Social/Moral	Moral and social values for environmental quality	Lack of social respect for the law
	Societal respect for the law	Lack of public support for environmental concerns
	Clear government will to enforce environmental laws	Lack of government willingness to enforce.
Personal	Positive personal relationships between program personnel and facility managers.	Fear of change
	Desire, on the part of the facility manager, to avoid legal process	Ignorance about requirements.
	Desire to avoid jail, the stigma of enforcement, and adverse publicity.	Ignorance about how to meet requirements
Management	Jobs and training dedicated to compliance	Lack of internal accountability for compliance.
	Bonuses or salary increases based on environmental compliance	Lack of management systems for compliance
		Lack of compliance training for personnel
Technological	Availability of affordable technologies	Lack of appropriate technology
		Technologies that are unreliable

Source: http://www.inece.org

In the context of garages in Nairobi, the economic factors affecting compliance with environmental regulations include capital outlay available for investment in environmental compliance infrastructure. The moral or social factors include the lack of government willingness to enforce environmental regulations as well as lack of social values for environmental quality. The personal factors include ignorance about environmental requirements. The main management factor influencing compliance is lack

of management systems for compliance in garages including environmental management systems. The technological factors include lack of affordable technologies for environmental management as well as technologies that are unreliable.

A study by the State of Oregon Department of Environmental Quality found that companies were more concerned about forced shut-down, the environment, criminal prosecution, reputation, pressure from the community, and pressure from customers than about actual or potential fines

2.3 Conceptual Framework

The business sustainability of motor vehicle garages is to a large extent, determined by the degree of compliance with applicable environmental regulations and standards for effluent management from garages. Various factors (intervening variables) affect the degree of compliance with environmental regulations and standards for effluent in garages. These factors include the effluent management infrastructure in place, available resources for environmental management (both financial and human), the extent to which the garage owners or operators are conversant with applicable environmental regulations and standards, and the willingness of the garage owners to put in place corrective measures for non-compliance.

The degree of compliance with applicable Environmental Regulations and Standards is also a function of the type of garage (whether corporate or independent). Attributes to garage type include size of garage, ownership and scope of services provided.

Figure 2.1 below shows the conceptual model of the research.

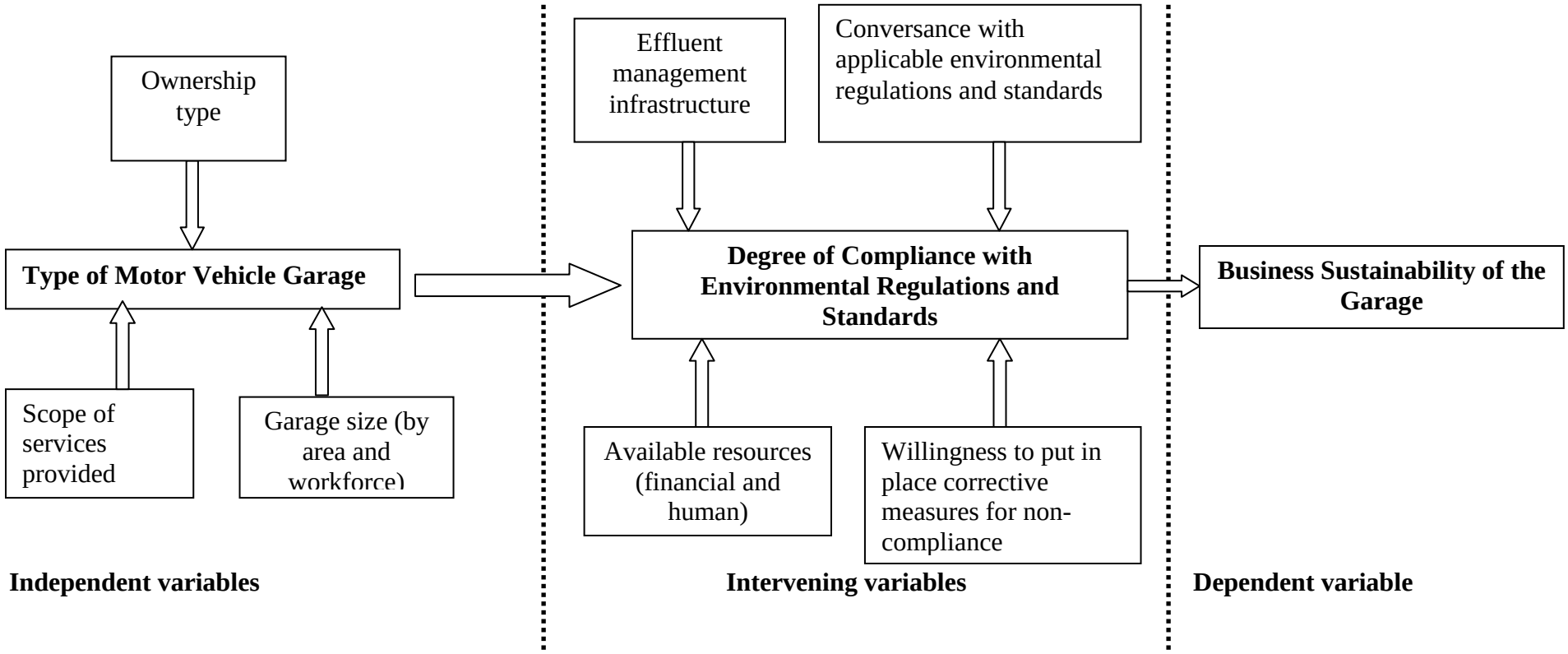

Fig 2.1: Conceptual model (Source: Author)

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

The research adopted both descriptive and inferential research designs to analyze results and draw conclusions. The rationale for using descriptive research design is that the research was expected to investigate and describe the effluent management systems in motor vehicle garages as they exist. The research would also generally take raw data and summarize it into a usable form. On the other hand, inferential statistics enabled the use of a sample to make generalizations about the population from which the sample was drawn.

3.2 Sampling Procedure

For the study, simple random sampling method, which is a form of probability sampling method was used. In the study, the population was classified into two strata, namely: corporate motor vehicle garages and independent motor vehicle garages.

The assumption made in the sampling was that the elements selected in the sample were representative of the population of study.

3.3 Sample size

For this study, a sample size of thirty two (32) motor vehicle garages was used, determined as follows: 10 corporate motor vehicle garages and 22 independent motor vehicle garages. The corporate garages were randomly drawn from the 41 corporate members of the Kenya Motor Industry Association.

The sample size of 10 corporate garages was determined using the Creative Research Systems survey software with the following considerations:

(i) Confidence level: 95 %

(ii) Confidence interval: 27

(iii)Population: 41

The sample size of thirty two (32) was selected for the following reasons:

i) Researcher's understanding of the target population

ii) The time available for data collection

iii) Limited budget for the research
iv) The nature of the population (the study population was heterogenous, which requires a sizeable number)
v) Data on the population of independent garages in Nairobi was not available; hence a reasonable sample size was taken.

The assumption made was that the 32 selected garages were representative of all the garages in Nairobi.

3.4 Methods of Data Collection

3.4.1 Primary data collection

Primary data was collected through interviews and field observation guided by a checklist. Interviews were held with owners, managers and supervisors of the motor vehicle garages where the study was done.

Field observations involved physical examination of the effluent management facilities including spillage prevention and containment facilities, effluent drains, oil-water separators and effluent treatment plants among others. Photographs were also taken during the collection of primary data.

3.4.2 Secondary data collection

Secondary data was collected from study of facility effluent drainage plans (where available), environmental management system manuals, environmental audit reports, effluent analysis reports and reading of literature on effluent management in motor vehicle garages. Reference was also made to internet sources on effluent management.

3.5 The Study Area

This study was conducted in Nairobi City County (NCC). The Nairobi City County is one of the 47 Counties of Kenya and is located in the southern part of Kenya. It also serves as Kenya's political and commercial capital. Nairobi City County borders Machakos County to the east, Kiambu County to the north and Kajiado County to the south and west.

According the 2009 National Population and Housing Census, Nairobi had a population of 3,375,000 people with a population density of 4,800 square kilometres. The NCC covers an area of 696 km^2 (269 square miles). The County has 17 constituencies namely Langata, Kibra, Dagoretti North, Dagoretti South, Westlands, Embakasi South, Embakasi North, Embakasi Central, Embakasi East, Embakasi West, Ruaraka, Kasarani, Starehe, Mathare, Kamukunji, Makadara and Roysambu. The garages at which the study was conducted were randomly picked from the constituencies in Nairobi.

The figure below contains a map of Kenya showing the locations of Nairobi City County.

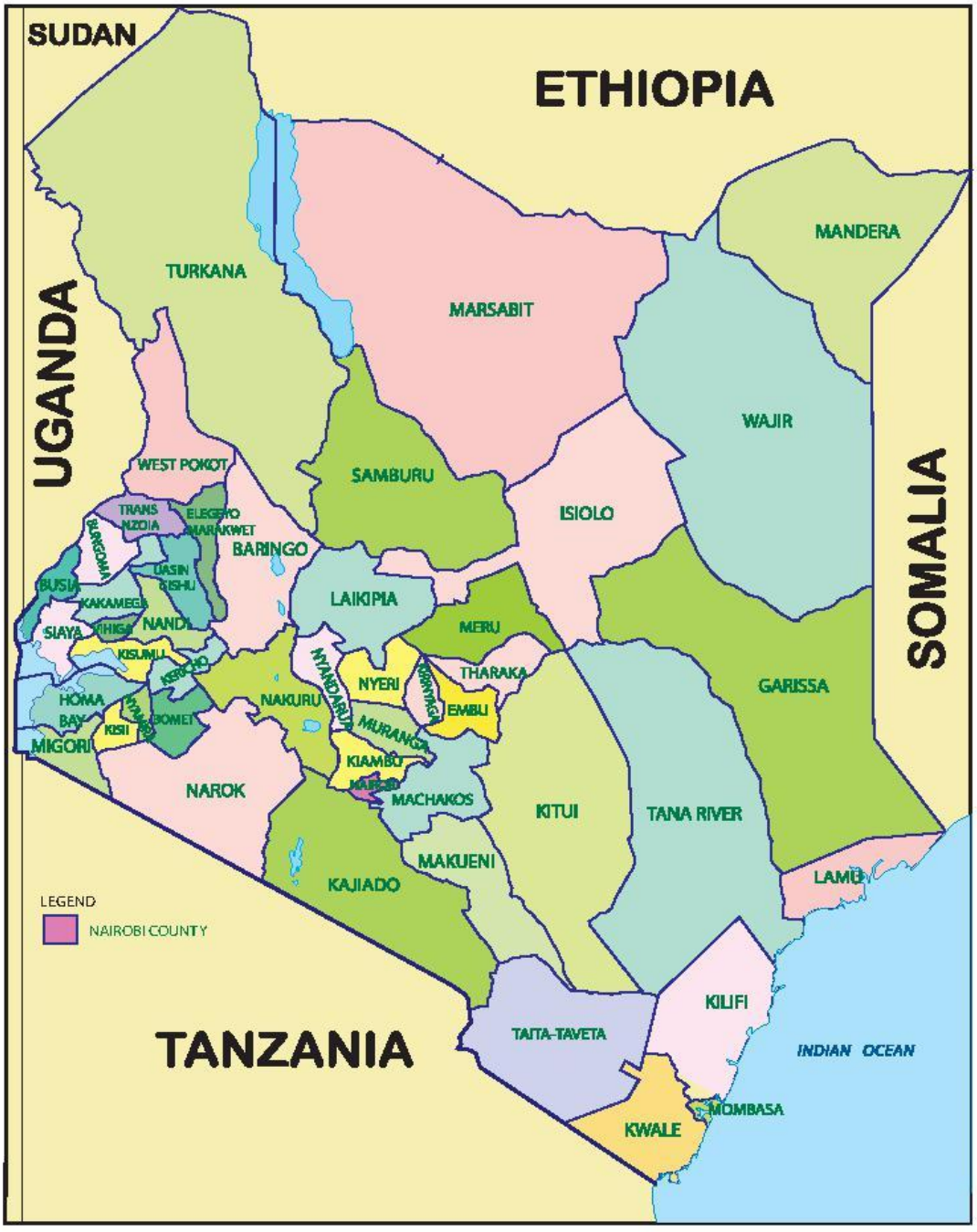

Fig 3.1 Map of Kenya showing Nairobi City County (Source: Tourist Maps (K) Ltd)

The map below shows the various sub-counties in Nairobi City County.

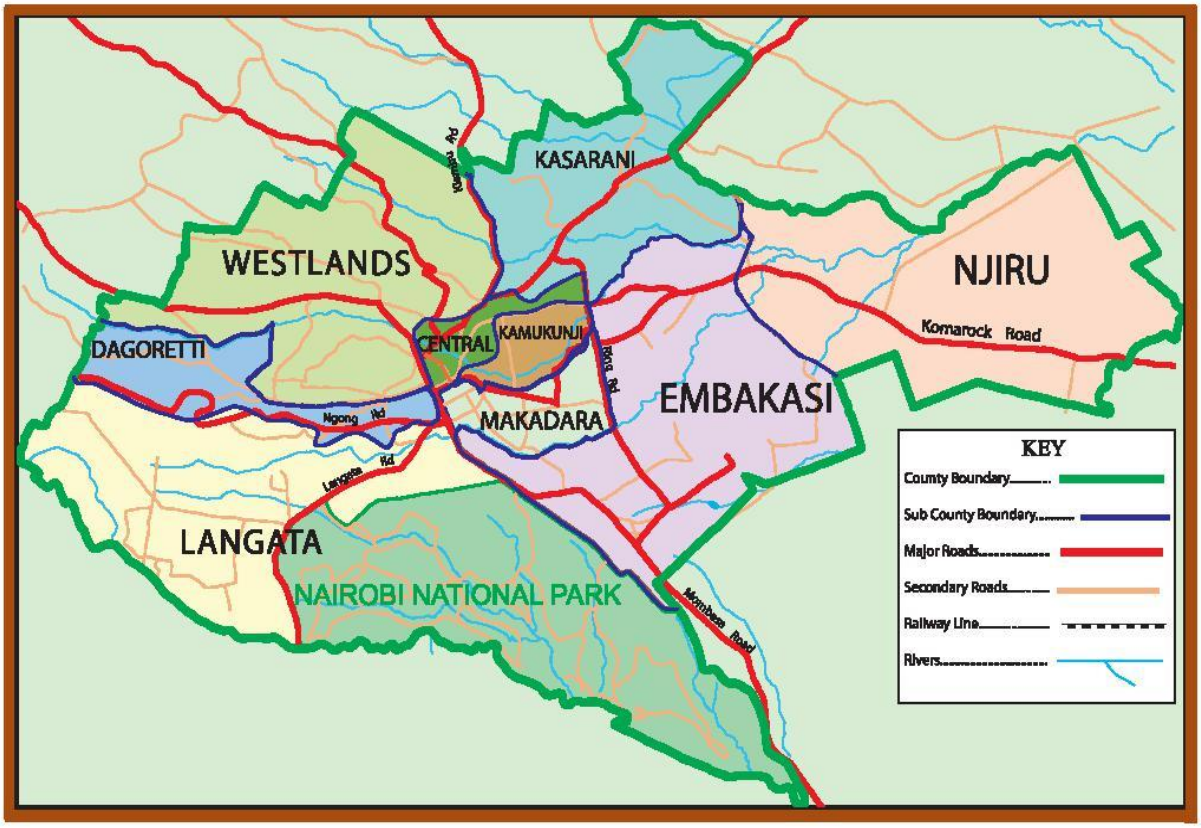

Fig 3.2 Nairobi City County and its sub-counties (Source: Tourist Maps (K) Ltd)

3.5.1 Locations of garages

The map below shows the locations of the garages within Nairobi City County where the research was undertaken.

Fig 3.3 Garage distribution in Nairobi County

3.6 Data Management, Analysis and Presentation

3.6.1 Data Management

Data management involved data cleaning, verification of findings and appropriate data coding. The purpose of data coding was to enable the researcher to reduce the bulk of information into a form than could be more easily handled and analyzed.

3.6.2 Data Analysis

Data from the study was analyzed using Statistical package for social sciences (SPSS version 17). Descriptive and inferential analysis was conducted. Descriptive analysis involved the use of frequencies in their absolute and relative forms (percentage). Inferential analysis (t-test) was done to find out if there was any relationship between the types of motor vehicle garages and the degree of compliance with applicable legal environmental requirements.

The following equation was used in the hypothesis testing using t-test:

$$SE\ (\mu_x - \mu_y) = \sqrt{\{(SE\mu_x)^2 + (SE\mu_y)^2\}}$$

Where:

x is the scores from corporate garages;

y is the scores from independent garages;

$SE\ (\mu_x - \mu_y)$ is the standard error of the difference between the means;

$SE\mu_x$ is the standard error of the sample means of x; and

$SE\mu_y$ is the standard error of the sample means of y.

The justification for choice of t-test for data analysis was due to relatively small sample size and the analysis involved comparison of mean compliance scores for two independent variables (corporate garages and independent garages).

The assumptions made in using the t-test was that the background populations of the samples were normally distributed and the standard deviations of the populations were equal.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter highlights the findings of the study based on the data collected from the respondents. The chapter is organized under sub-sections guided by the research questions. Both descriptive statistics and inferential statistics were used to analyze the data. In the descriptive statistics, relative frequencies and percentage was used where the results are presented in form of tables and charts. In inferential statistics, t-test was used to test the hypothesis.

4.2 General Information

4.2.1 Response Rate

From the target number of garages, all the 32 garages (100%) participated in the study as shown in the diagram below.

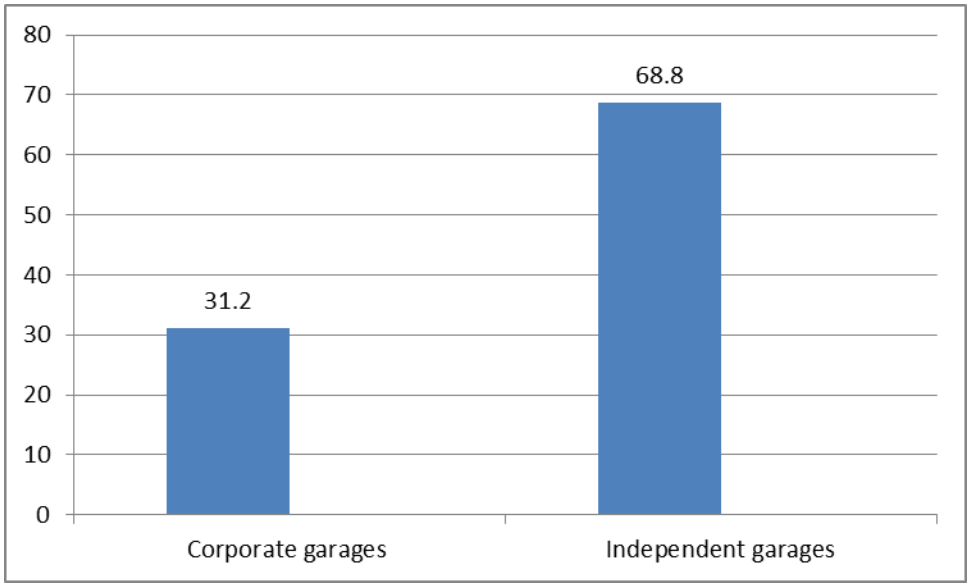

Fig 4.1 Distribution of respondents (%) (Source: Author)

The 100 % response rate was considered very good to make conclusions for the study (Mugenda and Mugenda, 2003).

4.2.2 Positions held by respondents

The diagram below shows positions of respondents in their organizations in the garages that took part in the study. The (x) axis shows the number of respondents holding positions named on the (y) axis.

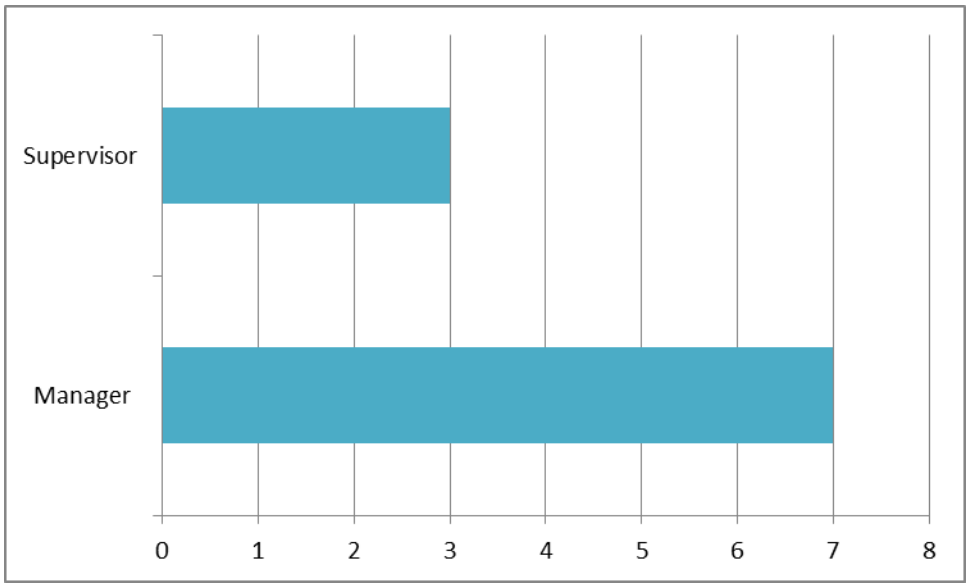

Fig 4.2 a. Positions of respondents in corporate garages (Source: Author)

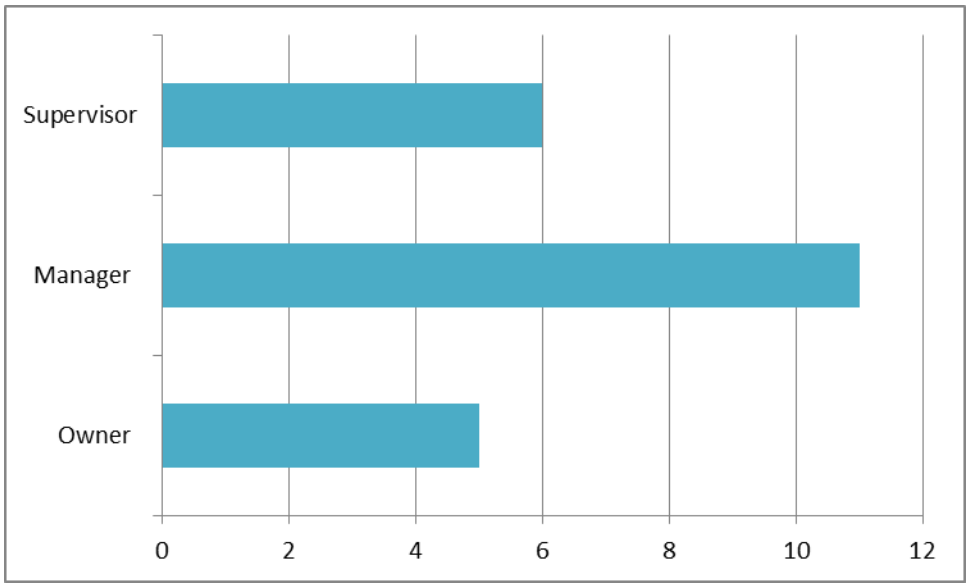

Fig 4.2 b. Positions of respondents in independent garages (Source: Author)

Respondents from 7 (70 %) of the corporate garages were managers while 3 (30 %) were supervisors. Respondents from 5 (22.73 %) of the respondents from independent garages were owners, 11 (50 %) were managers and 6 (27.27 %) were supervisors. All the respondents were at decision making level in their garages.

4.3 Effluent Management Systems

4.3.1 Sources of effluent

The study sought to establish sources of effluent in the garages. The findings are shown in the diagrams below.

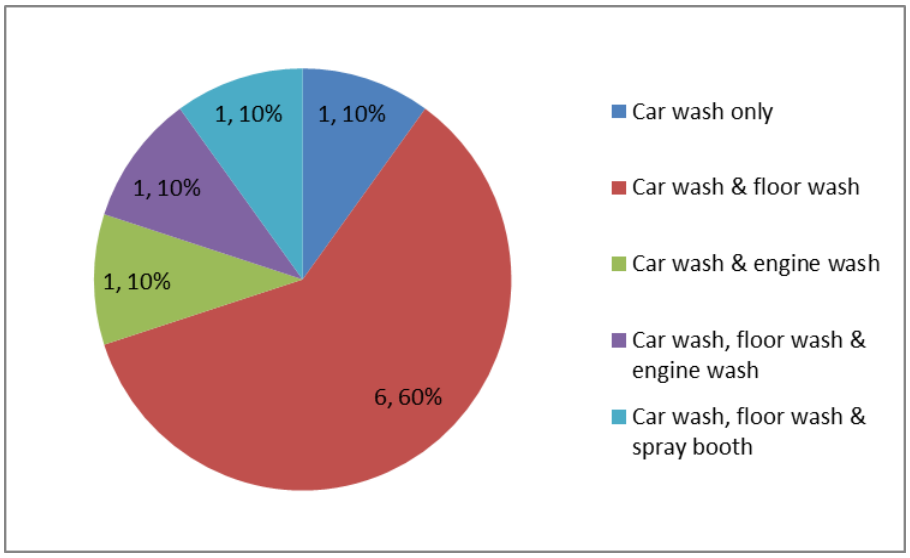

Fig 4.3 a. Sources of effluent in corporate garages

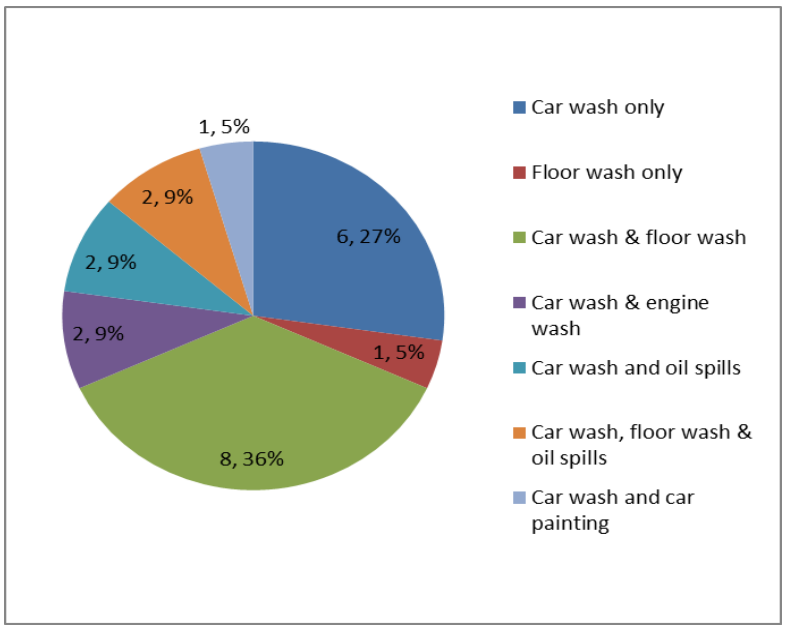

Fig 4.3 b. Sources of effluent in independent garages

The study established that they were various sources of effluent in the garages. For corporate garages, the sources were car wash (10 %), car wash and floor wash (60 %), car wash and engine wash (10 %), car wash, floor wash and engine wash (10 %) and car wash, floor wash and spray booth (10 %).

For independent garages, the sources of effluent were car wash (27 %), floor wash (5 %), car wash and floor wash (36 %), car wash and engine wash (9 %), car wash and oil spills (9 %), car wash and car painting (5 %) and car wash, floor wash and oil spills (9 %).

Plates (1) and (2) below show some of the sources of effluent in some of the garages that took part in the study.

Plate 1: Car wash at RMA Motors Garage

Plate 2: Car wash at KWIK FIT Garage

4.3.2 Effluent management facilities

The study sought to identify facilities used for the management of effluent in the garages. The findings are shown in the diagrams below. The (y) axis shows the number of garages while the (x) axis shows the type of effluent management facilities.

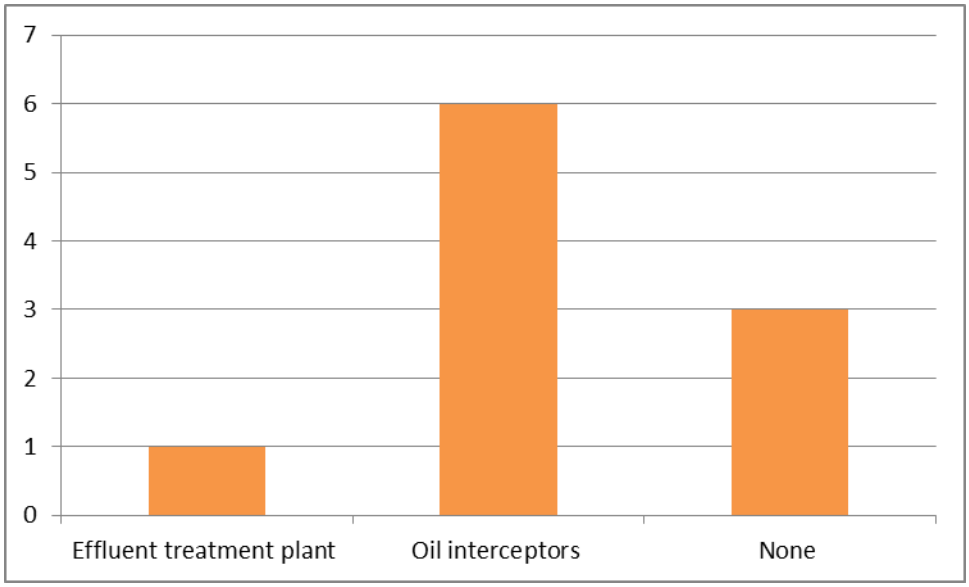

Fig 4.4 a. Facilities for effluent management in corporate garages (Source: Author)

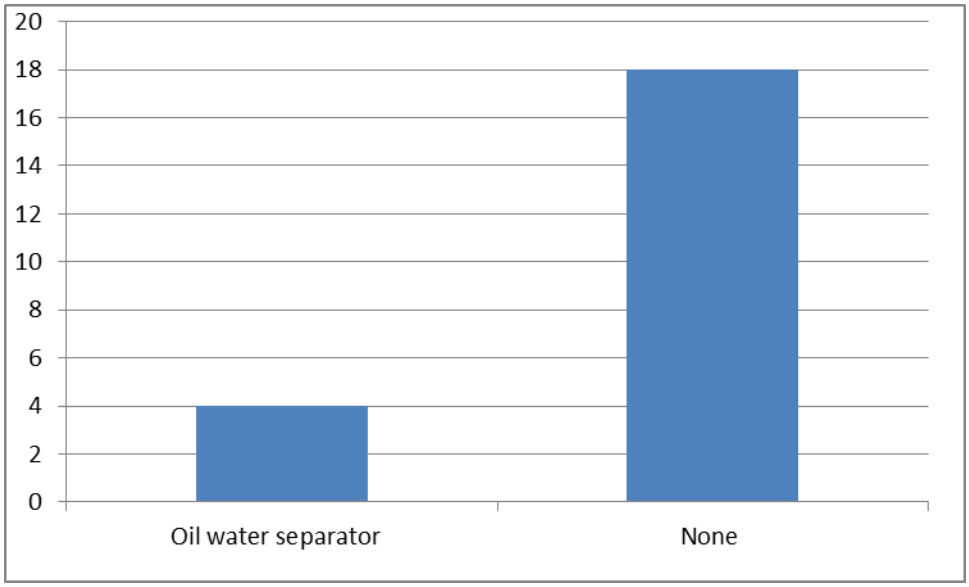

Fig. 4.4 b. Facilities for effluent management in independent garages (Source: Author)

The study found that 1 (10 %) of the corporate garages had an effluent treatment plant, 6 (60 %) had oil interceptors while 3 (30 %) did not have any facilities for management of effluent. The study also found that 4 (18.18 %) of the independent garages only had oil water separators for the management of effluent while majority of the independent garages (81.82 %) did not have any facilities for management of effluent.

Comparing corporate and independent garages with regard to effluent management facilities, the study found that whereas most of the corporate garages (70 %) had facilities for effluent management, most of the independent garages (81.82 %) did not have any facilities for management of effluent.

Plate 3 below shows a oil water separator at one of the corporate garages that took part in the study.

Plate 3: Oil/water separator at Toyota Kenya Workshop

4.3.3 Point of discharge of effluent

The study sought to fnd out where the effluent from the garages ended up. Table 4.1 below shows the points of discharge of effluent from the garages.

Table 4.1: Point of discharge of effluent

Type of garage	**Point of discharge**				**Total (Number)**
	Sewer line	Storm drain (NCC)	Storm and sewer line	Land	
Corporate (Number)	7	2	1	0	10
Corporate (%)	**70**	**20**	**10**	**0**	**100**
Independent (Number)	14	6	0	2	22
Independent (%)	**63.64**	**27.27**	**0**	**9.09**	**100**

The study shows that most (70%) of the corporate garages discharged their effluent into the sewerline. 20 % of the corporate garages discharged their effluent into the Nairobi City County storm water drainage while one of the garages discharged some of its effluent into the sewerline and the rest into storm water drainage.

The study found that 63.64 % of the independent garages were discharging effluent into the sewerline, 27.27 % of the garages into the NCC storm drainage while 9.09 % of the independent garages were discharging their effluent into open land.

Plates (4) and (5) below show points of discharge of effluent from some of the garages that took part in this study.

Plate 4: Discharge of effluent into sewerline at Subaru Kenya Garage

Plate 5 : Discharge into open land at an independent garage

4.3.4 Effluent discharge licences

The study sought to find out if the garages had obtained effluent discharge licences as required by Kenya's environmental regulations. Table 4.2 below presents the findings**.**

Table 4.2: Availability of effluent discharge licences in the garages

Type of garage	**Effluent discharge licence & source**			**Total (Number)**
	No licence	NWSC	NEMA	
Corporate	3	4	3	10
Independent	20	2	0	22
Total	**23**	**6**	**3**	**32**
Total (%)	71.87	18.75	9.38	100

(Source: Author)

The study found that only 28.13 % of the total number of garages had effluent discharge licences while majority of the garages (71.87 %) did not have effluent discharge licences.

4.3.4.1 Comparison between corporate and independent garages on effluent discharge licence

From the table above, the study found that 70 % of the corporate garages had effluent discharge licences. On the contrary, only 2 (9.09%) of the independent garages had effluent discharge licences.

4.3.4.2 Sources of effluent discharge licence

The study sought to establish where the garages had obtained their effluent discharge licences from. The results are as shown in figures 4.5a and 4.5b below. The (x) axis shows the number of garages.

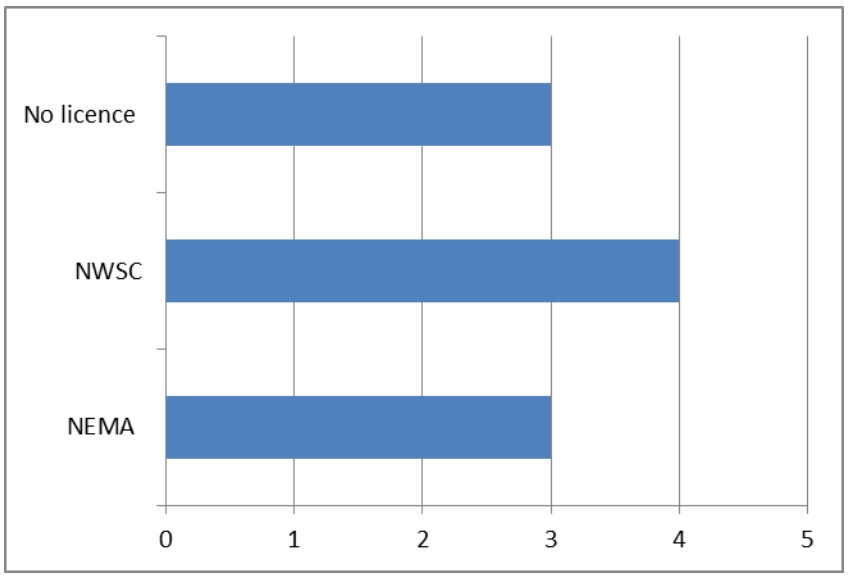

Fig. 4.5a: Sources of effluent discharge licences in corporate garages

(Source: Author)

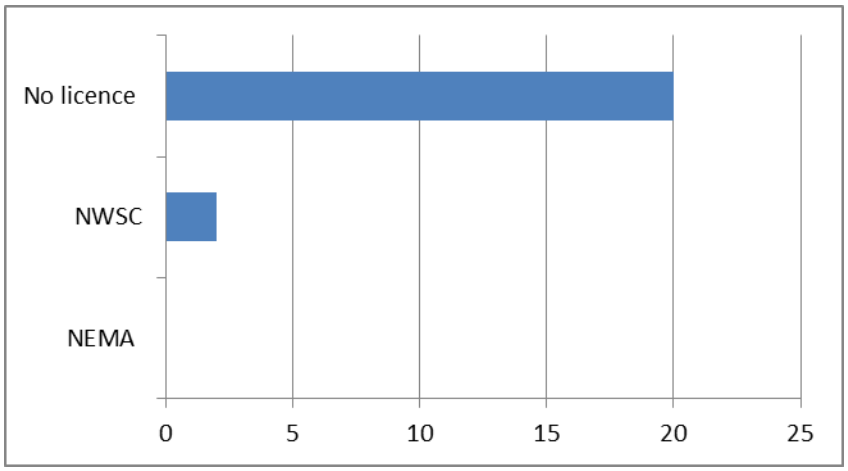

Fig. 4.5b: Sources of effluent discharge licences in independent garages

(Source: Author)

The study found that 57.14 % of the corporate garages that were licenced had obtained their effluent discharge licence from Nairobi Water and Sewerage Company while 42.86 % of the licenced corporate garages had obtained the licences from NEMA.

The study found that the two licenced independent garages had obtained their licences from the Nairobi Water and Sewerage Company.

Plate (6) below shows an effluent discharge licence on display at Toyota Kenya Workshop.

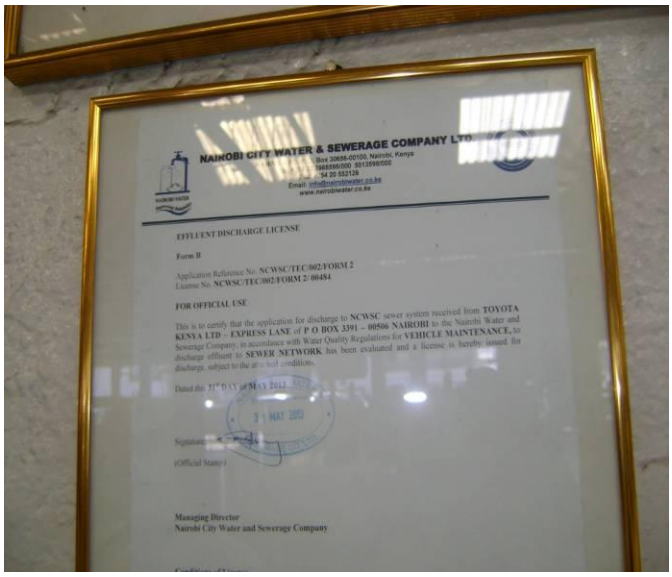

Plate 6: Effluent discharge licence displayed at Toyota Kenya Workshop

4.3.5 Effluent quality monitoring

The researcher further sought to establish whether the garages carried out periodic effluent sampling and analysis as required by environmental regulations. The results are as shown in figure 4.6 below.

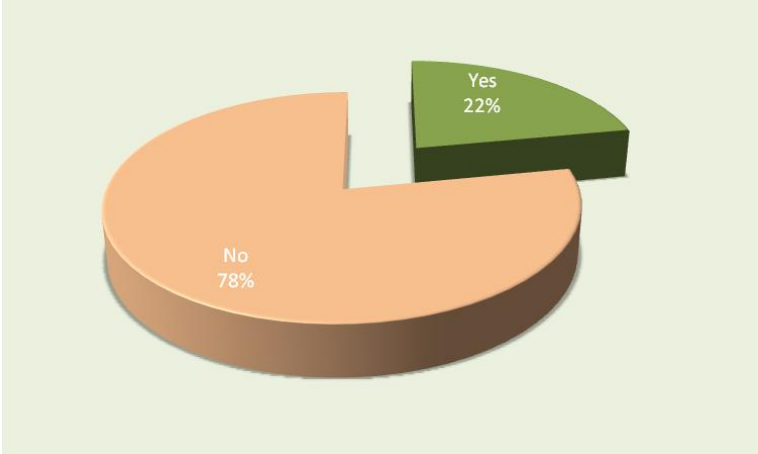

Fig. 4.6: Effluent quality monitoring

The study established that most of the garages (78%) did not carry out periodic sampling and analysis as required. Only 22 % of the garages were carrying out effluent sampling and analysis.

4.3.5.1 Comparison between corporate and independent garages on effluent quality monitoring

Comparison was made between corporate and independent garages on effluent quality monitoring. The results are shown in table 4.3 below.

Table 4.3 Effluent sampling and analysis in corporate and independent garages

	Corporate Garages		**Independent Garages**	
Effluent Sampling	**Percent**	**Frequency**	**Percent**	**Frequency**
Yes	80.0	8	18.18	4
No	20.0	2	81.82	18
Total	100.0	10	100.0	22

(Source: Author)

The results show that 80 % of the corporate garages were monitoring their effluent compared to only 18.18 % of the independent garages.

4.3.5.2 Frequency of effluent quality monitoring

The study also sought to establish the frequency of effluent quality monitoring by the garages. The results are presented in table 4.4 below.

Table 4.4 Frequency of effluent quality monitoring

Frequency of sampling and analysis	Frequency	Percent
Monthly	4	12.5
None	18	56.25
Quarterly	4	12.5
Semi annually	2	6.25
Annually	4	12.5
Total	**32**	**100.0**

(Source: Author)

The study found that 12 (37.5 %) garages conducted their effluent monitoring monthly, quarterly and annually. 6.25 % of the garages conducted their effluent quality monitoring semi-annually. A sample of effluent quality analysis report is appended.

4.3.6 Effluent quality standards

The study also sought to establish if the standards of effluent generated from the garages that participated in the study met the standards set in the Environmental Management and Coordination (Water Quality) Regulations, 2006. The results are shown in figure 4.7 below**.**

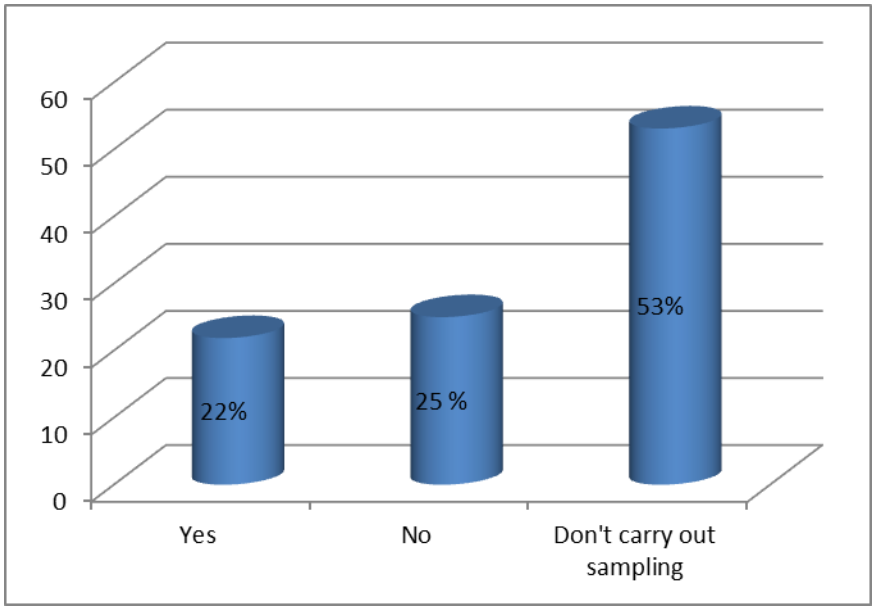

Fig. 4.7: Compliance with effluent quality standards (Source: Author)

The study found that effluent in 25 % of the garages that carried out effluent quality monitoring did not meet the standards specified in the environmental regulations. Only 22 % of the garages were compliant with effluent quality standards specified in the water quality regulations.

4.3.6.1 Effluent quality parameters

The researcher sought to establish particular parameters that did not meet the legal effluent standards from the garage. Copies of the latest effluent analysis reports from the garages were obtained and content analyzed. The results are shown in table 4.5 below.

Table 4.5: Parameters that did not meet effluent standards

Parameter	Frequency	Percent
None	7	22
Do not carry sampling and analysis	17	53
pH	2	6.25
BOD	1	3.125
COD	1	3.125
Oil and Grease	1	3.125
TSS	2	6.25
Total coliforms	1	3.125
Total	**32**	**100.0**

(Source: Author)

The study found out that parameters that did not meet the effluent quality standards were pH (6.25 %), BOD (3.125 %), COD (3.125 %), Oil and grease (3.125 %), TSS (6.25 % and Total coliforms (3.125%). pH and TSS were the most non-compliant parameters.

4.3.7 Separation of foul water from storm water

The study sought to establish whether garages had separate drainage systems for contaminated (foul) water from storm (uncontaminated) water as required under EMCA, 1999. The results are shown in tables 4.6 a and 4.6 b below.

Table 4.6 a: Separation of drainage in corporate garages

Response on drainage separation	Frequency	Percentage
Yes	6	60
No	4	40
Total	**10**	**100**

Table 4.6 b: Separation of drainage in independent garages

Response on drainage separation	**Frequency**	**Percentage**
Yes	4	18.2
No	18	81.8
Total	**22**	**100**

The study found that most (60%) of the corporate garages separated foul water from storm water while only 18.2 % of the independent garages had separated the storm water from foul (contaminated) water.

4.3.8 Facilities for accidental spillage containment

The study sought to find out what facilities various garages had for containment of accidental spillage of oils and other potential liquid pollutants used in the garages. The results are shown in tables 4.7 a and 4.7 b below.

Table 4.7 a: Facilities for accidental spillage containment in corporate garages

Response on spillage containment	Frequency	Percentage
Yes	9	90
No	1	10
Total	**10**	**100**

Table 4.7 b: Facilities for accidental spillage containment in independent garages

Response on spillage containment	Frequency	Percentage
Yes	18	81.8
No	4	18.2
Total	**22**	**100**

The study found that 90 % of the corporate garages and 81.8 % of the independent garages had facilities for containment of accidental spillage of oils and other potential liquid pollutants.

The common type of accidental spillage containment facility was concrete-bunded storage area such as the one shown in plate 7 below.

Plate 7: Accidental spillage containment structure at RMA Motors (K) Ltd

4.3.9 Environmental audits

The study sought to establish if the garages were conducting annual environmental audits as required under Kenya's environmental regulations. The results are shown in the table below.

Table 4.8 a: Compliance with environmental audit requirement in corporate garages

Annual environmental audits	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	10	100.0	100.0	100.0
No	0	0	0	100.0

(Source: Author)

Table 4.8 b: Compliance with environmental audit requirement in independent garages

Annual environmental audits	Frequency	Percent	Cumulative Percent
Yes	13	59.1	**59.1**
No	9	40.9	**100**
Total	**22**	**100**	

(Source: Author)

The study found that all corporate garages were conducting annual environmental audits while only 59.1 % of the independent garages were conducting the annual audits.

4.3.10 Plans for improved effluent management

Garages were asked to state the plans they had in place for improved management of effluent. The responses are summarized in figure 4.8 below. The (y) axis shows the % of garages.

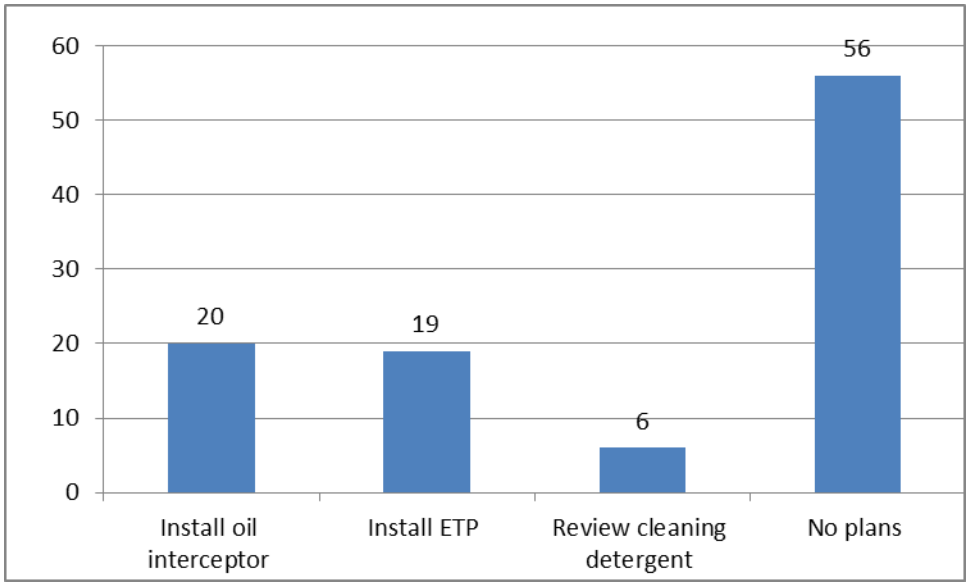

Fig. 4.8: Plans for improved effluent management (%)

The study found that most of the garages (56 %) did not have plans for upgrading their effluent management systems for enhanced compliance. 20% of the garages indicated that they had plans to construct an oil interceptor, 19% of the garages said that they intended to install effluent treatment plants while another 6 % said that they were considering to review their cleaning detergent.

4.4 Relationship between garage type and the degree of compliance

A compliance assessment criteria was developed as shown in table 4.9 below.

Table 4.9: Compliance assessment parameters

1	Presence of effluent treatment facility – Oil water separator/effluent treatment plant
2	Monitoring of effluent discharge (quarterly)
3	Availability of effluent discharge licence (from NEMA or Nairobi Water & Sewerage Company)
4	Discharge of effluent into sewer line
5	Separation of foul water from storm water
6	Compliance with effluent quality standards
7	Facilities for accidental spillage containment
8	Conducting annual environmental audits

For each of the selected garages, a compliance score was assigned for each of the 8 parameters. (1) was assigned for compliance with each parameter and (0) for non-compliance. For fairness, an equal number of subjects, N of 10 was taken from either category. The 10 independent garages were selected by simple random sampling. The scores for the garages are shown in table 4.10 below.

Table 4.10 Compliance Scores for the Garages

Corporate Garage	Score (Maximum Possible score = 8)	Independent Garage	Score (Maximum Possible score = 8)
Toyota Kenya	8	KEHAR	3
DT Dobie	8	KWIKFIT	5
Subaru	8	MotorGari	2
Simba Colt	8	Palm Motors	3
Car and General	8	CITI hoppa	4
RMA Motors	8	Oto Doktuz Lavington	4
Honda	7	Tash Auto Garage	2
FOTON	6	Bufallo Auto	3
Toyotsu Automart	8	Autospares Ngara	1
Hyundai	7	Autofit Ltd	4
Total Score (∑)	**76**		**31**
Mean (∑/N)	**7.6**		**3.1**

The corporate garages had a higher mean compliance score than the independent garages.

4.4.1 Testing of the hypothesis

The research hypothesis which stated that "There is no significant relationship between the type of motor vehicle garage and the degree of compliance with the legal environmental requirements for effluent management systems for motor vehicle garages in Kenya" was tested by means of t-test at 95 % confidence interval. The test results are shown in table 4.11 below.

Table 4.11 Results of hypothesis testing (using t-test)

x	**y**	**$(x-\mu_x)^2$**	**$(y-\mu_y)^2$**
8	3	0.16	0.01
8	5	0.16	3.61
8	2	0.16	1.21
8	3	0.16	0.01
8	4	0.16	0.81
8	4	0.16	0.81
7	2	0.36	1.21
6	3	0.256	0.01
8	1	0.16	4.41
7	4	0.36	0.81
$\sum n_x = 76$	$\sum n_y$ 31	$\sum(x-\mu_x)^2 = 2.096$	$\sum(y-\mu_y)^2 = 12.9$
μ_x=7.6	$\mu_y = 3.1$		
$I\mu_x - \mu_y I = 4.5$			

Calculations

Pool best estimate: $\delta^n = \sqrt{\{(2.099+12.9)/(10+10-2)\}} = \sqrt{14.996/18} = 0.91275$

$SE\mu_x = 0.91275/\sqrt{10} = 0.28866$ and $SE\mu_y = 0.28866$

$SE\ (\mu_x - \mu_y) = \sqrt{\{(SE\mu_x)^2 + (SE\mu_y)^2\}} = \sqrt{(0.28866^2 + 0.28866^2)} = 0.40823$

$t_{Calculated} = (I\mu_x - \mu_y I)/ SE\ (\mu_x - \mu_y) = 4.5/0.40823 = 11.023$

$t_{critical}$ at 18 df (two tailed test) and 95 % confidence level from t-tables = 2.101

Therefore; $t_{Calculated} > t_{critical}$ i.e. 11.023 >2.101

The null hypothesis is therefore rejected. Therefore, the study finds that there is a significant relationship between the type of motor vehicle garage and the degree of compliance with the applicable legal environmental requirements for effluent management systems for motor vehicle garages in Kenya.

CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and conclusions

The general objective of this study was to assess the effluent management systems in motor vehicle garages in Nairobi. The specific objectives of the study were to examine the types of effluent management systems used by motor vehicle garages in Nairobi; to establish whether the effluent management systems in motor vehicle garages met applicable legal environmental requirements for motor vehicle garages in Kenya; to find out if there was any relationship between the types of motor vehicle garages and the degree of compliance with applicable legal environmental requirements; and to recommend measures to be undertaken by motor vehicle garages whose effluent management systems did not meet the applicable legal environmental requirements.

The study found that the sources of effluent in garages were car washing, floor washing and spray booths. The study found that whereas most of the corporate garages (70 %) had facilities for effluent management, most of the independent garages (81.82 %) did not have any facilities for management of effluent. According to the study, the effluent management systems found in the garages were oil/water separators and effluent treatment plant. The study found that among the corporate garages only one (10 %) had an effluent treatment plant while 6 (60 %) had oil interceptors. Among the independent garages, only 4 (18.18 %) had oil water separators while 18 (81.82 %) did not have any facilities for management of effluent.

According to the study, the points of discharge of effluent from the garages were sewerage system, storm water drainage system and land. 70 % of the corporate garages were discharging effluent into the sewerage system and 20 % into the storm drain. 63.64 % of the independent garages were discharging effluent into the sewerage system, 27.27 % into the storm drainage and 9.09 % onto open land.

According to the study findings, 28.13 % of the garages had effluent discharge licences while majority of the garages (71.87 %) did not have effluent discharge licences. Corporate garages were more compliant with this requirement since 70 % of them had effluent discharge licences compared to only 9.09% of the independent garages.

The study found that most of the garages (78%) were not carrying out effluent quality monitoring. The independent garages were poorly compliant with requirement since only 18.18 % of them were conducting effluent quality monitoring compared with corporate garages that had 80 % compliance. The study found that 60% of the corporate garages separated foul water from storm water while only 18.2 % of the independent garages had separated the storm water from foul water. Whereas all corporate garages involved in the study were conducting annual environmental audits, only 59.1 % of the independent garages were conducting the annual audits from the study findings.

With regard to facilities for accidental spillage containment, the study found that 90 % of the corporate garages and 81.8 % of the independent garages respectively had facilities for containment of accidental spillage of oils and other potential liquid pollutants. The most common facility for accidental spillage containment was concrete bunding of storage areas for liquids pollutants.

Comparison of mean compliance score between corporate and independent garages showed that corporate garages had a higher mean compliance score than the independent garages.

Upon testing of the hypothesis through t-test, the null hypothesis was rejected. The study found that there was a significant relationship between the type of motor vehicle garage and the degree of compliance with the legal environmental requirements for effluent management systems for motor vehicle garages in Kenya.

Despite a high level of non-compliance with environmental requirements, the study found that most of the garages (56 %) did not have plans for upgrading their effluent management systems for enhanced compliance. Only 20% of the garages had plans to

construct an oil interceptor, 19% were planning to install effluent treatment plant while 6% said that they were considering reviewing their cleaning detergent.

The independent garages in Nairobi generally had poor effluent management systems compared to the corporate garages.

5.2 Recommendations

This study recommends that garages in Nairobi should install suitable and effective effluent management systems to treat effluent before discharge into the environment. The garages should, at the very minimum, have a 3-chamber oil/water separator to intercept oil before discharge into the sewer line. Garages, especially those generating large volumes of effluent, should invest in advanced effluent treatment systems such as effluent treatment and recycling plants. Unless they have effluent treatment and recycling plants, garages should all discharge their effluent into the sewer line with approval from the Nairobi Water and Sewerage Company. All garages should obtain effluent discharge licences from respective authorities in accordance with the provisions of the Environmental Management and Coordination (Water Quality) Regulations of 2006. Garages whose effluent ends up in the sewer line should obtain their effluent licences from the Nairobi Water and Sewerage Company while those discharging effluent directly into the environment should obtain their licences from NEMA. The garages should fully comply with the conditions of the effluent licences, including but not limited to quarterly sampling and analysis of effluent in NEMA-approved laboratories.

Foul (contaminated) water drainage from garages should be separated from storm water from roofs, yards and other uncontaminated sources. The former should be channeled into the effluent treatment system while the latter should be directed into storm drains. These systems should be well maintained for continued operational efficiency and records of maintenance kept.

Garages should have facilities for accidental spillage containment and prevention including drip trays, sumps and concrete bunding. There should also be arrangements for arresting and cleaning of fugitive spills such as suitable absorbent and oil spill kits.

Garages should also conduct annual environmental audits and submit reports to NEMA as required under the Environmental Management and Coordination (Impact Assessment and Audit) Regulations of 2003.

NEMA and the Nairobi City County Government should educate garage owners and the wider public on environmental regulatory requirements and conduct periodic inspections to assess compliance. Garages found flouting environmental regulations should be given improvement orders and if they fail to comply, be prosecuted as a deterrent measure to other pollutants.

Independent garages should borrow good practices from the corporate garages, most of which have international standards for environmental management.

5.3 Suggestions for further research

Further research could be conducted to establish the factors underlying a high level of non-compliance with environmental regulatory requirements in independent garages. Research could also be conducted on developing the most efficient, cost effective and sustainable system for management of effluent from garages.

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APPENDICES

Appendix I: Interview Schedule

a) Introduction

My name is James Thiaine and I am a student at the University of Nairobi where I am undertaking a Master of Arts degree in Environmental Planning and Management. As part of fulfillment of the requirements of the masters degree, I am undertaking a research project whose title is "*Assessment of Effluent Management Systems in Selected Motor Vehicle Garages in Nairobi."* As part of the research, I am visiting your organization to enable me gather useful information towards my research project. I will be very grateful if you can spare a few minutes to respond to the questions in this interview. The information you provide will be held in utmost confidence, and will be used for the said purpose only.

Section A: Basic data

Name of respondent	_____
Name of organisation	_____
Location	
Position	_____
Category of organisation (tick one)	Corporate Garage ☐ Independent Garage ☐

Section B: Questions

1. What is (are) the source (s) of wastewater (effluent) in your facility?

_____

_____

_____

2. How does your facility manage the wastewater generated (where is the wastewater channeled into)?

_____

_____

_____

_____

3. (a) Does you facility have an effluent discharge licence?

Yes	No

b) If your answer is yes above, from where have you obtained the effluent discharge licence?

NEMA	Nairobi Water and Sewerage Company

4. (a) Do you carry out effluent quality monitoring (by periodic sampling and analysis)?

Yes	No

a) If your answer is yes above, what is your frequency of effluent sampling and

Monthly	Quarterly	Semi annually	Annually

5. (a) If you carry out sampling and analysis of effluent, does your effluent meet the standards specified in the Environmental Regulations?

Yes	No

b) If your answer is no above, which particular parameters do not meet the legal effluent standards (copies of latest effluent analysis reports to be provided)?

- pH
- BOD
- COD
- TSS
- Zinc
- Total coliforms
- Lead
- Oil and Grease
- Copper
- Sodium
- Iron
- Phosphates
- Nitrates

6. What plans do you have in place to ensure that the parameters that do not comply meet the applicable standards?

- Install an oil interceptor
- Install an effluent treatment plant
- Plans other than oil interceptor and effluent treatment plant (specify)
- We have no plans for improvement

7. Does your facility comply with the following legal environmental, health and safety requirements?

Annual environmental audits
Annual health and safety audits
Fire safety audit
Risk assessment

Thank you

Appendix II: Observation Checklist

Name of facility: _____

Location: _____GPS coordinates_____

Category (tick one):_____

Corporate Garage	Independent Garage

No	Item	Observation (s)
1.	Activities taking place at the facility	
2.	Sources of effluent	
3.	Facilities for management of effluent e.g oil/water separator, effluent treatment plant	
4.	Separation of foul water from storm water	
5.	Point of discharge of effluent	
6.	Arrangements for accidental or emergency spillage containment	

7.	Facilities for collection and storage of used oils or fuels	
8.	Disposal arrangements for used oil, coolants and other fluids	
9	Concrete floor condition to prevent soil contamination	
10	Display of environmental licence (effluent discharge licence)	
11	Availability and use of personal protective equipment by personnel	
12	Availability and communication of environmental policy	
13.	Availability of facility drainage plan	
14.	Other relevant observations	

Appendix III: Sample effluent quality monitoring report

agriQ Quest
Member of the Bigg Group

KENAS/TL/14

AgriQ Quest Limited
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Nairobi, Kenya
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CERTIFICATE OF ANALYSIS

Client: Toyota Kenya Ltd. **Sample Id:** Effluent

Batch Ref: Effluent From Engine Room

Batch No: 13/0765 **Lab. Ref.:** AQ 36358

Date Received: 20/06/2013 **Date Analysis Started:** 21/06/2013 **Date Completed:** 03/07/2013

PARAMETER	Method	Results	[1]Standard (Max Limits)
Chemical			
pH	QMA 05	7.26	6.0 - 9.0
Colour in hazen units (H.U)	QMA 48	11	40
Biological Oxygen Demand - (BOD_5 at 20°C), mg/l	ISO 5815	10.2	500
Chemical Oxygen Demand (COD), mg/l	ISO 6060	28.8	1000
Total Dissolved Solids (TDS), mg/l	QMA 17	80	2000
Total Suspended Solids (TSS), mg/l	QMA 18	24	250
Oil and grease, in mg/l	QMA 09	0.04	10
Zinc as Zn, mg/l	QMA 10	<0.001	5.0
Calcium as Ca, mg/l	QMA 10	11.1	[2]
Copper as Cu, mg/l	QMA 10	0.11	1.0
Manganese as Mn, mg/l	QMA 10	0.36	[2]
Iron as Fe, mg/l	QMA 10	0.05	[2]
Sodium as Na, mg/l	QMA 10	38.8	[2]
Nitrate as NO_3, mg/l	QMA 13	1.80	20
Phosphates as PO_4, mg/l	QMA 21	6.32	30
Microbiological			
Total Coliforms, cfu per ml	ISO 4832	560	[2]

< = Less than; below detection level of 0.001 mg/l;

[1]Standard values quoted from Environmental Management & Coordination (Water Quality) Regulations 2006, Legal Notice No. 120, Fifth Schedule 'Guideline Standards for Discharge of Effluent into Public Sewers'

[2] No Reference values quoted for these parameters

QMA - Quest Laboratories Work Procedure adopted from ISO and APHA Methods

ISO - International Organization for Standardization

APHA - American Public Health Association - Standard Methods for the Analysis of Water & Wastewater, 14th Edition

Comment on Analysis

The effluent meets the requirements of the standard in the parameters tested.

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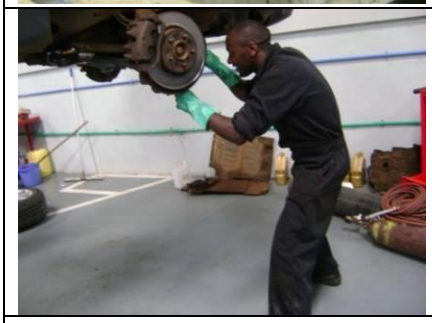
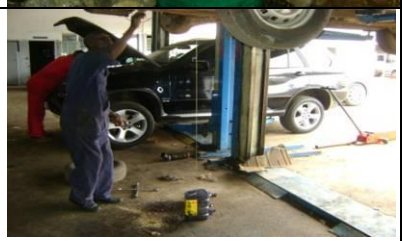
Walter Ogara

Head of Laboratory Services

Appendix IV: Comparison between practices at corporate and independent garages

Corporate Garage	**Independent Garage**	Observation
		Effluent drainage
		Waste management
		Floor condition
		Effluent management facilities

		Used oil storage
		Use of personal protective equipment
		Final effluent destination

Appendix V: Raw data

Table 4.12: Raw data (corporate garages)

	Garage	Location	GPS Coordinates	Position of respondent	Source of effluent	Point of discharge	Facilities for effluent management	Effluent discharge licence and source
1	Hyundai Holdings EA Ltd	Mombasa Road	S01^{0}19.728' E036^{0}50.659'	Supervisor	Car wash and engine wash	Sewerline	Oil interceptors	NEMA
2	DT Dobie	Lusaka Road	S01^{0}29.868' E036^{0}83.677'	Manager	Car wash and floor wash	Sewerline	Effluent treatment plant	None
3	Foton East Africa Ltd	Industrial Area	S01^{0}18.520' E036^{0}49.730'	Manager	Car wash	Storm drain	None	NEMA
4	Car and General	Industrial Area	S01^{0}18.205' E036^{0}49.839'	Supervisor	Car wash and floor wash	Sewer line	None	NWSC
5	Toyotsu Automart (K) Ltd	South C	S01^{0}32.996' E036^{0}83.600'	Manager	Car wash and floor wash	Storm drains	Oil interceptors	NEMA
6	Honda	Mombasa Road	S01^{0}19.870' E036^{0}51.492'	Manager	Car wash and floor wash	Sewer line	None	NWSC
7	Simba Colt Motors	Mombasa Road	S01^{0}19.782' E036^{0}51.267'	Supervisor	Car wash and floor wash	Sewer line	Oil interceptors	NWSC
8	Toyota Kenya Ltd	Mombasa Road	S 01°30.499' E 036°82.800'	Manager	Car wash, engine wash, floor wash	Sewer line	Oil interceptors	NWSC
9	Subaru Kenya	Industrial Area	S01^{0}17.902' E036^{0}50.377'	Manager	Car wash, floor wash and spray booth	Sewer and storm	Oil interceptors (2 chamber)	None
10	RMA Motors	Industrial Area (Enterprise Road)	S 01.31870° E 036.86390°	Manager	Car wash and floor wash	Sewer line	Oil interceptors	None

Table 4.13: Raw data (independent garages)

	Independent	Location	GPS Coordinates	Position of respondent	Source of effluent	Point of discharge	Facilities for effluent management	Effluent discharge licence
1	Regency Autogarage	Ngara	S01^{0}16.452' E036^{0}49.053'	Manager	Car wash, oil spills	Sewerline	None	None
2	Motogari Service Centre	Industrial area	S01^{0}18.131' E036^{0}49.663'	Owner	Car wash and floor wash	Sewerline	None	None
3	Amboseli Motors	Lavington	S01^{0}17.016' E036^{0}45.580'	Owner	Car wash and engine wash	Land	None	None
4	Neosilver arrow Automobiles	Lavington	S01^{0}17.107' E036^{0}45.582'	Manager	Car wash and floor wash	Sewerline	None	None
5	Kwikfit	Westlands	S01^{0}15.748' E036^{0}48.211'	Manager	Carwash and floor wash	Sewerline	Oil water separator	NWSC
6	Amazon Tyres and Service Centre	Westlands	S01^{0}15.899' E036^{0}48.207'	Supervisor	Car wash and floor wash	Storm drain (NCC)	Oil water separator	None
7	Oto Doktuz Ltd	Lavington	S01^{0}16.682' E036^{0}46.121'	Owner	Floor wash	Sewerline	None	None
8	Shell Industrial area	Industrial area	S01^{0}18.117' E036^{0}49.705'	Supervisor	Car wash	Sewerline	Oil water separator	None
9	Kehar	Industrial area	S01^{0}19.00' E036^{0}50.00'	Manager	Car wash	Sewerline	None	None
10	Autofit Ltd	Westlands	S01^{0}15.932' E036^{0}48.081'	Owner	Car wash and floor wash	Sewerline	None	NWSC
11	Jacaranda Motors	Lavington	S01^{0}16.852' E036^{0}46.159'	Manager	Car wash, floor wash, oil spills	Storm drain (NCC)	None	None
12	Silverstone	Lusaka	S01^{0}18.229'	Supervisor	Car wash and	Sewerline	None	None

	Tyres Ltd	Road	E036^{0}49.687’		floor wash			
13	Tash Auto Garage	Dagoretti Corner	S01^{0}18.229’ E036^{0}49.687’	Owner	Car wash	Land	None	None
14	Patron Garage	Funzi Road	S01^{0}18.191’ E036^{0}50.625’	Mechanic	Car wash	Sewerline	None	None
15	Saladin	Dagoretti Corner	S01^{0}17.961’ E036^{0}45.831’	Manager	Car wash, engine wash	Sewerline	None	None
16	City Hopper Workshop	Industrial Area	S01^{0}17.785’ E036^{0}49.708’	Supervisor	Car wash and floor wash	Storm drain (NCC)	None	None
17	Tafriro motors	Westlands	S01^{0}16.228’ E036^{0}48.556’	Supervisor	Car wash	Storm drain (NCC)	None	None
18	Stantech Motors Ltd	Industrial Area	S01^{0}18.471’ E036^{0}49.759’	Manager	Car wash, floor wash	Sewerline	Oil water separator	None
19	Bufallo Auto Lab	Industrial Area	S01^{0}17.663’ E036^{0}49.955’	Supervisor	Car wash, oil spills	Sewerline	None	None
20	Fourth Gear Ltd	Funzi Road	S01^{0}18.190’ E036^{0}50.630’	Manager	Car wash, car painting	Storm drain (NCC)	None	None
21	Tool Box Auto Garage	Mathare	S01^{0}15.820’ E036^{0}51.686’	Manager	Car wash	Storm drain (NCC)	None	None
22	Palm Motors	Dakar Road	S01^{0}18.119’ E036^{0}50.663’	General manager	Car wash, floor wash, oil spills	Sewerline	None	None